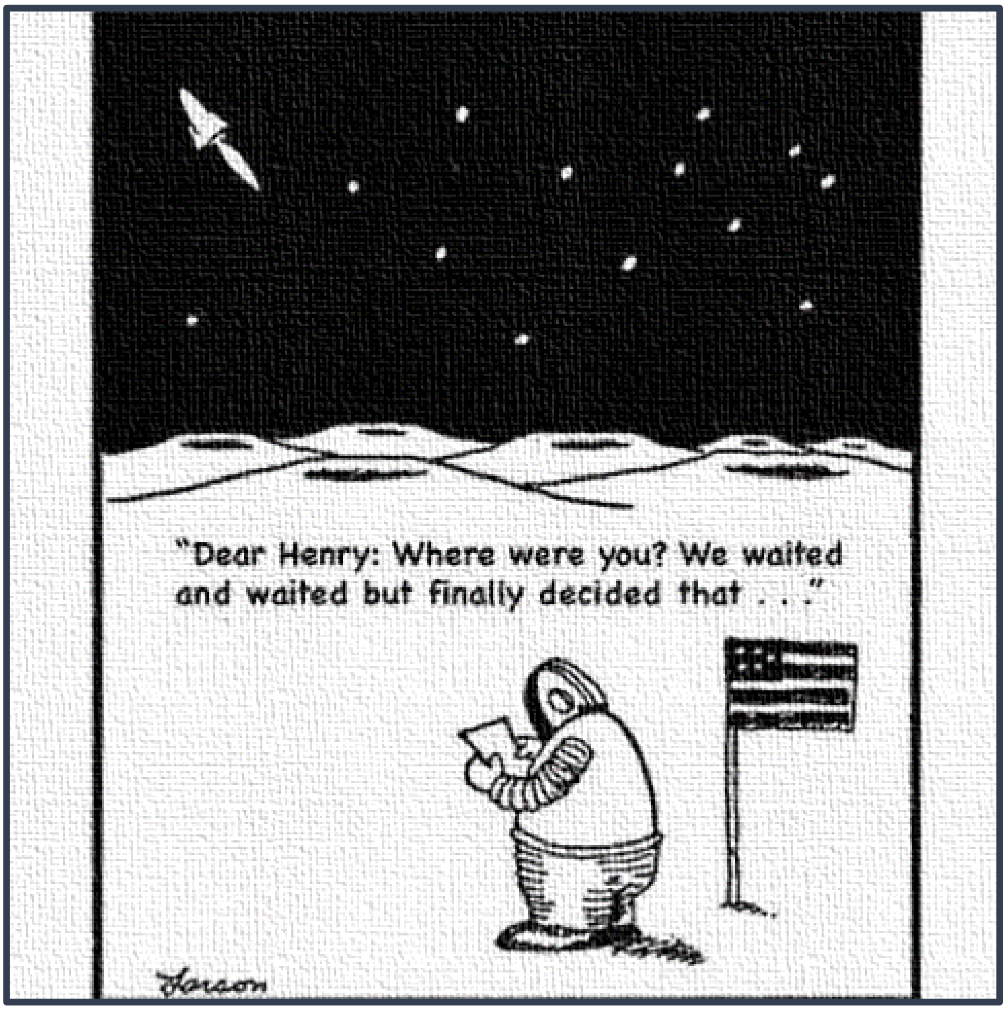
SPACE EXPLORATION



English B, EUX SPACE

Midtbyens Gymnasium

Space exploration - content

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Apollo 11 (documentary directed by Todd Douglas Miller, 2019. 93 mins)

Constructing a lunar base
NASA has teamed up with Danish architectural office Bjarke Ingels Group (BIG) and ICON, a startup company that claims you can 3D-print a lunar base from moon dust https://edition.cnn.com/style/article/3d-print-lunar-base-moon-dust-spc-intl/index.html Space Radiation. iBook, NASA, 2020 (excerpt)
Research on space
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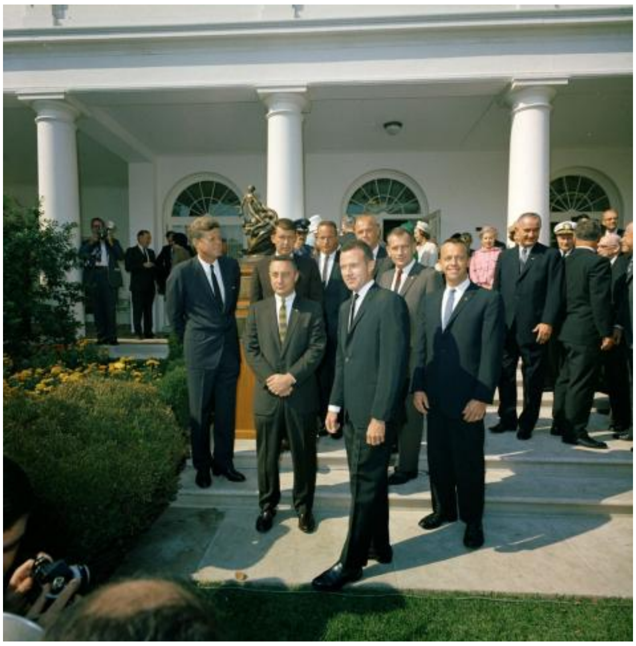
Into the Great Unknown

Space Program

In 1961, President John F. Kennedy began a dramatic expansion of the U.S. space program and committed the nation to the ambitious goal of landing a man on the Moon by the end of the decade.



In 1957, the Soviet Union launched the satellite *Sputnik,* and the space race was on. The Soviets' triumph jarred the American people and sparked a vigorous response in the federal government to make sure the United States did not fall behind its Communist rival.

A new space program, Project Mercury, was initiated two years later, during President Dwight D. Eisenhower's administration. Seven men were selected to take part in the program: Scott Carpenter, Leroy Gordon Cooper, John Glenn Jr., Virgil "Gus" Grissom, Walter Schirra Jr., Alan Shepard Jr., and Donald "Deke" Slayton. Project Mercury's goals were to orbit a manned spacecraft around Earth, investigate the ability of astronauts to function in space, and recover astronauts and spacecraft safely.

Then, in 1961, the nation suffered another shock when Soviet cosmonaut Yuri Gagarin became the first man to orbit the Earth. The United States, it seemed, was still falling behind.

President Kennedy's Challenge

President Kennedy understood the need to restore America's confidence and intended not merely to match the Soviets, but surpass them. On May 25, 1961, he stood before Congress to deliver a special message on "urgent national needs." He asked for an additional $7 billion to $9 billion over the next five years for the space program, proclaiming that "this nation should commit itself to achieving the goal, before the decade is out, of landing a man on the Moon and returning him safely to the earth." President Kennedy settled upon this dramatic goal as a means of focusing and mobilizing the nation's lagging space efforts.

Skeptics questioned the ability of the National Aeronautics and Space Administration (NASA) to meet the president's timetable. Within a year, however, Alan Shepard and Gus Grissom became the first two Americans to travel into space.

An American in Orbit

On February 20, 1962, John Glenn Jr. became the first American to orbit Earth. Launched from Cape Canaveral, Florida, the *Friendship 7* capsule carrying Glenn reached a maximum altitude of 162 miles and an orbital velocity of 17,500 miles per hour. After more than four hours in space, having circled the earth three times, Glenn piloted the Friendship 7 back into the atmosphere and landed in the Atlantic Ocean near Bermuda.

Glenn's success helped inspire the great army of people working to reach the Moon. Medical researchers, engineers, test pilots, machinists, factory workers, businessmen, and industrialists from across the country worked together to achieve this goal. By May 1963, astronauts Scott Carpenter, Walter Schirra Jr., and L. Gordon Cooper had also orbited Earth. Each mission lasted longer than the one before and gathered more data.

To the Moon

As space exploration continued through the 1960s, the United States was on its way to the Moon. Project Gemini was the second NASA spaceflight program. Its goals were to perfect the entry and re-entry maneuvers of a spacecraft and conduct further tests on how individuals are affected by long periods of space travel. The Apollo Program followed Project Gemini. Its goal was to land humans on the Moon and assure their safe return to Earth. On July 20, 1969, the *Apollo 11* astronauts—Neil Armstrong, Michael Collins, and Edwin "Buzz" Aldrin Jr.—realized President Kennedy's dream.

https://www.jfklibrary.org/learn/about-jfk/jfk-in-history/space-program

Why We Explore

Human Space Exploration

Humanity's interest in the heavens has been universal and enduring. Humans are driven to explore the unknown, discover new worlds, push the boundaries of our scientific and technical limits, and then push further. The intangible desire to explore and challenge the boundaries of what we know and where we have been has provided benefits to our society for centuries.
Human space exploration helps to address fundamental questions about our place in the Universe and the history of our solar system. Through addressing the challenges related to human space exploration we expand technology, create new industries, and help to foster a peaceful connection with other nations. Curiosity and exploration are vital to the human spirit and accepting the challenge of going deeper into space will invite the citizens of the world today and the generations of tomorrow to join NASA on this exciting journey.

A Flexible Path

This is the beginning of a new era in space exploration in which NASA has been challenged to develop systems and capabilities required to explore beyond low-Earth orbit, including destinations such as translunar space, near-Earth asteroids and eventually Mars.
NASA will use the International Space Station as a test-bed and stepping stone for the challenging journey ahead. By building upon what we learn there we will prepare astronauts for the challenges of long-duration flight and the permanent expansion of human exploration beyond where we have been before. Explorers may visit near-Earth asteroids where we may get answers to the questions humans have always asked. Visiting an asteroid will provide valuable mission experience and prepare us for the next steps–possibly for the first humans to step on Mars.
Robotic exploration continues to deliver profound answers about our Universe by visiting far-off destinations, providing reconnaissance and collecting scientific data. When combining both human and robotic exploration methods we will use technology and our senses to increase our ability to observe, adapt, and uncover new knowledge.

Why the International Space Station?

The first step in embarking on a long and challenging journey involves laying solid groundwork for a successful endeavor. The International Space Station serves as a national laboratory for human health, biological, and materials research, as a technology test-bed, and as a stepping stone for going further into the solar system. On the International Space Station we will improve and learn new ways to ensure astronauts are safe, healthy and productive while exploring, and we will continue expand our knowledge about how materials and biological systems behave outside of

the influence of gravity.
NASA will continue its unprecedented work with the commercial industry and expand an entire industry as private companies develop and operate safe, reliable and affordable commercial systems to transport crew and cargo to and from the International Space Station and low Earth orbit.

Why Translunar Space?

Translunar space is vast expanse surrounding the Earth-moon system, extending far beyond the moon’s orbit and dominated by the two bodies’ gravity fields. Exploring in translunar space, beyond the protection of the Earth’s geomagnetic field, will provide unprecedented experience in deep-space operations. Operating in translunar space, NASA can research galactic cosmic radiation–potentially the most threatening element to humans exploring deep space–and develop mitigation strategies that may also lead to medical advancements on Earth.
The Lagrange points–places in cislunar space where the gravitational influences of the Earth and moon cancel each other out–are advantageous areas for exploration and research in which almost no propulsion is required to keep an object or spacecraft stationary. The Lagrange point on the far side of the Earth-Moon system, called L2, also provides a “radio silence” zone for astronomical observations.
Missions to translunar space will give NASA and its partners the opportunity to develop tools and operational techniques to support decades of future exploration, while remaining in relative proximity to Earth.

Why Asteroids?

