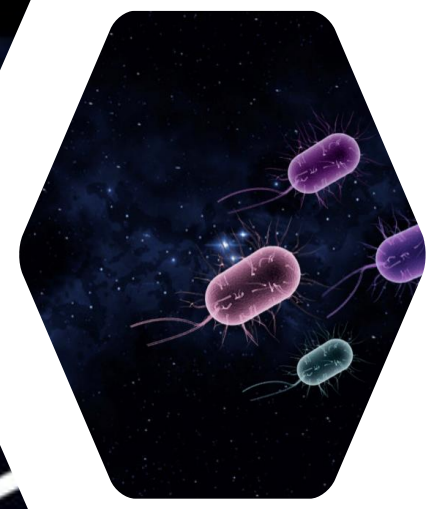


GERMS IN SPACE

A COMPARATIVE ANALYSIS OF GERM GROWTH ACTIVITY ON EARTH AND IN SPACE

By Christopher

Future Astronaut – Space Explorer

Science Project Assignment 2021

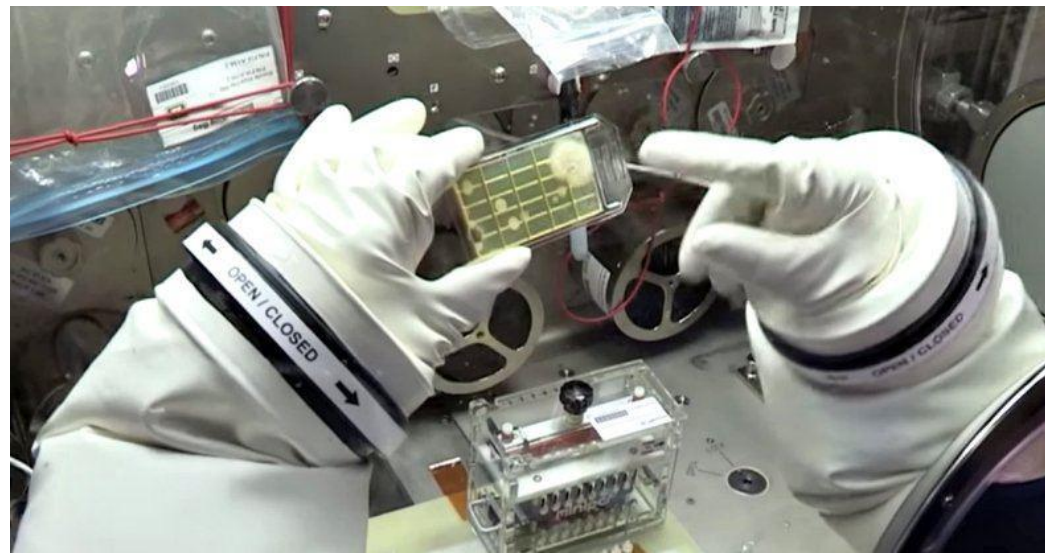
HELLO & WELCOME

INTRODUCTION

On planet Earth, we are accustomed to having gravity which is a force that keeps everything from floating around.

In space, there is very little gravity. On the International Space Station we call it microgravity.

Gravity affects things very differently. It is important to understand how it affects germs in space.



PURPOSE

The purpose of my research is to understand how germs grow in low gravity environments.

I also intend to understand the different types of germs present on the ISS compared to the germs that I will collect in my experiment here on Earth.

I hope to learn about the challenges and concerns with germ behavior on Earth so that I can better understand its behavior in space. This is very important as humanity prepares to establish a permanent presence in space and to explore beyond. We need to understand how humans will grow food in space and how germs will impact human health and performance in low gravity environments.

Through my research, I hope to develop solutions that will benefit life on Earth and in space.

HYPOTHESIS

PROBLEM STATEMENT

How does microgravity environments affect the growth of germs (bacteria, fungi, etc) in space?

Like with most biological forms of life, a few common parameters that are ideal for bacterial growth are gravity, moisture, light, temperature and nutrients.

In space (on the ISS), the only thing that will be different is the low gravity environment.

