SPACE 2XPLORE™

Live4Space: Martian Death Rays

for

The SBWIB BioFlex Program

S2X Experts:
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space2Xplore.org

Way, LLC
Science Solutions 4 Everyone

Who Are We?

- **Alvin L. Smith, Ph.D., PMP** - President & CEO – Over 23 years experience in biological and planetary science. NASA scientist/engineer.

- **Jelani A. Smith, M.S.** - Strategic and Technical Consultant – Over 20 years in engineering and management experience.

- **Space2Xplore Consultants**
  - **Sean Lueder –** Coding Training Specialist; educator (robotics, coding, Technology Integrationist)
  - **Bryant Baldwin –** Robotics Training Specialist; mech. engineer (CAD/3D; MATLAB, Rapid Prototyping & Testing)
  - **Rachel Chai, MSCE, EIT –** Space Design Training Specialist; civil engineering (AutoCAD, 3D printing, MATLAB)
  - **Ryan Hendrickson -** Space Biology Training Specialist (Live4Space Lead); certified educator; astrobiology; planetary protection
  - **Carissma McGee –** Astronomy Training Specialist; student (Astrophysics, planetary science, STEM)
  - **Jonathan Gaither –** Space Biology Training Specialist; student (Biology, planetary protection, astrobiology)
  - **Dakotah Tyler** – Astronmy Training Specialist; student (astronomy, astrophysics) **onboarding*
  - **Jordyn McClain** – Space Design Training Specialist; materials engineer (medical devices, polymers, CAD, 3D printing) **onboarding*
  - **Venessa Smith** – Child Specialist; over 27 years as Guardian ad Litem (child advocacy, safety and welfare)
  - **Melvin Stallings –** Educator and STEAM Curriculum developer – Cyber Green Group, LLC

***Background checks on all consultants will be done.*

Vision and Mission Statement

- **Vision:** Build a brighter future for disadvantaged communities by inspiring, engaging, and empowering students to contribute, collaborate, learn, and innovate through space-related concepts, essentially giving them "Space2Xplore" the universe around them.

- **Mission:** Cultivate the next generation of STEAM leaders to solve the technological problems of the 21st Century, by exposing students to knowledge, mentorship, hands-on project-based learning, & space-related activities.

Live4Space

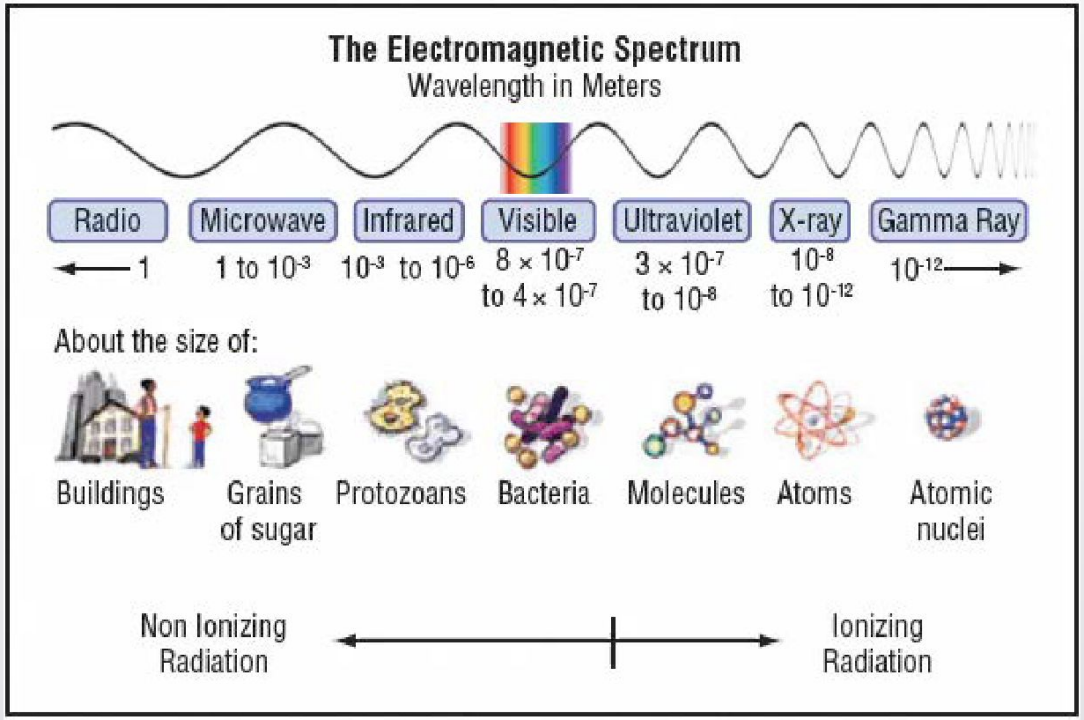
- Life in space produces profound changes in biology. All organisms on Earth have adapted to perform under conditions of gravity, atmosphere, and cycles of light and darkness that have not changed in millions of years, conditions which are altered aboard spacecraft like the ISS. In order for humans to spend long durations in space to reach distant planets or simply conduct exciting research, we must try to solve the complex problem of living in space.
- This abbreviated module for BioFlex will introduce students to:
  - Discovering how biological systems respond, acclimate and adapt to the space environment
  - Understanding the purpose of the research and experiments being conducted on the ISS