Asteroids are believed to have formed early in our solar system's history–about 4.5 billion years ago–when a cloud of gas and dust called the solar nebula collapsed and formed our sun and the planets. By visiting these near Earth objects to study the material that came from the solar nebula, we can look for answers to some of humankind's most compelling questions, such as: how did the solar system form and where did the Earth's water and other organic materials such as carbon come from?
In addition to unlocking clues about our solar system, asteroids may provide clues about our Earth. By understanding more about asteroids we may learn more about past Earth impacts and possibly find ways to reduce the threat of future impacts.
Future robotic missions to asteroids will prepare humans for long-duration space travel and the eventual journey to Mars. Robotic missions will provide reconnaissance information about asteroid orbits, surface composition, and even return samples to Earth for further evaluation. These robotic missions are a critical step in preparing humans to visit asteroids where we will learn about the valuable resources available in space, and further develop ways to use them in our quest for more efficient and affordable exploration.

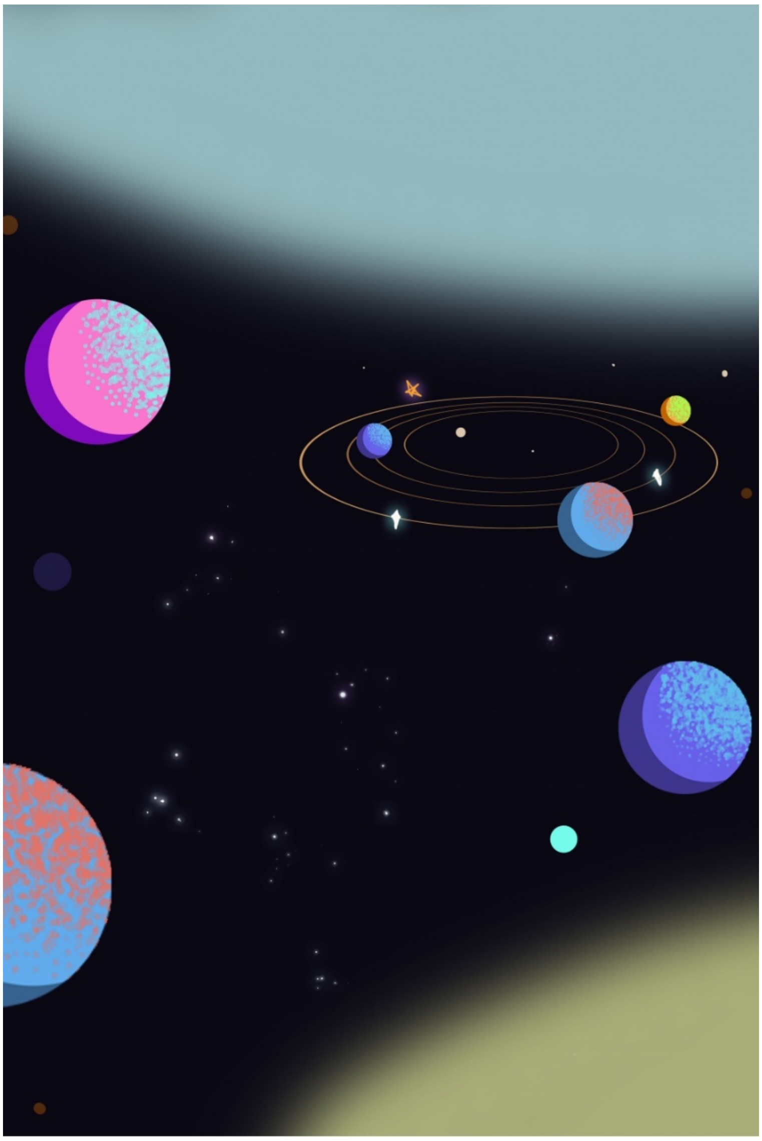
Why Mars?

Mars has always been a source of inspiration for explorers and scientists. Robotic missions have found evidence of water, but if life exists beyond Earth still remains a mystery. Robotic and

scientific robotic missions have shown that Mars has characteristics and a history similar to Earth's, but we know that there are striking differences that we have yet to begin to understand. Humans can build upon this knowledge and look for signs of life and investigate Mars' geological evolution, resulting in research and methods that could be applied here on Earth.
A mission to our nearest planetary neighbor provides the best opportunity to demonstrate that humans can live for extended, even permanent, stays beyond low Earth orbit. The technology and space systems required to transport and sustain explorers will drive innovation and encourage creative ways to address challenges. As previous space endeavors have demonstrated, the resulting ingenuity and technologies will have long lasting benefits and applications.
The challenge of traveling to Mars and learning how to live there will encourage nations around the world to work together to achieve such an ambitious undertaking. The International Space station has shown that opportunities for collaboration will highlight our common interests and provide a global sense of community.

https://www.nasa.gov/exploration/whyweexplore/why_we_explore_main.html

Space in Fiction



Space Oddity

David Bowie, 1969

Ground Control to Major Tom
Ground Control to Major Tom
Take your protein pills and put your helmet on
Ground Control to Major Tom (ten, nine, eight, seven, six)
Commencing countdown, engines on (five, four, three)
Check ignition and may God's love be with you (two, one, liftoff)
This is Ground Control to Major Tom
You've really made the grade
And the papers want to know whose shirts you wear
Now it's time to leave the capsule if you dare
"This is Major Tom to Ground Control
I'm stepping through the door
And I'm floating in a most peculiar way
And the stars look very different today
For here
Am I sitting in a tin can
Far above the world
Planet Earth is blue
And there's nothing I can do
Though I'm past one hundred thousand miles
I'm feeling very still
And I think my spaceship knows which way to go
Tell my wife I love her very much she knows
Ground Control to Major Tom
Your circuit's dead, there's something wrong
Can you hear me, Major Tom?
Can you hear me, Major Tom?
Can you hear me, Major Tom?

Can you "Here am I floating 'round my tin can
Far above the moon
Planet Earth is blue
And there's nothing I can do"

Rocket Man
Elton John, 1972

She packed my bags last night pre-flight
Zero hour nine AM
And I'm gonna be high as a kite by then
I miss the earth so much I miss my wife
It's lonely out in space
On such a timeless flight
And I think it's gonna be a long long time
'Till touch down brings me round again to find
I'm not the man they think I am at home
Oh no no no I'm a rocket man
Rocket man burning out his fuse up here alone
And I think it's gonna be a long long time
'Till touch down brings me round again to find
I'm not the man they think I am at home
Oh no no no I'm a rocket man
Rocket man burning out his fuse up here alone
Mars ain't the kind of place to raise your kids
In fact it's cold as hell
And there's no one there to raise them if you did
And all this science I don't understand
It's just my job five days a week
A rocket man, a rocket man
And I think it's gonna be a long long time
'Till touch down brings me round again to find

I'm not the man they think I am at home

Oh no no no I'm a rocket man

Rocket man burning out his fuse up here alone

And I think it's gonna be a long long time

'Till touch down brings me round again to find

I'm not the man they think I am at home

Oh no no no I'm a rocket man

Rocket man burning out his fuse up here alone

And I think it's gonna be a long long time

And I think it's gonna be a long long time

And I think it's gonna be a long long time

And I think it's gonna be a long long time

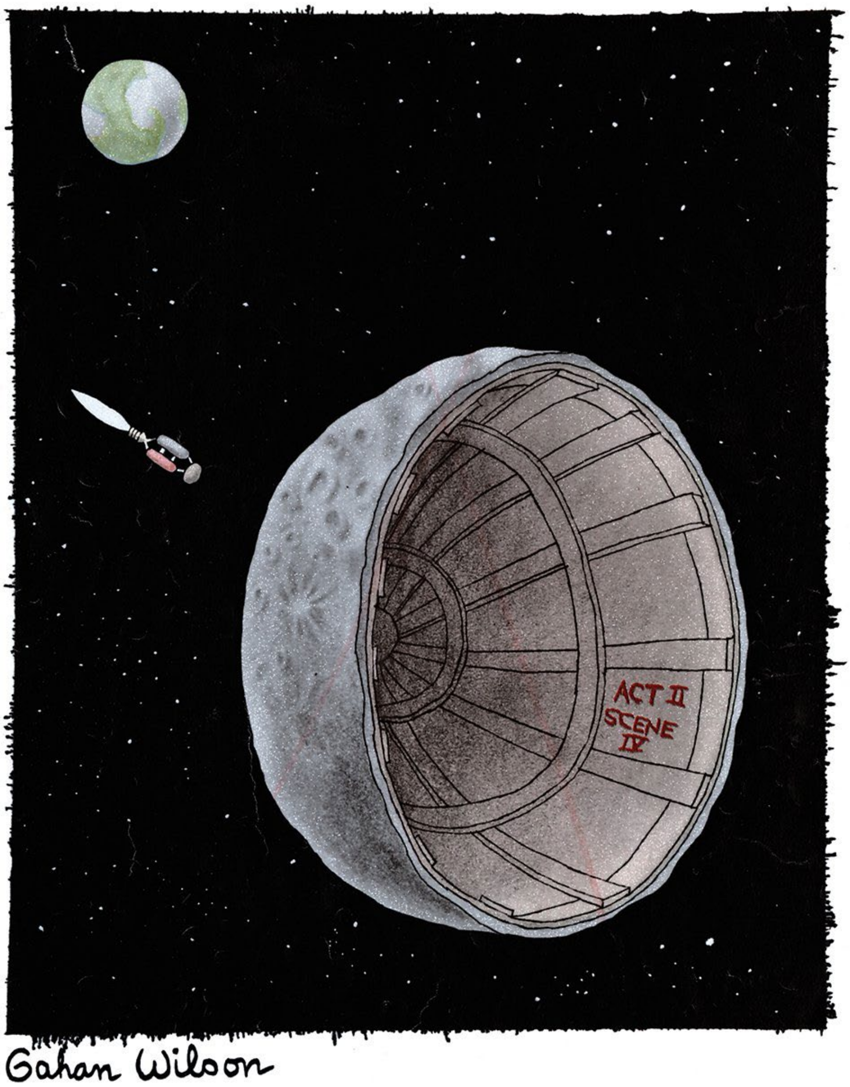
And I think it's gonna be a long long time

And I think it's gonna be a long long time

And I think it's gonna be a long long time

And I think it's gonna be a long long time

Fly me to the moon…



"... Only a minute or so more and man will have his first view of the other side of the moon!"

APOLLO 11

Todd Douglas Miller (2019)

Documentary analysis

You are to analyse the documentary in matrix groups by means of the guide to documentary analysis in The English Handbook: https://theenglishhandbook.systime.dk/?id=c900

Team up in the vertical groups (A-E) and focus on your part of the analysis while watching the documentary. Prepare to present your findings in the horizontal groups (1-5). Remember to substantiate your analysis with specific examples (quotes, screen shots etc.)