HYPOTHESIS

I hypothesize that the germs in space will not grow as much as germs found on earth. Their growth patterns, rates and bacterial colonies will differ.

I also hypothesize that different types of germs may be found on the ISS compared to here on Earth. Some of the germs found in space may thrive on the ISS because the low gravity environment is what they prefer.

MATERIALS

- 13 Petri Dishes
- 15g Nutrient Powder (Agar)
- 1 Roll of Transparent Tape
- 6 Disposable Aprons
- 12 Swabs
- 20 Pairs of Disposable Gloves
- 13 Zip Top Bags
- Exploration Guide
- 1 Gallon of Distilled Water
- 1 Laboratory Beaker
- 1 Laboratory Beaker
- 1 Microwave Safe Container
- 1 Stirring Utensil
- Silicon Pot Holder
- Thermometer
- Magnifying Glass
- Microscope
- 1 Black Marker

MATERIALS


Fisherbrand
Petri Dish, Stackable (Deep Dish)
100mm x 25mm
Sterile, Polystyrene
Cat. No. FB0875711
Quantity: 13 / Sleeve
Made in U.S.A.
Fisher Scientific
For laboratory use only
Contents sterile if sleeve is unopened.
dreamUp
DARE TO DREAM
Sharpie
KING SIZE
A+ HOMEWORK
TRANSPARENT TAPE
Cotton Tipped Wood Applicators
CORDOVA
STYLE: 4096T
SIZE: LARGE
NITRI-COR SOFT(TM) NITRILE
NITRI-COR SOFT™ NITRILE, INDUSTRIAL GRADE, POWDER-FREE, 3-MIL, 10EA
WHITE POLYETHYLENE DISPOSABLE APRON
MFG# DAP1.25-24X42
SKU# A5010
• FULL SIZE BIB TYPE APRON
• WATERPROOF PROTECTION FROM NECK TO KNEE
MADE IN CHINA

PROCEDURES

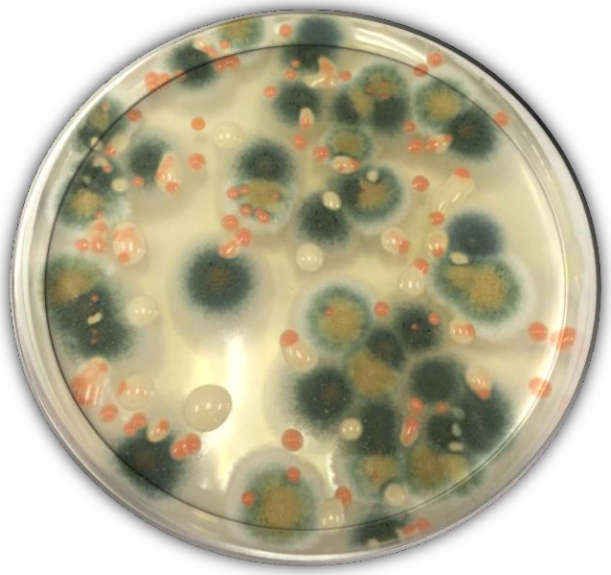
- **It was important to practice aseptic techniques to ensure that my experiment was not contaminated.**
- **I followed the sterilization procedures for my equipment provided with a previous space-related ISS experiment.**
- **I iterated the procedures as needed.**

PROCEDURES

- I cleaned my 13 Petri dishes and corresponding covers with a 10% bleach solution for around 5 minutes.
- I also cleaned the beaker using this method.
- I rinsed my petri dishes and caps 5 times in distilled water.
- With supervision, I prepared my agar solution with a hot plate, distilled water and a beaker.
- I then placed 10ml of agar growth medium in each test tube after it cooled off.
- I collected my germ samples from around my home with the cotton swabs and smeared on agar.
- I labeled each sample with the tape and covered the petri dishes with lids.
- I recorded my observational data inside my experiment log for 15 days.
- I monitored the external conditions (temperature, light, moisture & nutrients).

EXPERIMENT

For 15 days I observed and recorded data on the germ growth rate, behavior and characteristics.
Additionally, I plotted the data within Excel to analyze it.