Live4Space is About…Space Biology

- Common physiological changes that astronauts experience:
  1. Loss of bone density and muscle mass
  2. Short-term fluid redistribution (facial/chest puffiness)
  3. Neurovestibular problems (space sickness)
  4. Intraoptic pressure (vision problems)
  5. Orthostatic intolerance (inability to stand up)
  6. **Radiation exposure (potential genetic mutations)**

What is Radiation?

- A form of energy that is emitted or transmitted in the form of rays, electromagnetic waves, and/or particles
- Some radiation can be seen (visible light) or felt (infrared radiation), while other forms like x-rays and gamma rays are not visible and can only be observed directly or indirectly
- Radiation can be either non-ionizing (low energy) or ionizing (high energy).

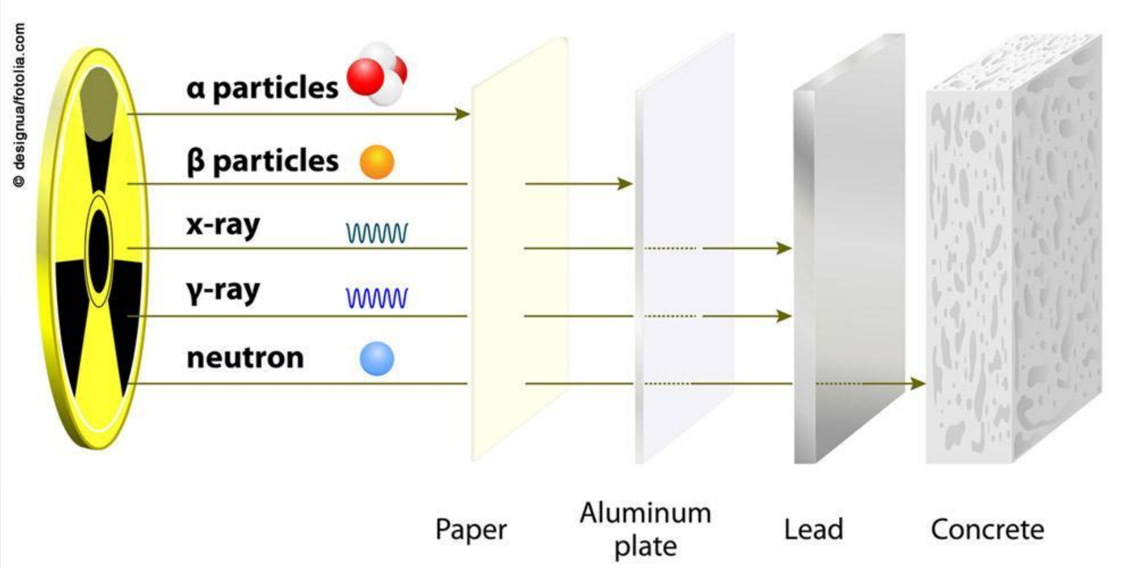


Types of Radiation

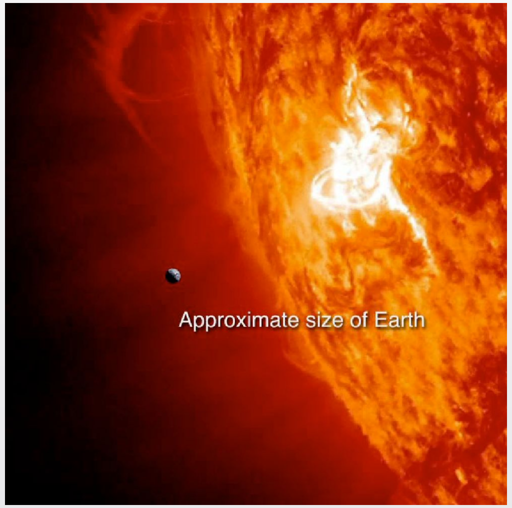
- **Ionizing** - Particles or photons that have enough energy to "ionize" an atom or molecule by completely removing an electron from its orbit
  - Alpha particles (a helium atom nucleus moving at very high speeds),
  - Beta particles (a high-speed electron or positron),
  - Gamma rays,
  - X-rays,
  - Galactic cosmic radiation (GCR)
- **Non-ionizing** - Does not have enough energy to remove electrons
  - Radio frequencies,
  - Microwaves
  - Infrared,
  - Visible light, and
  - Ultraviolet (UV) light

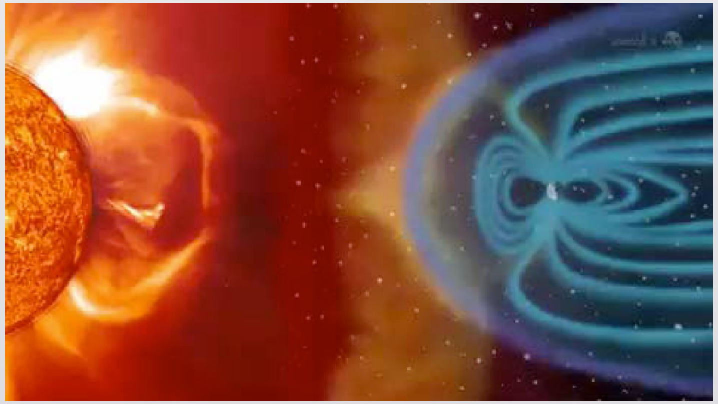
Radiation Dangers

- Non-ionizing radiation is still damaging, but it can easily be shielded out of an environment.
- Ionizing radiation is much more difficult to avoid. Ionizing radiation has the ability to move through substances and alter them as it passes through.