	1	2	3	4	5
A	*student names*				
B					
C					
D					
E					

A: Short summary and type of documentary: (1./2. in the guide to documentary analysis) Write a short Summary and determine the type of documentary

B: Main message and argumentation: What is the filmmaker's purpose with the documentary? What is the argument of the documentary and which claims are made? Is the backing for the claims reliable? (3./part of 4. in the guide to documentary analysis)

C: Point of view and cinematic techniques: Is the attitude/viewpoint of the filmmaker visible in the documentary? What cinematic techniques are used to support the claims/viewpoint and how are they used? (part of 4. in the guide to documentary analysis) For analysis of cinematic techniques you may find the opening scenes from *Apollo 11* useful: https://www.youtube.com/watch?v=NgUYurzK-tM

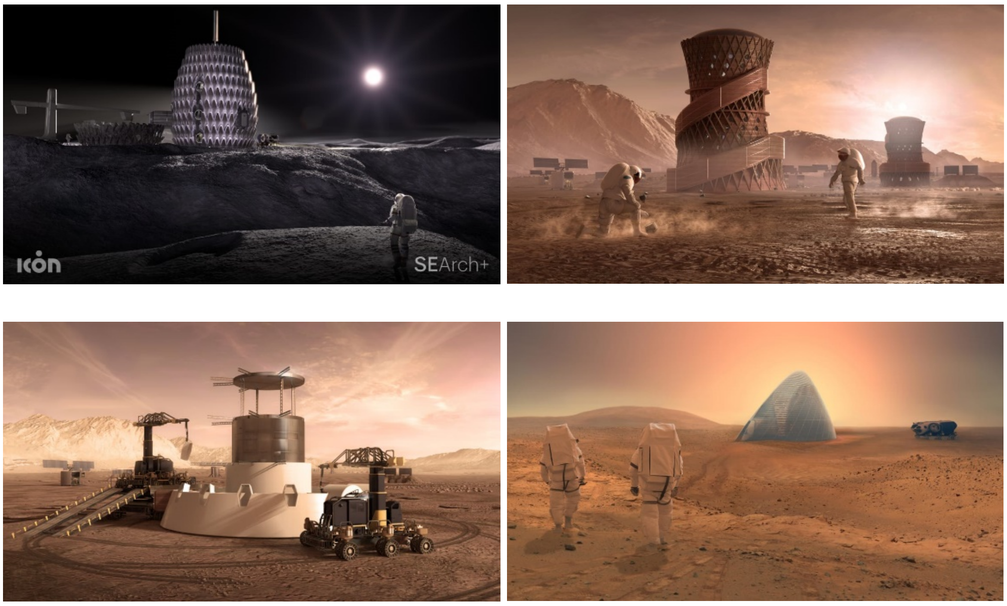
D: Type of documentary and purpose: (2./part of 4. in the guide to documentary analysis) Determine the type of documentary. Do the type and structure of documentary help achieve its purpose? Is there a use of appeal forms to support the main message and how are they used?

E: Cinematic techniques and shot-by-shot analysis: (part of 4./5.): What cinematic techniques are used to support the claims/viewpoint and how are they used? Do a shot-by-shot analysis of a few scenes which can support your analysis. You may find the opening scenes from *Apollo 11* useful: https://www.youtube.com/watch?v=NgUYurzK-tM

CNN

NASA wants to build a lunar base by 2030. Could 3D printing with moon dust be the answer?

Updated 18th December 2020



With the huge cost of transporting materials, people and machinery into space, extraterrestrial construction concepts have to utilize local materials and versatile, compact technology. Designs like SEArch+ and ICON's 3D-printed lunar base (pictured) incorporate both -- their initiative, Project Olympus, uses moon dust as the main building material.

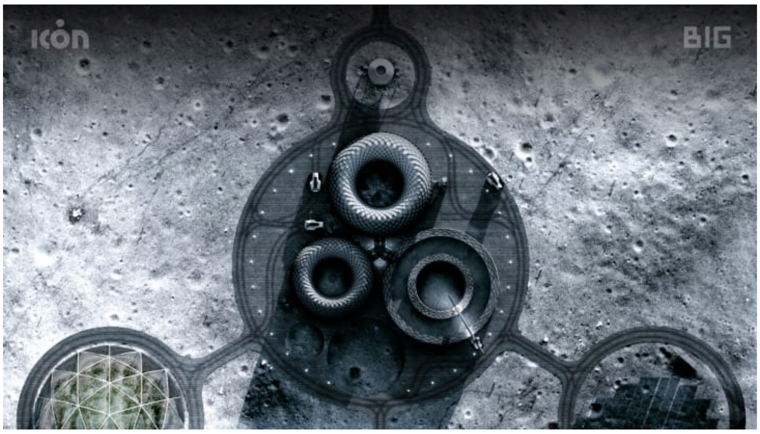
Written by Rebecca Cairns

The last time a person stepped foot on the moon was 1972. Now, the moon is back on NASA's space agenda. This time around the agency isn't just visiting -- it's planning to stay.

With its Artemis missions starting next year, NASA aims to have astronauts on the moon in 2024 and anticipates a permanent lunar base by the end of the decade. This would be the first habitat ever constructed on an extraterrestrial surface, and the challenges are unprecedented.

Sending a large quantity of construction materials to the moon would be expensive and time-consuming. But Texas-based startup ICON says it has a sci-fi solution -- 3D printing a lunar base from moon dust.

ICON is working with NASA to develop technology that can turn moon dust into a concrete-like material, says co-founder and CEO Jason Ballard. Moon dust, also known as lunar regolith, is the sand-like topsoil that covers the moon's surface, formed from minerals and tiny shards of glass created over millions of years as meteoroids hit the moon. It's sharp, abrasive, and extremely clingy -- the Apollo astronauts found it stuck to everything, including their space suits. There's plenty of it, which means there's a huge supply of raw materials if ICON is successful.

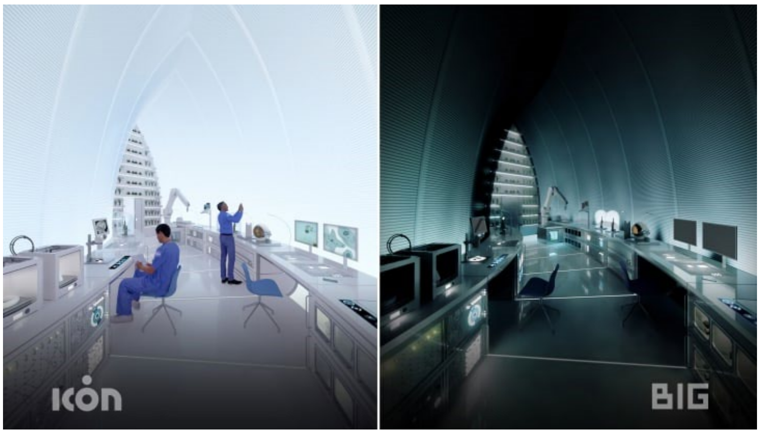


BIG's concept for Project Olympus includes donut-shaped buildings which could be entirely constructed with ICON's 3D printer.
Credit: Bjarke Ingels Group / ICON

The initiative is named Project Olympus after the largest-known volcano in the solar system -- aptly conveying the mountain-sized challenge the team faces. But Ballard isn't just shooting for the moon. By designing a lunar habitat, he hopes to make construction on Earth cleaner, faster and cheaper, too.

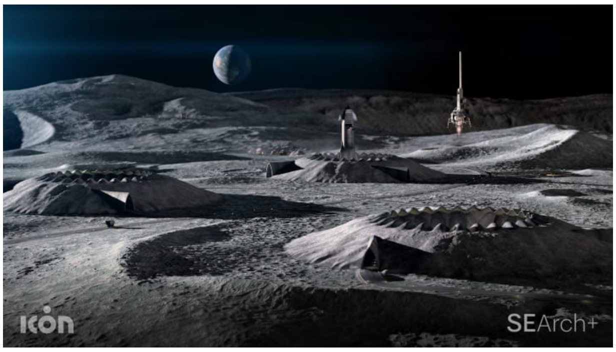
Project Olympus

ICON has been using 3D printing technology to build social housing in Mexico and Texas, since 2018. Using a concrete-based mixture called lavacrete, its Vulcan printer can print around 500-square-feet in 24 hours.
But the moon is a "radically different world," says Ballard. From Earth, it looks like a serene, smooth, silver orb but it is subject to high levels of radiation, violent moonquakes, extreme temperature swings and frequent strikes by micrometeorites that crash through its thin atmosphere, he says.
And turning moon dust into building material is another huge challenge. The team is experimenting with small samples of moon dust in a lab -- working out how to change its state with microwaves, lasers and infrared light, while using "little to no additives," says Ballard.



The research area in ICON's proposed lunar structure is illuminated with smart lights that simulate day and night on Earth, to help astronauts retain a normal sleep-wake cycle. Credit: Bjarke Ingels Group / ICON

ICON worked with two architectural firms, Bjarke Ingels Group (BIG) and Space Exploration Architecture (SEArch+), to explore the possibilities of 3D printing technology.
The team studied habitats in extreme environments, including the McMurdo Station in Antarctica and the International Space Station, and used their findings to create a range of lunar design concepts, says Ballard.
The architects had to consider how to create an environment that is safe as well as comfortable to live in, says BIG founder Bjarke Ingels.
The proposal by SEArch+ features a tall, multi-story structure with protective 3D-printed petals shielding a core that would be built on Earth, while BIG designed a circular structure which could be entirely printed on the moon.
BIG's design includes a visible membrane of water padding the walls of the bedroom -- "a good insulant against radiation," says Ingels -- which will give astronauts extra protection while they sleep.
The radiation means that windows must be kept to a minimum, so Ingels carefully chose the location of the building's only one -- which always faces Earth.



SEArch+ imagined a base "that will allow astronauts to frequently come and go from the surface," with landing pads, roads, sheds and habitats says co-founder Rebeccah Pailes-Friedman. Credit: SEArch+ / ICON

A "double shell" structure and exterior latticework, which can be packed with loose lunar dust, provide additional protection from radiation and meteorites, says Ingels.
In addition to living and working spaces for astronauts, the lunar base would need to incorporate landing pads, roads and storage sheds. Human presence in space has been "dominated by

engineering" so far, says Ingels. With multiple industries working together he hopes that the first permanent structure on the moon can be "aspirational" in design as well as an engineering marvel.

A gateway to the galaxy

NASA began exploring 3D printing as a possible space construction technology with the launch of the 3D-Printed Habitat Competition in 2015. Both SEArch+ and ICON took part in the initiative, with SEArch+ placing first for its design of the Mars X House.
With the Artemis missions launching next year, NASA's first step towards a lunar habitat is the "Gateway," a space station in the moon's orbit, says spokesperson Clare Skelly. Astronauts will live and work on the Gateway and shuttle to the moon, staying in their landers for up to a week.

ICON's 3D-printer, Vulcan, draws the outline of the building one layer at a time. It can print up to 500 square feet in 24 hours. Credit: ICON

Its goal, however, is a permanent base, from which to explore the moon in more depth and and test technology for human survival in space. NASA wants to construct facilities to house four astronauts for up to a month, says Skelly. It's an essential first step to Mars -- and beyond.
Skelly says it has not yet been decided if the lunar habitat will be constructed using 3D printing, but "NASA could award ICON additional funding" and might give the company the opportunity to test its technology on the lunar surface.

Using moon tech on Earth

Ballard is optimistic about the technology's Earthbound potential, too. He believes the findings from Project Olympus could help to solve the global housing crisis.
As a relatively new technology, there's little definitive data on the advantages of 3D printing in construction. However, a 2020 review notes that it could reduce construction waste by 30% to 60%, labor costs by 50% to 80%, and construction time by 50% to 70% which would make building cheaper, faster and more sustainable.