EXPERIMENT PREPARATION

BEAKER	AGAR AMOUNT	WATER AMOUNT	NUMBER OF PETRI DISHES FOR PLATING	HEATING TIME
1500ml	15g	600ml	13	90-120 seconds

- **I used an agar called Standard Method Agar provided by DreamUp to make my agar.**
- **Using safety equipment and with supervision, I mixed and heated my distilled water and agar making sure that the agar was dissolved completely.**
- **The media appeared cloudy initially but after boiling it and occasionally stirring it, it cleared up.**

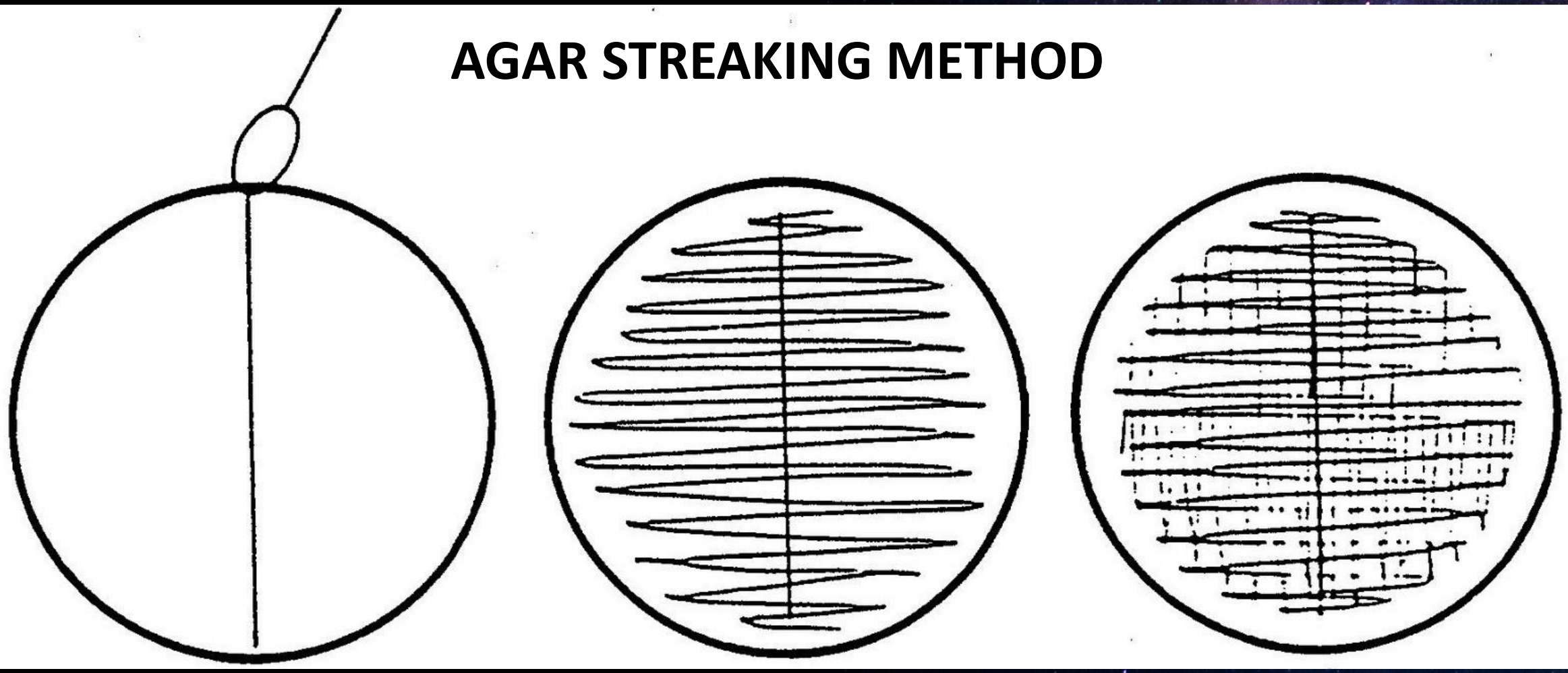
EXPERIMENT PREPARATION

BEAKER	AGAR AMOUNT	WATER AMOUNT	NUMBER OF PETRI DISHES FOR PLATING	HEATING TIME
1500ml	15g	600ml	13	90-120 seconds

- **After I prepared my agar solution using distilled water, I let it cool for 20 minutes then I checked the agar temperature.**
- **At 40C, I distributed the agar evenly in my 13 petri dishes.**
- **I immediately placed the lid on the petri dishes after filling them.**
- **I allowed the prepared petri dishes to cool more so that the agar media would solidify.**
- **I placed them upside down so that condensation would not form on the media.**

EXPERIMENT PROCEDURES

AGAR STREAKING METHOD



- I collected my samples from various locations using a sterile cotton swab.
- I streaked my samples on the agar media.
- I labeled and sealed my petri dishes with clear tape to secure the lids.
- I placed each dish in a sealed clear transparent bag and kept them upside down.
- Samples were kept at room temperature – around 73 degrees F.