Radiation is All Around Us

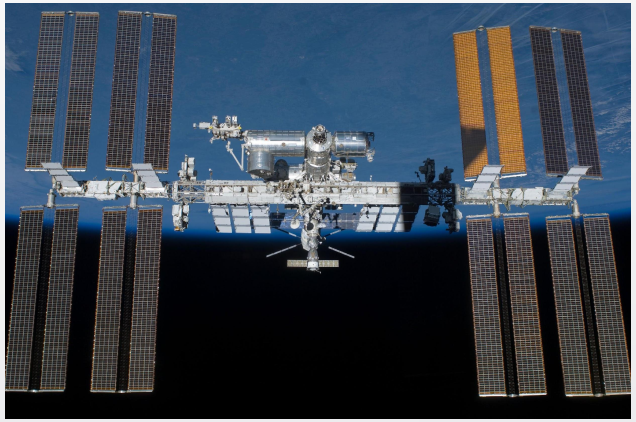




- In our daily lives we are exposed to electromagnetic radiation through microwaves, cell phones, and diagnostic medical applications such as x-rays.
- Earth's biggest source of radiation is the Sun. The Sun emits all wavelengths in the electromagnetic spectrum. The majority is in the form of visible, infrared, and ultraviolet radiation (UV).
- Galactic Cosmic Radiation, or GCR, comes from outside the solar system but primarily from within our Milky Way galaxy.
- GCR is extremely damaging to materials and biology. We are largely shielded from GCR on Earth because of our planet's atmosphere and magnetic field, called Van Allen Belts, *discovered by NASA-JPL's Explorer 1 (First US satellite).*

Astronauts: Living & Working in Space

- As we travel farther from Earth's protective shields we are exposed to the full radiation spectrum and its damaging effects
- The International Space Station has well-shielded areas, and astronauts and the ISS itself are largely protected by the Van Allen Belts (low Earth orbit – "LEO").
- During a deep space journey to the Moon (240,000 miles or 385,000 kilometers away) or Mars (35,000,000 miles or 56,300,000 kilometers away at closest approach)



What’s Your Limit?

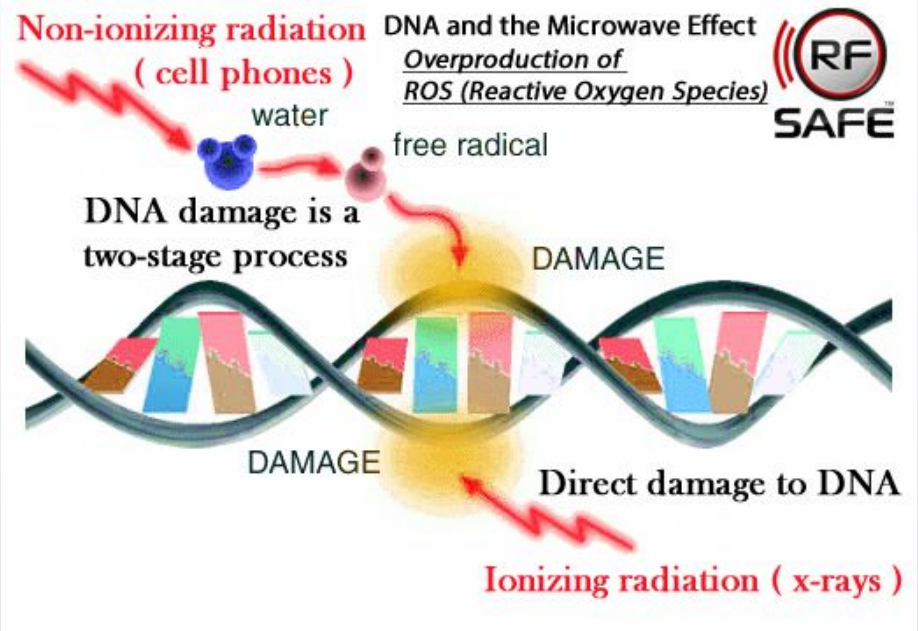
- Astronauts who spend three months in the ISS will be subjected to over three times the maximum recommended dosage of radiation for one year.
- Radiation has shortened the astronauts lives, in some cases considerably. It is believed Apollo astronauts by 4 years.