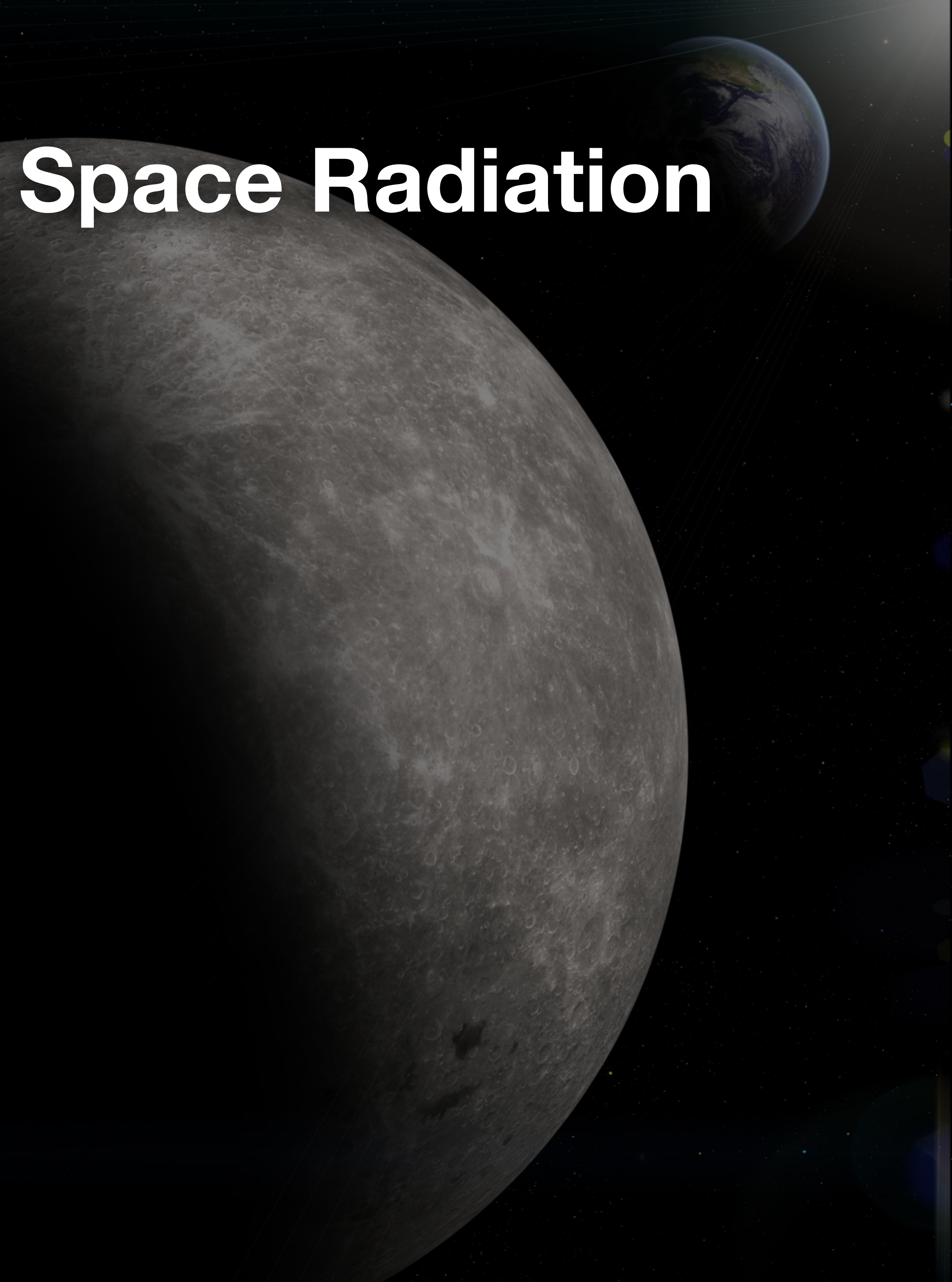

ICON's first 3D construction project was a collaboration with non-profit New Story in Mexico, to build a social housing community for people who had lost their homes in natural disasters. Credit: Joshua Perez / ICON

While the technology is largely used on bespoke projects right now, Ballard hopes that the possibility to use "rawer, more direct, local materials" could open up more opportunities for 3D construction -- which could be transformative for some of the 1.6 billion people still in need of adequate housing on Earth.
"It's kind of a funny thought," he says, "but it just may turn out that the answers to our problems on Earth are on the moon or Mars."

https://edition.cnn.com/style/article/3d-print-lunar-base-moon-dust-spc-intl/index.html

Space Radiation

Space Radiation



Contents

Chapter 3

Protection from Radiation

Chapter 3

Protection from Radiation

Protection from Radiation

Space radiation can penetrate habitats, spacecraft, equipment, spacesuits, and can harm astronauts. Minimizing the physiological changes caused by space radiation exposure is one of the biggest challenges in keeping astronauts fit and healthy as they travel through the solar system. As mentioned previously, ionizing radiation is a serious problem that can cause damage to all parts of the body including the central nervous system, skin, gastrointestinal tract, skeletal system, and the blood forming organs. However, biological damage due to radiation can be mitigated through implementation of countermeasures that are designed to reduce radiation exposure and its effects. In this section, we will discuss the use of radiation dosimetry and operational, engineering, and dietary countermeasures.

Why is NASA Studying Radiation Countermeasures?

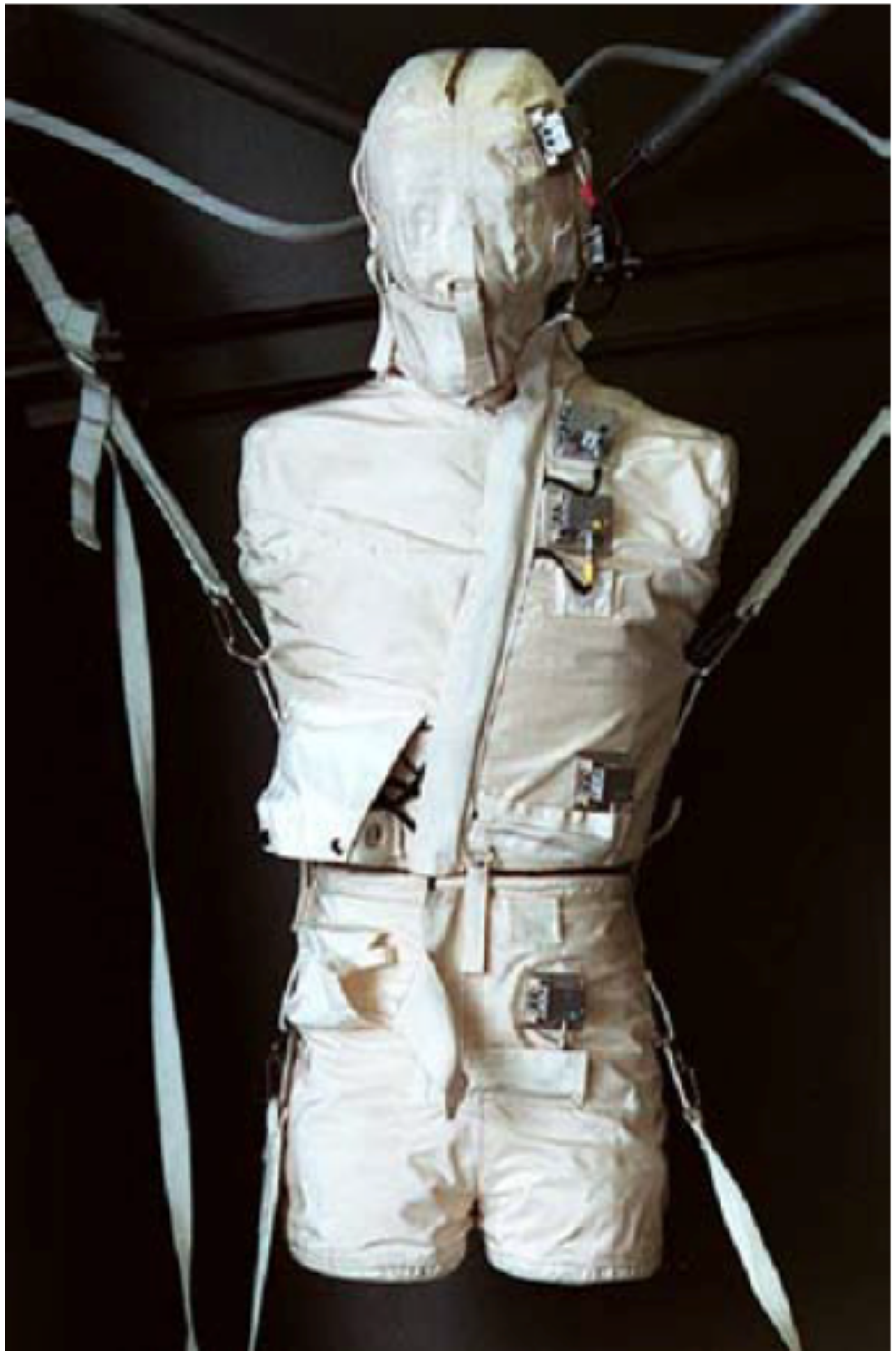
Radiation protection is essential for humans to live and work safely in space. To accomplish this challenging task, NASA has developed the Radiation Health Program. The goal of the program is to carry out the human exploration and development of space without exceeding acceptable risk from exposure to ionizing radiation. Legal, moral, and practical considerations require that NASA limit risks incurred by humans living and working in space to acceptable levels.[36] To determine acceptable levels of risk for astronauts, NASA follows the standard radiation protection practices recommended by the U.S. National Academy of Sciences Space Science Board and the U.S. National Council on Radiation Protection and Measurements.[37]

What is Radiation Dosimetry?

In low Earth orbit, astronauts lose the natural shielding from solar and cosmic radiation provided by the Earth's atmosphere. In deep space astronauts also lose the shielding provided by the

36 http://srag.jsc.nasa.gov

37 http://www.nasa.gov/audience/foreducators/postsecondary/features/F_Understanding_Space_Radiation_prt.htm



NASA uses an anatomical model of a human torso and head that contains more than 300 radiation sensors.

Earth's strong magnetic field. So, to achieve the goal of the NASA Radiation Health Program, it is necessary to monitor the radiation environment inside and outside a manned spacecraft.

An important part of every manned mission is radiation dosimetry, which is the process of monitoring, characterizing, and quantifying the radiation environment where astronauts live and work. Radiation biology support during missions also includes: calculated estimates of crew exposure during extra-vehicular activity; evaluation of any radiation-producing equipment carried on the spacecraft; and comprehensive computer modeling of crew exposure. Space station crew members routinely wear physical dosimeters to measure their accumulated exposure and, post flight, provide a blood sample to measure radiation damage to chromosomes in blood cells. In addition, experiments on the Space Station have been carried out using a synthetic human torso, which has over 300 strategically placed dosimeters to determine the levels of cosmic radiation absorbed by specific organs in the human body during space flight. Active monitoring of space radiation levels within the Space Station is achieved with dosimeters both to identify the best-shielded locations within the Space Station and to give early warning should radiation levels increase during a mission due to solar storms.

All these sources of information are carefully analyzed before, during, and after to help mission planners mitigate the four significant radiation-related health risks that are described in the

NASA Bioastronautics Critical Path Roadmap: cancer, radiation damage to the central nervous system, chronic and degenerative tissue diseases, and acute radiation sickness. See the previous section for information on the biological effects of radiation.