EXPERIMENT SETUP

EXPERIMENT SAMPLES

GARAGE LIGHT SWITCH

OFFICE DOOR

DOORBELL

FISH TANK LID

COMPUTER KEYBOARD

REMOTE CONTROL

DOOR HANDLE

FAVORITE STOOL

CELL PHONE

STEERING WHEEL

SOCCER BALL

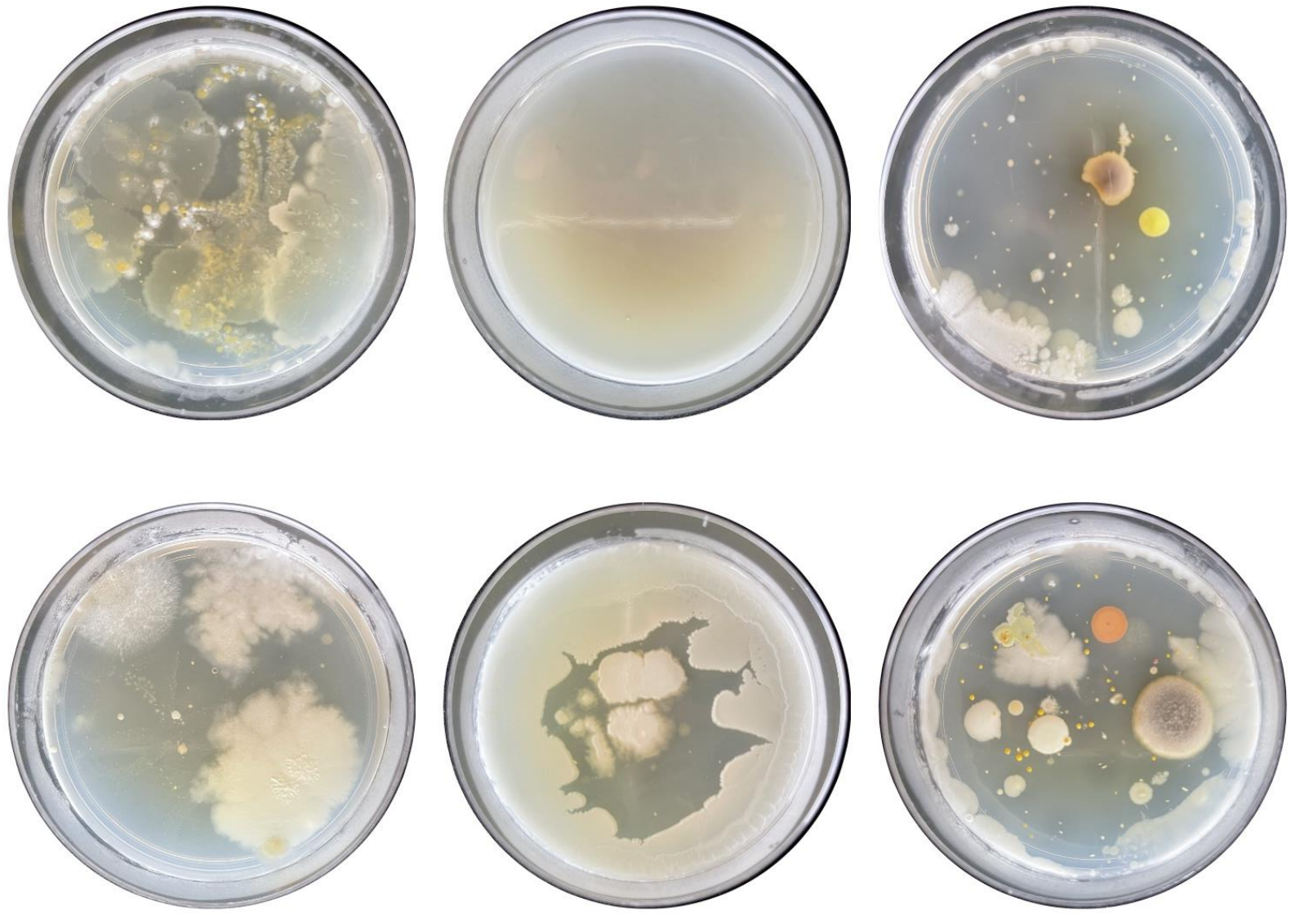
LIGHT SWITCH

KITCHEN SINK

EXPERIMENT SETUP

DATA COLLECTION

During this experiment I collected a lot of data for current and future analysis.



DATA COLLECTION METHODOLOGY

I collected both QUANTITATIVE & QUALITATIVE data.

A OBSERVATION OF MORPHOLOGY & OTHER FACTORS

B GENERAL MORPHOLOGY ANALYSIS

C COMPARATIVE ANALYSIS – EARTH vs SPACE

D GROWTH RATE ANALYSIS

DATA COLLECTION A

OBSERVATION LOG (DAYS 1 – 15)