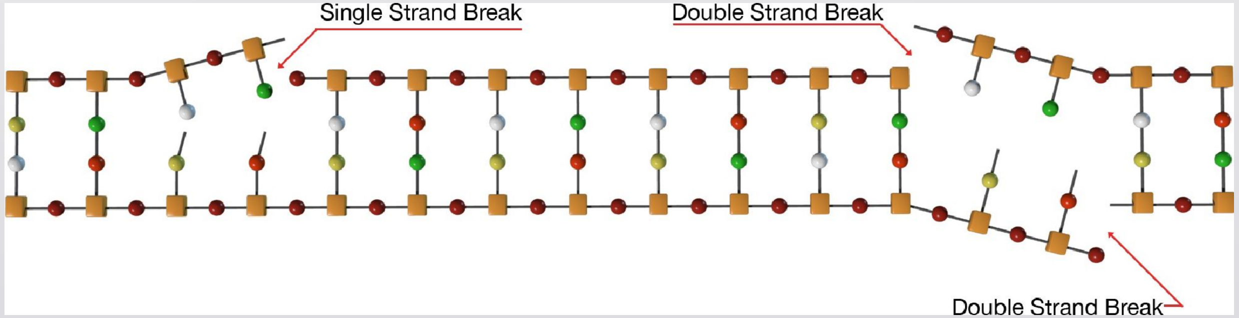
Depth of Radiation Penetration and Exposure Limits for Astronauts and the General Public (in mSv)				
	Exposure Interval	Blood Forming Organs (5 cm depth)	Eyes (0.3 cm depth)	Skin (0.01 cm depth)
Astronauts	30 Days	250	1,000	1,500
	Annual	500	2,000	3,000
	Career	1,000-4,000	4,000	6,000
General Public	Annual	1	1,500	50

Mission Type	Radiation Dose
Space Shuttle Mission 41-C (8-day mission orbiting the Earth at 460 km)	5.59 mSv
Apollo 14 (9-day mission to the Moon)	11.4 mSv
Skylab 4 (87-day mission orbiting the Earth at 473 km)	178 mSv
ISS Mission (up to 6 months orbiting Earth at 353 km)	160 mSv
Estimated Mars mission (3 years)	1,200 mSv

Radiation Damages DNA and Organs

- Radiation changes the number or order of nucleotides (mutation) within a DNA molecule
- Damage to DNA alters the three-dimensional configuration of the helix.
- Causes significant problems in cell structures and even in their function.