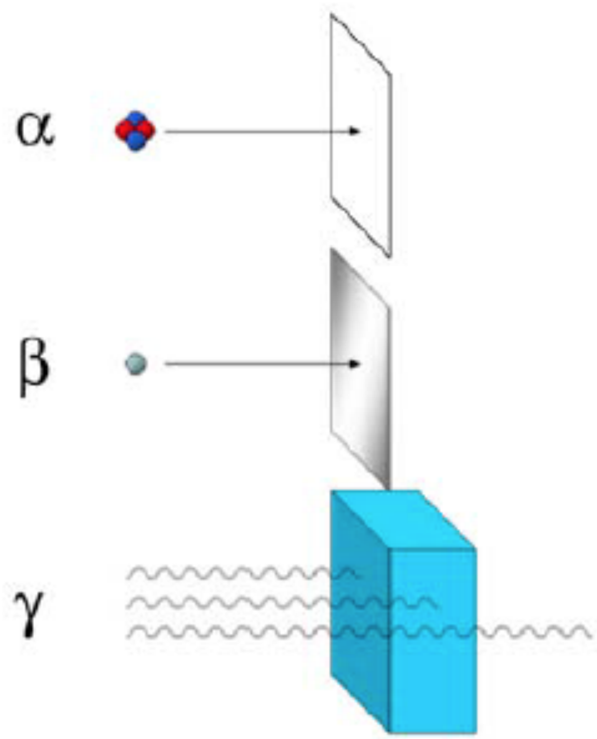
Movie 3.1 There and Back: What is involved with a flight to Mars?

What Are Operational Countermeasures?

Currently, the main operational countermeasure against the adverse affects of radiation is simply limiting astronaut exposure, which means limiting the amount of time astronauts are allowed to be in space. This is accomplished primarily by shortening overall mission duration on the Space Station to 3-6 months, reducing the time astronauts spend outside of the spacecraft during spacewalks, and planning space missions during times of reduced solar storm activity. However, since future long-term missions of exploration to the Moon and beyond will both take longer (a round-trip to Mars will last at least two years) and expose astronauts to a more damaging types of radiation, other strategies such as better shielding and mitigation strategies are necessary before astronauts can spend extended periods in deep space.

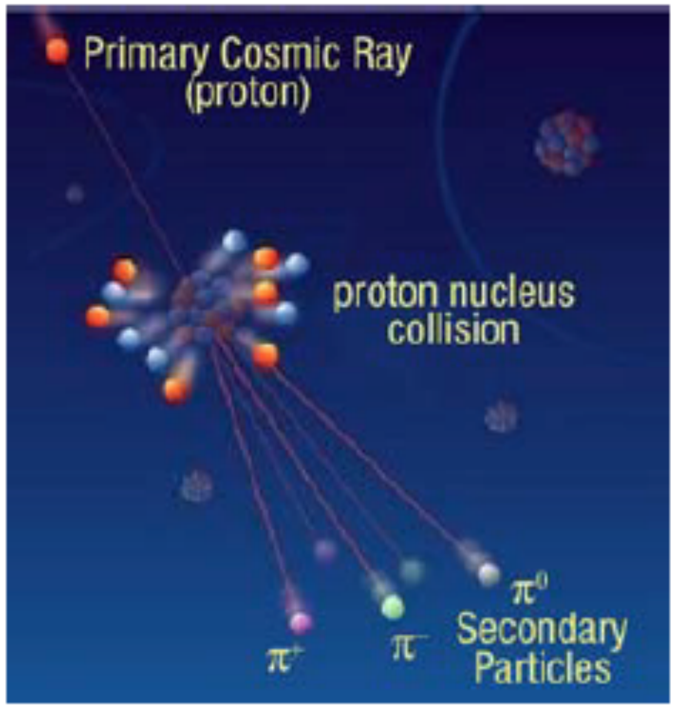
What Are Engineering Countermeasures?

Engineering countermeasures are structures or tools that are designed to shield astronauts from radiation.



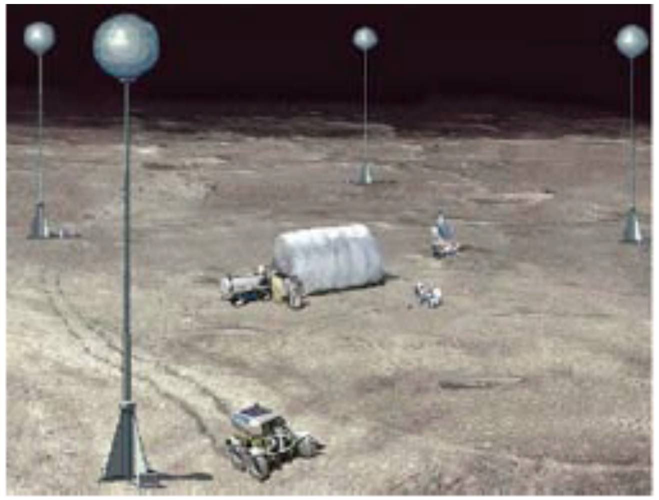
The composition and thickness of a material affects its ability to shield radiation.

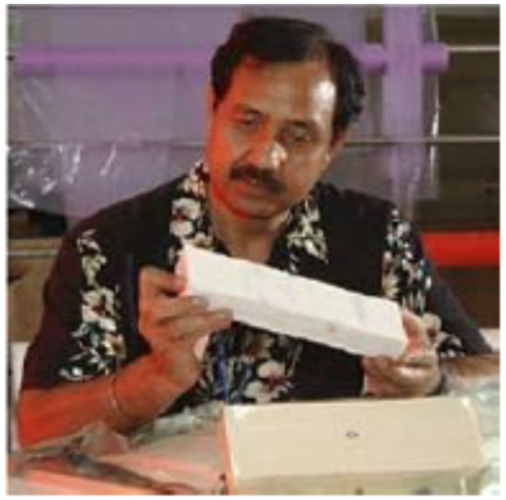
Depending on where astronauts are living and working, the radiation shielding requirements will vary because of exposure to different types and levels of radiation. The most penetrating ionizing radiation (gamma rays and galactic cosmic rays) can pass through aluminum but is stopped by thick and dense material such as cement. In general, the best shields will be able to block a spectrum of radiation. Aboard the space station, the use of hydrogen-rich shielding such as polyethylene in the most frequently occupied locations, such as the sleeping quarters and the galley, has reduced the crew's exposure to space radiation. Since the Space Shuttle and the International Space Station are in low Earth orbit, where the quantity and energy of the radiation is lower and the Earth's atmosphere provides protection, these spacecraft require less shielding than a base on the surface of the Moon. On the Moon, radiation shields would need to be very thick to prevent the primary cosmic rays (high-energy protons and heavy ions) from penetrating into habitation modules where astronauts will live. Such shielding could include the metal shell of a spacecraft or habitation module, an insulating layer of lunar water, or both.



Collisions between high-energy radiation and shielding can produce damaging secondary particles.

Problems with shields arise when space radiation particles interact with the atoms of the shield itself. These interactions lead to production of nuclear byproducts called secondaries (neutrons and other particles). If the shield isn't thick enough to contain them, the secondaries that enter the spacecraft can be worse for astronauts' health than the primary space radiation. Surprisingly, heavier elements such as lead produce more secondary radiation than lighter elements such as carbon and hydrogen. Consequently, a great deal of research has been performed on a lightweight polyethylene plastic, called RFX1, which is composed entirely of lightweight carbon and hydrogen atoms. Research shows that polyethylene is 50% better at shielding solar flares and is 15% better at shielding galactic cosmic radiation as compared to aluminum. Water is another hydrogen-rich molecule that can absorb radiation. However, the oxygen content in water makes it a lot heavier than polyethylene, and therefore is much more expensive to launch. Generally,





NASA has investigated electrostatic and plastic shielding. Combinations of different engineering, operational, and dietary countermeasures help improve radiation protection. Image Credit: NASA Goddard Space Flight Center.

lighter shields can greatly reduce the harmful effects of incoming space radiation particles, but they cannot completely stop them.

NASA scientists have also investigated the development of electrostatic radiation shields,[42] which generate positive and negative electric charges that deflect incoming electrically charged space radiation. Another method of radiation protection that has been proposed is to use the lunar regolith (the pulverized dusty material on the Moon's surface) to shield a human colony.

42 http://www.nasa.gov/centers/goddard/news/topstory/2004/0930grb.html

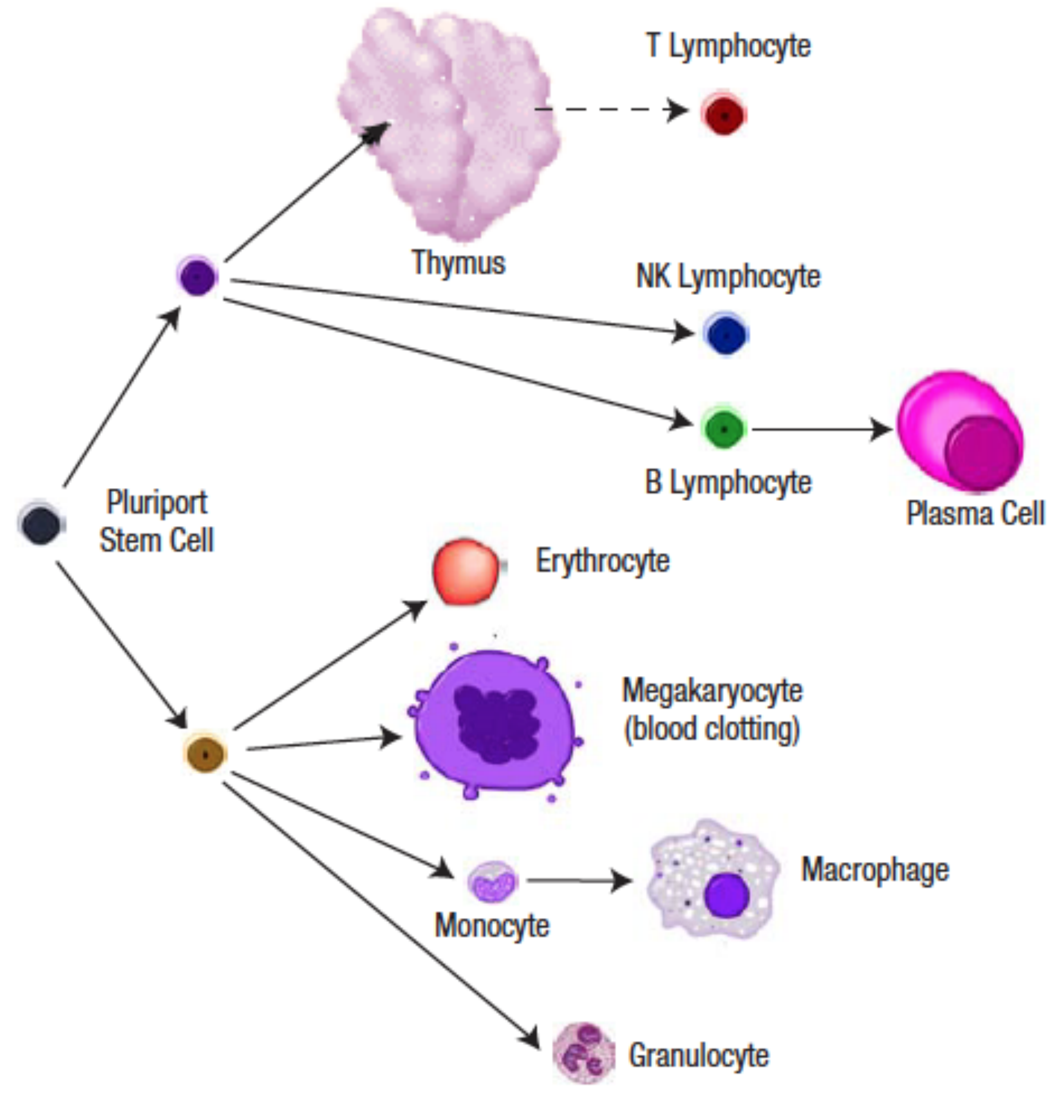
Although existing shielding can solve some radiation concerns, it makes spacecraft heavy and expensive to launch. Moreover, it does not provide complete protection against radiation. Shields five to seven centimeters thick can only block 30 to 35 percent of the radiation, which means that astronauts could still be exposed to up to 70 percent of the radiation that passes through the shields.[43] For this reason, NASA is also investigating the use of medical and dietary supplements to mitigate the effects of ionizing radiation.