DAILY OBSERVATION LOGBOOK

EXPERIMENT DAY

SAMPLE NUMBER

DAILY I RECORDED OBSERVATIONAL INFORMATION FOR EACH SAMPLE

MASTER OBSERVATION LOGBOOK

SAMPLE

DAY	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.	No growth observed.
3	Form: circular and punctiform. Elevation: flat. Margin: entire. Black-brown ovals, green popcorn shapes, tan-beige dots and colonies.	Form: circular. Elevation: raised. Margin: entire. Tan clumps-eggs (spindles), transparent specs.	Form: circular. Elevation: raised. Margin: entire. Tan spindle eggs and clumps. Transparent specs.	Form: irregular. Elevation: punctiform Margin: undulate. Transparent specks inside of colonies. Tan-brown egg (spindles) shapes, beidge streeks that look like dunes. Very strong pungent odor.	Form: irregular. Elevation: flat. Margin: erose.Small specs, tan-beidge popcorn shapes clusters.	Form: circular, rhizoid, spindle, irregular. Elevation: raised. Margin: entire. Small specks, transparent lumps, tan eggs.	Form:circular. Elevation: flat. Margin:entire.Agar is cloudy and opaque. Few transparent specs visible.	Form: spindle. Circular. Double circular. Elevation: flat. Margin: entire. Tan clumps-eggs.	Form: circular. Elevation: convex. Umbonate. Margin: entire.Tan-brown egg shapes and clumps , transparent clusters	Not much growth observed. Form: irregular spread. Elevation: flat. Margin: undulate but almost entire. Around 90% of the plate is covered with and off-white colored	Form:irregulr. Elevation: flat. Margin:entireBlack-brown circle shapes, filament-like strands.	Form: irregular. Elevation: raised. Margin: undulate. Tan eggs, transparent dots.	Form: irregular. Elevation: convex. Margin: undulate. White milky growth observed around edges of petri dish.
6	Form: irregular, punctiform, rhizoid. Elevation: flat, convex, crateriform. Margin: entire, lobate. Two large white colonies, small colonies on streak path.	flat, raised. Margin: filamentous, entire. Many transparent or tan colonies, thick border around perimeter of dish.	Form: circular, spindle, filamentous Elevation: raised, flat Margin: filamentous . 5 large circles; 1large fuzzy circle, 2 tan 2 milk	colonies. Some of the tan single colonies look like they're covered under the white stuff under the microscope it looks like grey nodules.	Form: irregular Elevation: flat Margin: crateriform. Bacteris has taken over tha agar. Small holes in the agar are visible across streak path.	flat Margin: entire. 4 large circles visible. 1 yellow, 1 transparent, 2 white. Several largw colonies along dish border and streak path. Strong odor	Form: circular Elevation: flat Margin: entire . Milky white cover over agar. Few dark spots visible		Form: circular, filamentous, spindle Elevation: flat Margin: entire, filamentous. Many dots in agar	rhizoid Elevation: flat Margin: entire. Most of tha agar is being covered. Few colonies visible	Elevation: flat Margin: entire. Agar covered by substance. White circles are visible on the dish	microscope. Agar covered by substance. Perimiter is not completely covered. Some air bubbles are visible on perimeter	Form: circular, irregular. rhizoid Elevation: flat Margin: entire. Most of plate is covered Parts of sample are yellow.
7	Form: punctiform, irregular, rhizoid, filamentous Elevation:flat, convex, crateriform margin: entire, filamentous. Many colonies	Form: irregular, punctiform, circular, filamentous Elevation: flat, raised Margin: entire, filamentous	Form: circular, spindle, filamentous Elevation: flat, raised Margin: entire, filamentous	Form: irregular, punctiform, circular, rhizoid Elevation: flat, raised Margin: entire	Form: irregularElevation: flat Margin: entire	Form: irregular, punctiform Elevation: flat Margin: entire	Form: irregilar, circular Elevation: flat Margin: entire looks like someone took a bite out of it	Form: circular, irregular Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat, raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat Margin: Entire	Form: irregular Elevation: flat Margin: entire