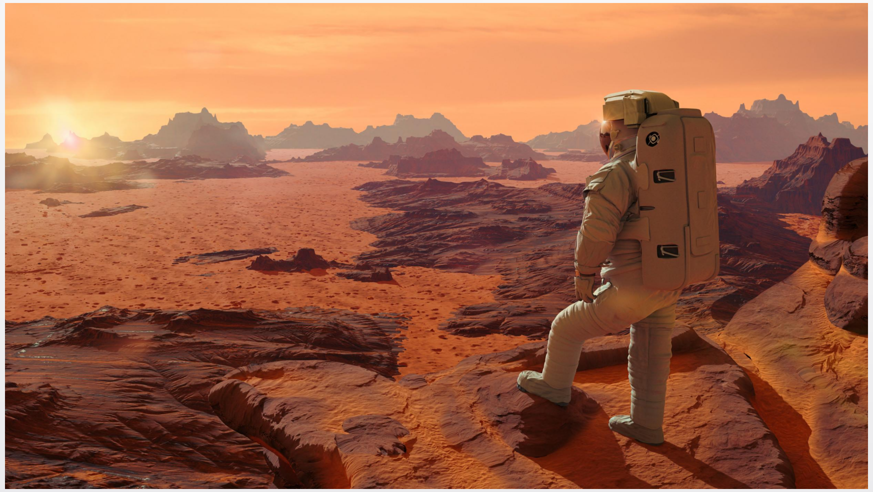


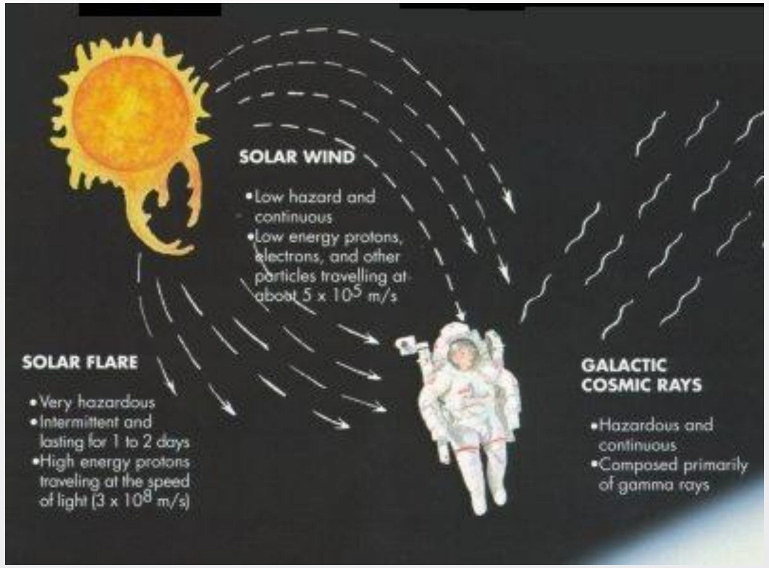


How Can Radiation Affect Me?

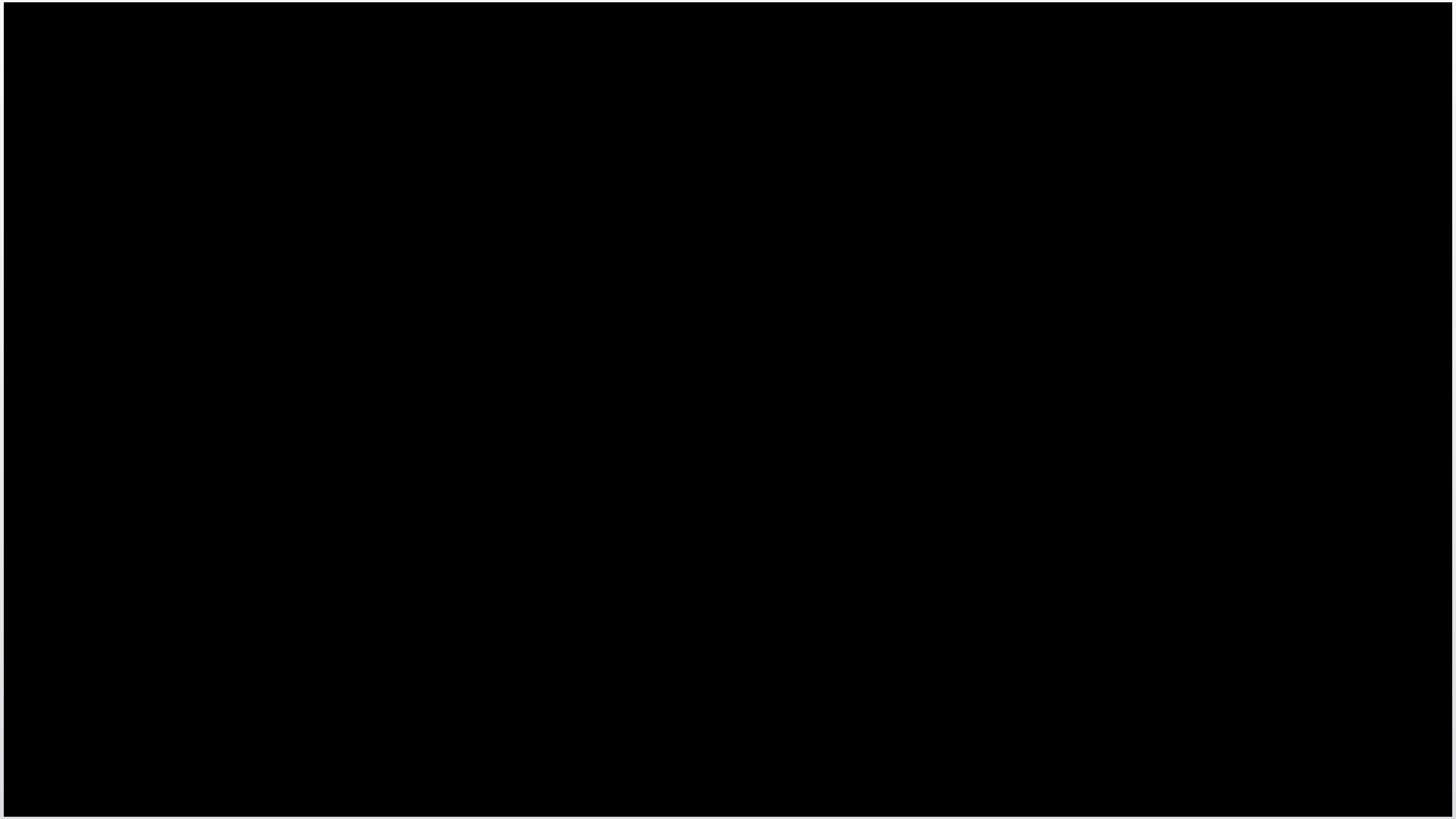
Chart II. Examples of Health Effects from Acute Radiation Exposure		
Exposure (mSv)	Acute Health Effects*	Time to Onset (without treatment)
Less than 100	No detectable health effects	
Above 100	Cell and chromosomal (DNA) damage	hours
Above 1,000	Nausea, vomiting, diarrhea: prodromic syndrome	1 to 2 days
Above 1,500	Damage to blood-forming organs: hematopoietic syndrome; possible death	≈1 month
3,000	50% death from hematopoietic syndrome	in 30 to 60 days
10,000	Destruction of intestinal lining	
	Internal bleeding	
	Death	1-2 weeks
20,000	Damage to central nervous system	
	Loss of consciousness	minutes
	Death	hours to days