NASA has investigated electrostatic and plastic shielding. Combinations of different engineering, operational, and dietary countermeasures help improve radiation protection. Image Credit: NASA Goddard Space Flight Center.

What are Dietary Countermeasures?

Dietary countermeasures are drugs, that when ingested by an astronaut, may have the potential to reduce effects of ionizing radiation. These supplements can be broadly categorized into two groups. The first group includes specific nutrients that prevent the radiation damage. For example, antioxidants like vitamins C and A may help by soaking up radiation-produced free-radicals before they can do any harm. Research has also suggested that pectin fiber from fruits and vegetables, and omega-3-rich fish oils may be beneficial countermeasures to

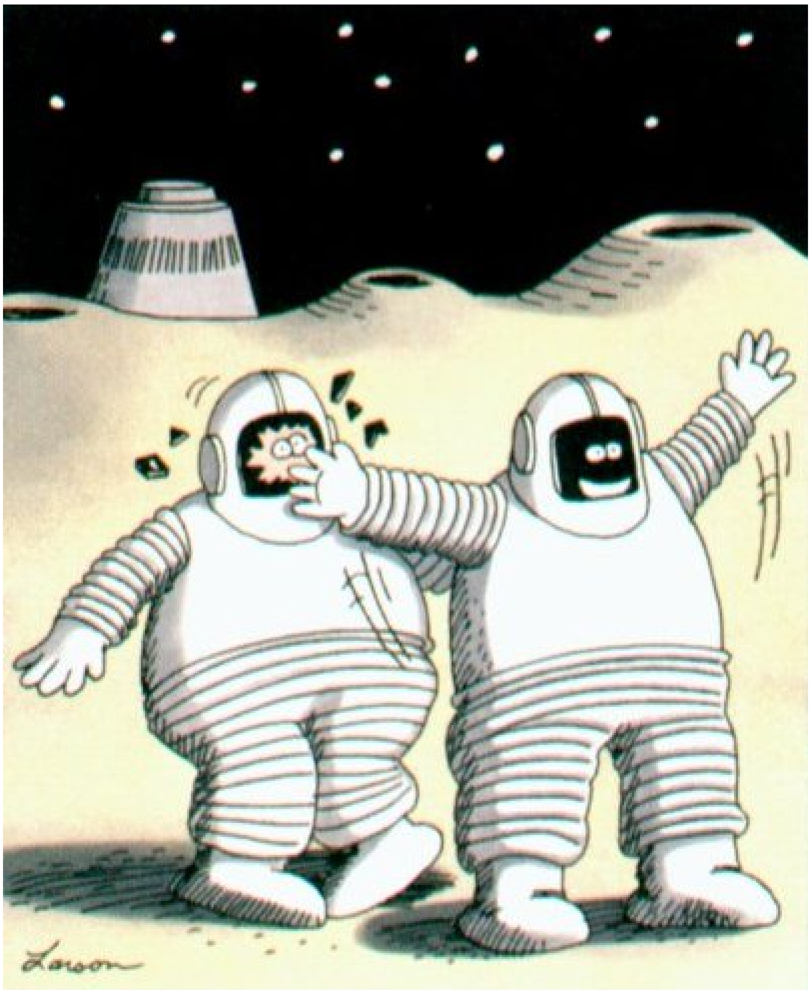
43 http://www.nasa.gov/vision/space/travelinginspace/keeping_astronauts_healthy_prt.htm



Stem cells in the bone marrow produce a wide range of blood cell types. Image Credit: Stem Cell World.

damage from long-term radiation exposure. Other studies have shown that diets rich in strawberries, blueberries, kale and spinach prevent neurological damage due to radiation. In addition, drugs such as Radiogardase (also known as Prussian blue) that contain Ferric (III) hexacyanoferrate (II) are designed to

Research on space



“We’ve made it, Warren! ... The moon!”

Group assignment - Space project

Aim: To research a topic by means of relevant sources and to convey your findings using the relevant vocabulary

- **In all 3 cases please team up with 2-3 other students (groups of 3-4)**
- Follow the instructions in the assignment "The greatest challenges for settlements in space" (page 34)

OR

- Choose a topic related to your vocational education and ask yourselves a question that requires you to do some research. You must use and document at least 5 credible sources and prepare to present your findings as a PowerPoint/Prezi presentation. List your sources on the last slide.

- A question could be: *What diet do you need in space to counteract the effect of radiation? How do you construct sustainable living-quarters on the Moon? Which technological challenges need to be solved in order to make the journey to Mars?* etc.

OR

- Choose a topic related to space exploration that interests you, and ask yourselves a question that requires you to do some research. You must use and document at least 5 credible sources and prepare to present your findings as a PowerPoint/Prezi presentation. List your sources on the last slide.

- A question could be: *What happens to the human body in space? Why have the Star Wars movies become immensely popular? Was the moon landing a hoax? Is Proxima B Earth's twin? How do you travel at the speed of light? What is Flat Earth theory?* etc.

Have fun :)

The greatest challenges for settlements in space

Group assignment (3-4 students)

Research and present the 5 greatest challenges for space colonization

You must use at least 5 reliable sources. Present your findings in PowerPoint, Prezi or the like. List your sources on the last slide.

Here are a few links for inspiration

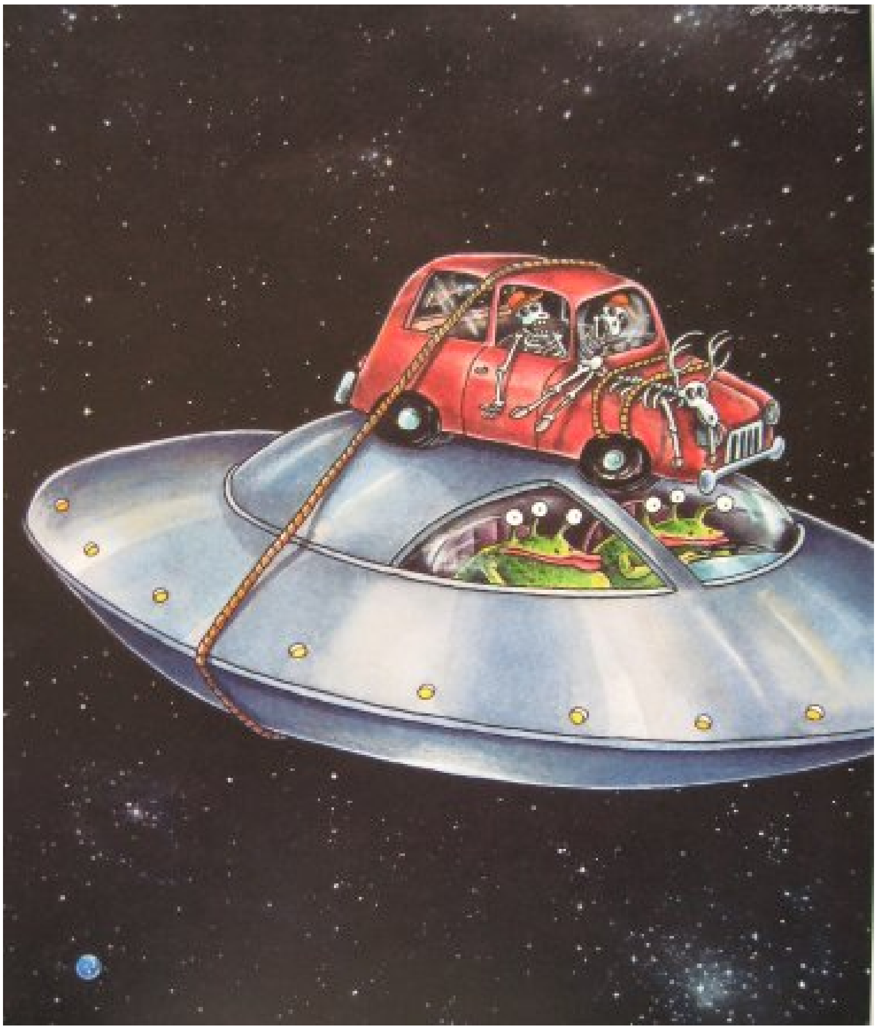
https://www.techtimes.com/articles/53454/20150516/top-5-problems-humanity-must-solve-before-colonizing-mars.htm

https://www.wired.com/2016/02/space-is-cold-vast-and-deadly-humans-will-explore-it-anyway/

http://cosmonautexperience.com/space-colonization-problems/

With the fear of funding issues looming, NASA looks to alternative methods of completing their moon base.

Colonizing Mars



Destination: Mars (CBC, 2016)

Duration: 48 mins

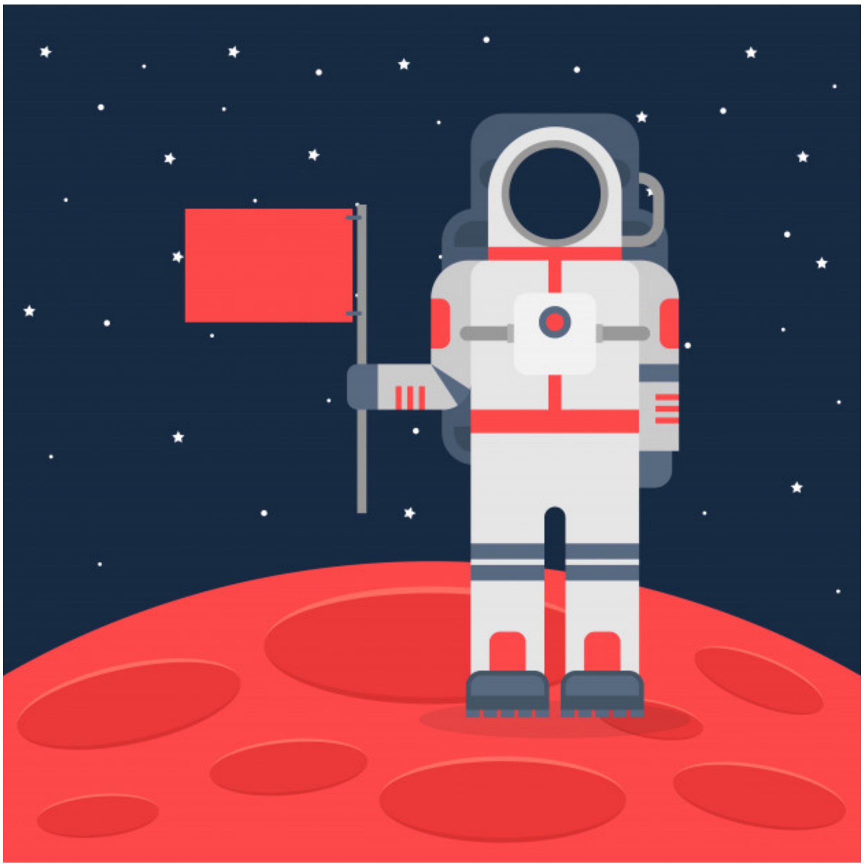
<u>Listening and viewing comprehension</u>

Watch the documentary Destination: Mars here: https://www.youtube.com/watch?v=C5qSK1QpHow

While watching, write down what you learn about the aspects listed below:

How does NASA and other scientific enterprises prepare to go to Mars?	Which private enterprises are involved – and how?	Challenges in colonizing and terraforming Mars	Is Mars a great backup planet? Why/why not?

Film Analysis



The Martian

Ridley Scott's *The Martian* from 2015 is a blockbuster movie starring Matt Damon about an ingenious astronaut who uses science and survival skills to remain alive while attempting to contact NASA. Students will explore themes related to isolation, perseverance, science, and survival through this film.

Stranded

- Who are the members of the Hermes crew? Describe their relationships to each other. Make a connection between the crew and a cohesive group that you have been part of. What sacrifices would you be willing to make for the people on your team?
- What causes the crew to lose sight of Watney? What are some strategies the crew used to try to find Watney?
- Why did the commander make the decision to leave Mars without Watney? What would have happened if she had not made this decision? Do you think good judgement was used in this scenario? Explain your answer. What would you have done?
- When Watney regains consciousness and assesses his situation, what challenges does he face? How does he prioritize his needs? What skills does he possess that will be useful in this scenario? How can you apply Watney's problem-solving strategies when you face a series of challenges?
- After Watney is declared dead and a memorial service is held in his name, why is NASA unwilling to use satellite images to locate the body? How do NASA officials conclude that Watney is still alive? Why are they pessimistic? How would you balance public relations, realistic expectations, and life-saving measures in a scenario like this?

Survival

- Why do you think an astronaut would study botany? How does Watney's background in botany help him survive? What are some skills you have that would help you survive in an emergency?
- What background knowledge does Watney have about past and future Mars explorations that helps him contact NASA?
- Why do you think Watney records a video diary of his experience? What can you infer about Watney's personality based on these recordings? What psychological needs does the diary fulfill? If you were to leave behind a message for others to discover after you had passed, what would it say?
- How does Watney react when he learns that NASA has kept the fact that he is alive from the crew? Why has NASA withheld that information? Do you think they made the right decision? When are times would you would rather not know the truth?

Rescue

- What are some challenges to getting supplies to Watney before his food supply runs out? How does the Chinese National Space Administration help? What are the advantages and disadvantages of working with other countries on technological advances?
- What is Rich Purnell's idea for rescuing Watney? Why won't NASA approve this plan? What do you think of the Hermes crew's decision to mutiny? If you had to choose between killing one person or risking the lives of several men, what would you choose? Why?
- What are some extraordinary measures the crew has to take to bring everyone home? Why do you think they are willing to take these chances? What parts of their character does each crew member reveal during the rescue? Do you consider yourself a risk-taker or are you more likely to play it safe? Explain your answer.
- When Watney returns to Earth, he becomes a professor. How is Watney's experience used as a metaphor for life? What do you think he wants his students to learn? How can you apply this lesson to your life?

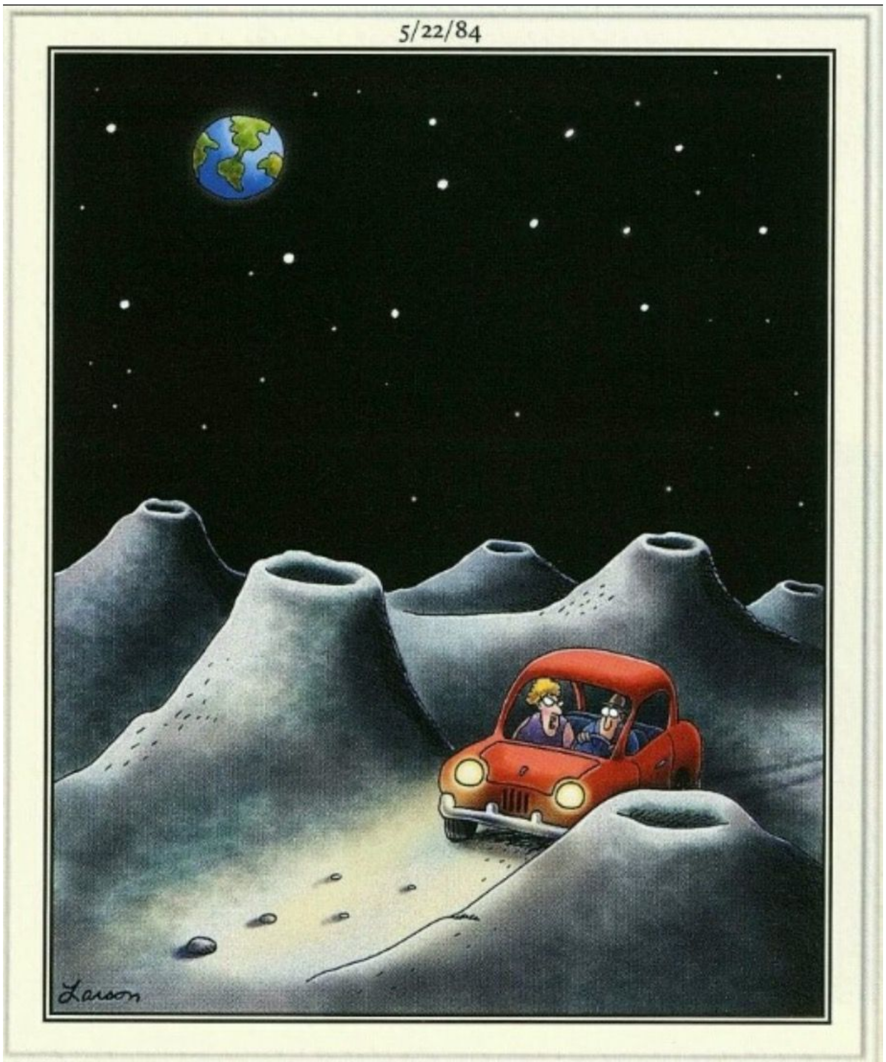
https://study.com/academy/print/lesson/the-martian-movie-discussion-questions.html?hideBoldTerms=true

Shot analysis

Choose a clip around 30 seconds long from the film and make an analysis of the cinematic techniques (framing, sound, lighting, colour etc.) and explain the impact on the audience. Please remember to take screenshots. Prepare to convey your analysis to some of your fellow students.

The chapter on film analysis in the English Handbook may come in handy:
https://theenglishhandbook.systime.dk/?id=175 ☺

Science Fiction



"For heaven's sake, Elroy! *Now* look where the earth is! ... Move over and let me drive!"

All Summer in a Day
By Ray Bradbury

"Ready ?"

"Ready."

"Now ?"

"Soon."

"Do the scientists really know? Will it happen today, will it ?"

"Look, look; see for yourself !"

The children pressed to each other like so many roses, so many weeds, intermixed, peering out for a look at the hidden sun.

It rained.

It had been raining for seven years; thousands upon thousands of days compounded and filled from one end to the other with rain, with the drum and gush of water, with the sweet crystal fall of showers and the concussion of storms so heavy they were tidal waves come over the islands. A thousand forests had been crushed under the rain and grown up a thousand times to be crushed again. And this was the way life was forever on the planet Venus, and this was the schoolroom of the children of the rocket men and women who had come to a raining world to set up civilization and live out their lives.

"It's stopping, it's stopping !"

"Yes, yes !"

Margot stood apart from them, from these children who could ever remember a time when there wasn't rain and rain and rain. They were all nine years old, and if there had been a day, seven years ago, when the sun came out for an hour and showed its face to the stunned world, they could not recall. Sometimes, at night, she heard them stir, in remembrance, and she knew they were dreaming and remembering gold or a yellow crayon or a coin large enough to buy the world with. She knew they thought they remembered a warmness, like a blushing in the face, in the body, in the arms and legs and trembling hands. But then they always awoke to the tatting drum, the endless shaking down of clear bead necklaces upon the roof, the walk, the gardens, the forests, and their dreams were gone.

All day yesterday they had read in class about the sun. About how like a lemon it was, and how hot. And they had written small stories or essays or poems about it:*I think the sun is a flower,That blooms for just one hour.* That was Margot's poem, read in a quiet voice in the still classroom while the rain was falling outside.

"Aw, you didn't write that!" protested one of the boys.

"I did," said Margot. "I did."

"William!" said the teacher.

But that was yesterday. Now the rain was slackening, and the children were crushed in the great thick windows.

Where's teacher ?"

"She'll be back."

"She'd better hurry, we'll miss it !"

They turned on themselves, like a feverish wheel, all tumbling spokes. Margot stood alone. She was a very frail girl who looked as if she had been lost in the rain for years and the rain had washed out the blue from her eyes and the red from her mouth and the yellow from her hair. She was an old photograph dusted from an album, whitened away, and if she spoke at all her voice would be a ghost. Now she stood, separate, staring at the rain and the loud wet world beyond the huge glass.

"What're *you* looking at ?" said William.

Margot said nothing.

"Speak when you're spoken to."

He gave her a shove. But she did not move; rather she let herself be moved only by him and nothing else. They edged away from her, they would not look at her. She felt them go away. And this was because she would play no games with them in the echoing tunnels of the underground city. If they tagged her and ran, she stood blinking after them and did not follow. When the class sang songs about happiness and life and games her lips barely moved. Only when they sang about the sun and the summer did her lips move as she watched the drenched windows. And then, of course, the biggest crime of all was that she had come here only five years ago from Earth, and she remembered the sun and the way the sun was and the sky was when she was four in Ohio. And they, they had been on Venus all their lives, and they had been only two years old when last the sun came out and had long since forgotten the color and heat of it and the way it really was.

But Margot remembered.

"It's like a penny," she said once, eyes closed.

"No it's not!" the children cried.

"It's like a fire," she said, "in the stove."

"You're lying, you don't remember !" cried the children.

But she remembered and stood quietly apart from all of them and watched the patterning windows. And once, a month ago, she had refused to shower in the school shower rooms, had clutched her hands to her ears and over her head, screaming the water mustn't touch her head. So after that, dimly, dimly, she sensed it, she was different and they knew her difference and kept away. There was talk that her father and mother were taking her back to Earth next year; it seemed vital to her that they do so, though it would mean the loss of thousands of dollars to her family. And so, the children hated her for all these reasons of big and little consequence. They hated her pale snow face, her waiting silence, her thinness, and her possible future.

"Get away !" The boy gave her another push. "What're you waiting for?"

Then, for the first time, she turned and looked at him. And what she was waiting for was in her eyes.

"Well, don't wait around here !" cried the boy savagely. "You won't see nothing!"

Her lips moved.

"Nothing !" he cried. "It was all a joke, wasn't it?" He turned to the other children. "Nothing's happening today. *Is* it ?"

They all blinked at him and then, understanding, laughed and shook their heads.

"Nothing, nothing !"

"Oh, but," Margot whispered, her eyes helpless. "But this is the day, the scientists predict, they say, they *know*, the sun…"

"All a joke !" said the boy, and seized her roughly. "Hey, everyone, let's put her in a closet before the teacher comes !"