Humans on Mars



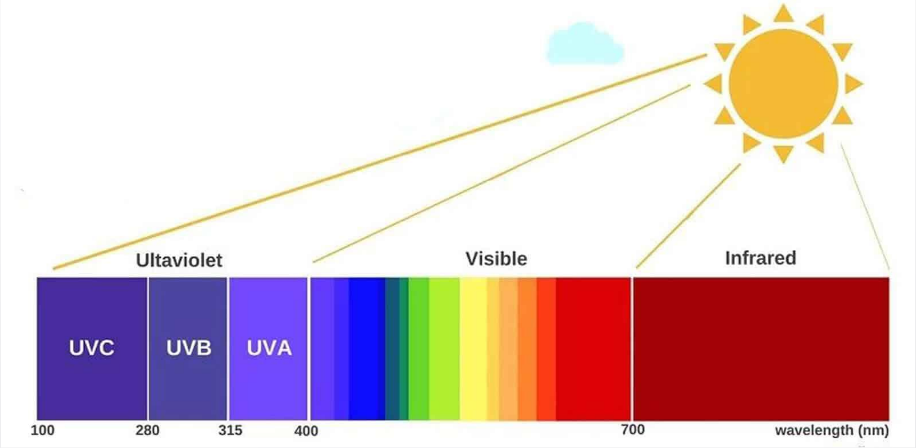


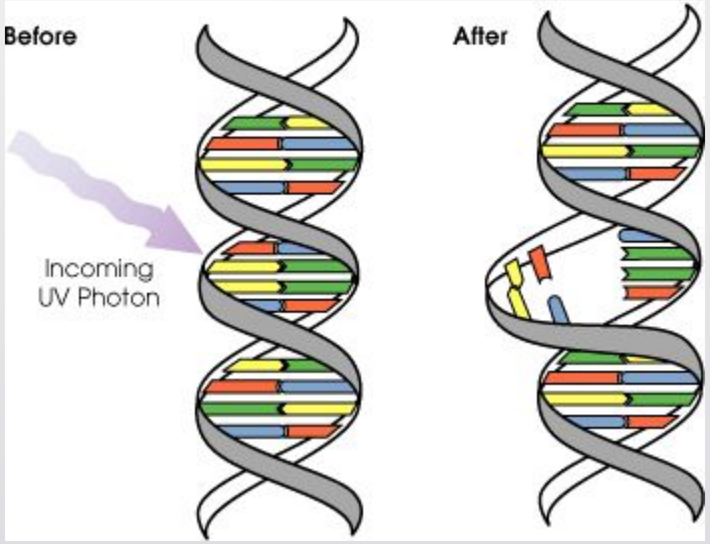
- **Humans will ultimately land and potentially inhabit Mars** for a considerable amount of time.
- NASA and commercial aerospace companies have vowed to put humans on Mars within the next decade.
- Humans will need to survive **space radiation** in order to return home safely.
- To fully understand the biological response of radiation in humans, NASA scientists study these effects using model organisms (e.g., bacteria, yeast, worms, plants, fruit flies, and many others).



Martian Death Ray Experiment

- In order to determine the effect of UV radiation on living cells we will use bacteria.
- Bacterial cells contain DNA just as plant and animal cells do, and the DNA in cells is damaged by UV radiation.
- On Earth we have our atmosphere, particularly the ozone to protect our DNA from harmful UV radiation.
- Mars however has no ozone layer and so its surface is not protected from this radiation.
- Using bacterial plates determine the effect of UV light on cellular life forms (bacteria).





SAFETY FIRST APPROACH!!

- **Always FOLLOW the S2X engineer and your teacher's directions, and ONLY do lab work when we are present.**
- Conduct yourself in a responsible manner at all times. **NO HORSEPLAY!**
- Do not touch any equipment or materials until you are told to do so.
- **NO** food, beverages, or gum in the lab.
- **NO** cell phones out during the experiments. (Don't worry about pictures… We got you!) – This *E. coli* strain is relatively safe, but you don't want to contaminate yourself.
- **Report ALL** accidents to the S2X engineer or your teacher immediately, even if you think it's minor!

Procedure

1. Break into 3 Groups
2. Label Plates (3 plates per group or 1 plate per student)
3. Group name, bacterial species, identify sides of plate for exposure.
4. Label bottom of plate, condensation, counting colonies.