"No," said Margot, falling back.

They surged about her, caught her up and bore her, protesting, and then pleading, and then crying, back into a tunnel, a room, a closet, where they slammed and locked the door. They stood looking at the door and saw it tremble from her beating and throwing herself against it. They heard her muffled cries. Then, smiling, the turned and went out and back down the tunnel, just as the teacher arrived.

"Ready, children ?" She glanced at her watch.

"Yes !" said everyone.

"Are we all here ?"

"Yes !"

The rain slacked still more.

They crowded to the huge door.

The rain stopped.

It was as if, in the midst of a film concerning an avalanche, a tornado, a hurricane, a volcanic eruption, something had, first, gone wrong with the sound apparatus, thus muffling and finally cutting off all noise, all of the blasts and repercussions and thunders, and then, second, ripped the film from the projector and inserted in its place a beautiful tropical slide which did not move or tremor. The world ground to a standstill. The silence was so immense and unbelievable that you felt your ears had been stuffed or you had lost your hearing altogether. The children put their hands to their ears. They stood apart. The door slid back and the smell of the silent, waiting world came in to them.

The sun came out.

It was the color of flaming bronze and it was very large. And the sky around it was a blazing blue tile color. And the jungle burned with sunlight as the children, released from their spell, rushed out, yelling into the springtime.

"Now, don't go too far," called the teacher after them. "You've only two hours, you know. You wouldn't want to get caught out !"

But they were running and turning their faces up to the sky and feeling the sun on their cheeks like a warm iron; they were taking off their jackets and letting the sun burn their arms.

"Oh, it's better than the sun lamps, isn't it ?"

"Much, much better !"

They stopped running and stood in the great jungle that covered Venus, that grew and never stopped growing, tumultuously, even as you watched it. It was a nest of octopi, clustering up great arms of fleshlike weed, wavering, flowering in this brief spring. It was the color of rubber and ash, this jungle, from the many years without sun. It was the color of stones and white cheeses and ink, and it was the color of the moon.

The children lay out, laughing, on the jungle mattress, and heard it sigh and squeak under them resilient and alive. They ran among the trees, they slipped and fell, they pushed each other, they played hide-and-seek and tag, but most of all they squinted at the sun until the tears ran down their faces; they put their hands up to that yellowness and that amazing blueness and they breathed of the fresh, fresh air and listened and listened to the silence which suspended them in a blessed sea of no sound and no motion. They looked at everything and savored everything. Then, wildly, like animals escaped from their caves, they ran and ran in shouting circles. They ran for an hour and did not stop running.

And then -

In the midst of their running one of the girls wailed.

Everyone stopped.

The girl, standing in the open, held out her hand.

"Oh, look, look," she said, trembling.

They came slowly to look at her opened palm.

In the center of it, cupped and huge, was a single raindrop. She began to cry, looking at it. They glanced quietly at the sun.

"Oh. Oh."

A few cold drops fell on their noses and their cheeks and their mouths. The sun faded behind a stir of mist. A wind blew cold around them. They turned and started to walk back toward the underground house, their hands at their sides, their smiles vanishing away.

A boom of thunder startled them and like leaves before a new hurricane, they tumbled upon each other and ran. Lightning struck ten miles away, five miles away, a mile, a half mile. The sky darkened into midnight in a flash.

They stood in the doorway of the underground for a moment until it was raining hard. Then they closed the door and heard the gigantic sound of the rain falling in tons and avalanches, everywhere and forever.

"Will it be seven more years ?"

"Yes. Seven."

Then one of them gave a little cry.

"Margot !"

"What ?"

"She's still in the closet where we locked her."

"Margot."

They stood as if someone had driven them, like so many stakes, into the floor. They looked at each other and then looked away. They glanced out at the world that was raining now and raining and raining steadily. They could not meet each other's glances. Their faces were solemn and pale. They looked at their hands and feet, their faces down.

"Margot."

One of the girls said, "Well… ?"

No one moved.

"Go on," whispered the girl.

They walked slowly down the hall in the sound of cold rain. They turned through the doorway to the room in the sound of the storm and thunder, lightning on their faces, blue and terrible. They walked over to the closet door slowly and stood by it.

Behind the closet door was only silence.

They unlocked the door, even more slowly, and let Margot out.

The Wait

by Doug Goodman

Tom just wanted to walk. For eight months, he'd floated through space. Sure, there'd been CEVISes and MAREDs and TVISes to keep his arms and legs pumping. The whole alphabet soup of exercise equipment had been made available for the voyage to Mars. There was even a video game system that allowed him to swim in zero g. That was his personal favorite. God bless the makers of Ocean Blast. There was nothing to work out the kinks in a team like hurling pixelated waterjets at the avatars of his crewmates. But as much effort as was focused on physical exercise, nothing in the universe was a substitute for gravity. Granted, Mars was only .375 the gravity of Earth's, which meant that a 150-pound adult male only weight 56.55 pounds on Mars, give or take, but it was still enough gravity to pull on his bones and circulate his blood and make him more biologically human than he'd felt since leaving Earth.

And now he was stuck in a capsule on Sol 1 waiting to go outside. Waiting for his body to readjust to gravity. Over eight months ago, he had started this journey to Mars with the ultimate goal of walking on the red planet. (Or you could call it Barsoom, if you were an Edgar Rice Burroughs fan.) Like his ten year old self, Tom just wanted to run around outside and play in the dirt.

After all that time spent in zero-g, the landing had been pure adrenaline rush. 1g and 12 minutes of falling from orbit. In his life, he knew he'd never ride a more thrilling roller coaster. When the heat shield popped? Well, that was like peaking on the world's tallest roller coaster, and then suddenly hearing a BOOM from under the seats.

After the parachutes deployed and saved them all, they successfully crashed onto Mars. That was 22 long hours ago. Soon, it would be time to suit up and make that first walk. What was it Commander Harrison had said? "One last step, one new beginning." That had a nice ring to it.

Everybody wanted out. And who could blame them? What's the longest voyage you've ever been on? 14 hours? Maybe if you were traveling to Australia from JSC, it would be almost a full day in a plane. Well, this was kind of like that, but with an additional eight months tacked on. First, Commander Harrison and Tom would do the Neil Armstrong. (Tom won the Buzz Aldrin in a bet with Eubanks. The Texans beat the Cowboys, and now Tom would be the second person to walk on Mars.) Once Harrison and Tom kicked up the red dirt, then it would be time for Eubanks and Bezmenov.

Houston had other plans. Houston wanted all astronauts to wait and let their bodies readjust to gravity. So the crew all wore pressurized suits to help their blood flow, and they did small exercises that equated to standing up and sitting back down in the Hab. Tom could stand. He could sit. Now he wanted to walk. And not just around the Hab they had brought like a backpack attached to Orion, but outside in the real world.

He understood the protocols, though. (Understood, yes. Appreciation was a different story.) His body had changed greatly while suspended in zero g, and now it needed time to get reacquainted with gravity. The blood rushing to his feet made his feet ache, his knees were wobbly, and his back was sore because it was once again being used to support weight. (On the plus side, special scraping pads had allowed him to keep 50% of his callouses – that gross, yet necessary thing all feet needed, so at least he wasn't having to regrow tissue.) Other astronauts had warned him it would feel like being beat up in a hockey game. Tom was more of a football kind of guy, but if this was what it felt like to play hockey, he didn't want any part of it.

He stared out the porthole window at the Martian landscape. He had risked his life to get here, and now he wanted out there real bad. He had brought a football in his personal equipment. He couldn't wait to toss the pigskin around with Eubanks. He wanted to see how far he could throw the ball. There were equations he could use to predict the distance based on Martian gravity and atmosphere, but it was still his throwing arm that was creating the velocity for the football. So he didn't want to risk a bet, though he and Eubanks knew that the single game passing record was 541 yards.

He imagined himself climbing into his Advanced Space Suit, throwing open the airlock, and jumping out there. He'd take that one last step out of the airlock and face-plant into Mars on national television. That WOULD break the Internet, he'd been assured.

So it was time to wait. Stretch. Answer e-mail. The psychologists recommended smiling while answering e-mail because it made you feel better.

Afterward, he answered pre-coordinated questions from elementary-school kids in places like Upper Sandusky, Ohio and Garden City, Kansas. "What's your favorite food?" *Easy. Tortilla*. *What else you got?* "How long have you been in space?" *241 days, 22 hours, and 16 minutes, but who's counting? Boom.* "If the entry stage rocket was modified with an R-25, why don't you just use its thrusters instead of parachutes?" *Who let the smart kid ask a tough question? Please escort him out.* Don't forget to smile.

When he wasn't communicating outside of MCC, then he was answering Houston's requests to verify and triple-check that every piece of equipment was working properly. Commander Harrison reminded him to do it with a smile. Then it was time to do a commercial.

Tom hated commercials. Oh, they had to be done. The bills had to be paid because going to Mars wasn't economy seating on the bus. And Tom really liked the tools that the advertising paid for.

So he looked into the camera, raised his container full of coffee, and said "Cousins Coffee – yesterday's coffee, today." With a smile.

After that, Tom stopped making commercials. He got to check the robots instead. You can't sabotage the agency's image while working on robots. And that's okay. He had worked with all of the robots. "Amelia Earhart" would give the world the greatest drone flight as she soared over Valles Marineris. Waiting outside the capsule was Robonaut 8, which he had helped design (and nicknamed "Redshirt 1" because, dude, this was a desert planet and they were kind of an away team, so if anything went bad, the robot would get it first). Robonaut 8 was adapted specifically for the Martian environment and did a lot of the setup work preparing the site for the Martian landing. In fact, it had placed a little laser in the desert floor, which the EDL systems used to help guide the capsule to the landing site. They didn't miss it by a centimeter.

On Sol 2, it would be time to "do human stuff." While Sol 1 was the big day of firsts, Sol 2 was what PAO secretly drooled over. That was when the astronauts would do things the rovers could not do. Specifically, Bezmenov, a geologist, would go out with Commander Harrison and dig up some dirt and drill into ice in the Gustav Crater. They would return with it to Earth, and no robot had done that. Bezmenov and Harrison would also provide perspective and humanize the missions.

But that would be Sol 2. Now it was Sol 1, and everybody was climbing out of their pressure suits and into their Advanced Space Suits and preparing for the hatch opening. The new PLSS systems were working properly. Everything was ready. They were minutes away from the walk. It was the culmination of decades of research and planning. Tom had only just been born when ISS assembly began. He was accepted into the astronaut training class when the first astronauts landed on an asteroid. And by some miracle, they called his number to be on the first terrestrial Mars mission. Eight other astronauts had visited Mars in fly-bys and orbits, but Bezmenov, Harrison, Eubanks and Ward would be the first to step foot on Mars.

Commander Harrison looked at him from her helmet. "When we step outside that door, we will be the first humans ever to walk on another planet."

Everything fell away after that. Tom took a deep breath. Light streamed through the door opening. Harrison stepped out. Said her line. Shook the hand of Robonaut 8. The camera in her helmet swiveled slowly in a panoramic view of the Martian landscape. Then she looked at her feet and took another couple steps. She turned around and helped Tom Ward down the ladder. He had a goofy smile on his face, like he was up to something. She hoped he wouldn't do anything stupid. When he started singing "Major Tom to Ground Control," she sighed. He then shouted into the microphone, "Look at us. WE'RE ON MARS!"

She would have to wait at least 40 more minutes for the world's response.