5. Each group will examine a different set of conditions. (See Table)
6. Add bacteria to each plate, (250ul). Spread bacteria around evenly using a loop.
7. With the lid of the plate off, cover one side of the plate with masking tape. Make a mark on the side of the plate indicating what side will be covered and what side will be exposed to UV.
8. Each group will use one of the S2X UV lamp chambers. UV is not great for the skin and can damage vision. Use caution!
9. Expose the bacteria to UV based on the conditions and times in table 1. Use the timers provided to have an accurate exposure time. Note deviations from exposure time
10. Once exposure time is reached. Remove the aluminum from the plate and cover the plate with the plate cover.
11. Place the plate into a 37°C incubator upside down to prevent condensation.
12. Incubate plates for 24 hours.
13. Alternatively, plates can be incubated at room temperature but incubation may take a couple more days.

Exposure Time & Data Charts

Experiment Condition #	Exposure Time	Bacterial Concentration	UV Light Source
1	50s	1x	A
2	250s	1x	A
3	500s	1x	A

Time of Exposure	Number of Colonies No UV	Number of Colonies UV	Colonies UV/Colonies No UV	Percent Reduction
50s				
250s				
500s				

Discussion Questions

- What can happen if UV or radiation causes mutations?
- Are all mutations bad?
- Are mutations passed on to next generation?
- How do you think your annual radiation dose will compare to your classmates and teacher?
- Other than bacteria, what other biological systems could we use to study radiation effects? Hypothesize on anticipated results.
- What countermeasures (e.g. engineering, operational, dietary) would you put in place to mitigate radiation effects for astronauts??

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Everyone deserves a little "space2xplore."

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4 Way, LLC
Science Solutions 4 Everyone