8	Form: irregular, punctiform, rhizoid Elevation: flat, convex, crateriform Margin: entire	Form: irregular, punctiform Elevation: flat, raised Margin: entire, filamentous	Form: circular, spindle, filamentous Elevation: flat, raised Margin: filamentous, entire	Form: irregular, punctiform, circular, rhizoid Elevation: flat, raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form: irregular, punctiform Elevation: flat Margin: entire	Form: irregular, circular Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat Margin:entire	Form: circular,irregular Elevation: flat,raised Margin:entire	Form: irregular Elevation: flat Margin: entire	Form:circular Elevation: flat Margin: entire	Form: circular, irregular Elevation:flat Margin:entire	Form: irregular Elevation: flat Margin: entire
9	Form: irregular, punctiform, rhizoid Elevation: flat,convex,craterform Margin: entrie	Form: irregular, punctiform Elevation: flat Margin:entire, filamentius	Form: circular,spindle,filamentous, irregular Elevation: flat, raised Margin: filamentous, entire	Form: irregular, punctiform, circular, rhizoid Elevation: flat, raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form:irregular, punctiform Elevation: flat Margin: entire	Form: irregular, punctiform Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat, raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form: circular Elevation: flat Margin: entire. Agar covered by substance. White circles are visible on	Form: circular, irregular Elevation: flat Margin: entire	Form: irregular Elevation: flat Margin: entire
10	Form: irregular Elevation: flat,convex,crateriform Margin: entire	Form: irregular, punctiform Elevation: flat Margin: entire	Form: circular, spindle, irregular Elevation: flat, raised Margin: entire	Form: irregular, punctiform,circular, rhizoid Elevation: flat, raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form: irregular, punctiform Elevation: flat Margin: entire	Form: irregular, punctiform Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat Margin: entire	Form:circular,irregular Elevation: flat,raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form: circular Elevation: flat Margin: entire.	Form: circular, irregular Elevation: flat Margin: entire	Form: irregular Elevation: flat Margin: entire
11	Form: irregular, rhizoid Elevation: flat,convex,crateriform Margin: entire	Form: irregular, punctiform, circular Elevation: flat Margin: entire	Form: circular, spindle, irregular Elevation: flat, raised Margin: entire	Form: irregular, punctiform, circular, rhizoid Elevation: flat raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form: irregular, punctiform, circular Elevation: flat Margin: entire	Form: Circular, irregular Elevation: flat Margin: entire	Form: punctiform, irregular Elevation: flat Margin: entire	Form: punctifrom, iregular Elevation: flat, raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form: circular Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat Margin: Entire	Form: irregular Elevation: flat Margin: entire
12	Form: irregular, rhizoid Elevation: flat, convex, crateriformr Margin: entire	Form: irregular, punctiform, circular Elevation:flat Margin: entire	Form: circular, spindle, irregular Elevation: flat, raised Margin: entire	Form: irregular, circular, rhizoid Elevation: flat, raised Margin: entore	Form: irregular Elevation: flat Margin:entire	Form: irregular, punctiform circular Elevation: flat Margin: entire	Form: Circular, irregular Elevation: flat Margin: entire	Form: punctiform, irregular Elevation: flat Margin: entire	Form: circular, irregular Elevation: flat, raised Margin: entire	Form: irregular Elevation: flat Margin: entire	Form: circular Elevation: flat Margin: entire	Form:circular, irregular Elevation: flat Margin: entire	Form: irregular Elevation: flat Margin: entire
13	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:
14	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:
15	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:	Form: Elevation: Margin:

DATA COLLECTION B

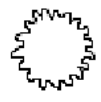
COLONY MORPHOLOGY GENERAL OBSERVATIONS FOR EACH SAMPLE

SAMPLE 13

COLONY MORPHOLOGY					
FORM		**ELEVATION**		**MARGIN**	
PUNTIFORM		FLAT		ENTIRE	
CIRCULAR		RAISED	X	ULDINATE	
FILAMENTOUS		CONVEX	X	FILAMENTOUS	
IRREGULAR	X	PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

I ALSO RECORDED DETAILS ABOUT MY OBSERVATIONS ON THIS CHART ALSO FOR EACH SAMPLE WITH A FOCUS ON THE COLONY MORPHOLOGY

MORPHOLOGY CLASSIFICATION CHART

MARGIN	COLOUR	ELEVATION	TEXTURE	SHAPE
 Curled	 Orange	 Raised	Slimy, moist	 Round
 Entire (smooth)	 Red or pink	 Umbonate	Matte, brittle	 Punctiform
 Filamentous	 Black	Flat	Shiny, viscous	 Rhizoid (root-like)
 Undulate (wavy)	 Brown	 Convex	Dry, mucoid	 Filamentous
 Lobate	Opaque or white	 Pulvinate (Cushion-shaped)	Translucent	 Irregular
 **Erose (serrated)**	**Milky**	**Growth into culture medium**	**Iridescent (changes colour in reflected light)**	 **Spindle**

Source: MicroDok

DATA COLLECTION

COLONY MORPHOLOGY GENERAL OBSERVATIONS FOR EACH SAMPLE

COLONY MORPHOLOGY — SAMPLE 1

FORM		ELEVATION		MARGIN	
PUNTIFORM	x	FLAT	x	ENTIRE	x
CIRCULAR	x	RAISED		ULDINATE	
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR		PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 2

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT		ENTIRE	X
CIRCULAR	X	RAISED	X	ULDINATE	
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR		PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 3

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT		ENTIRE	X
CIRCULAR	X	RAISED	X	ULDINATE	
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR		PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 4

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT	X	ENTIRE	
CIRCULAR		RAISED		ULDINATE	X
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR	X			LOBATE	
RHYZIOD				EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 5

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT	X	ENTIRE	
CIRCULAR		RAISED		ULDINATE	
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR	X	PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	X
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 6

FORM		ELEVATION		MARGIN	
PUNTIFORM	X	FLAT		ENTIRE	
CIRCULAR	X	RAISED	XX	ULDINATE	X
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR	X	PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	X
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 7

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT	X	ENTIRE	X
CIRCULAR	X	RAISED		ULDINATE	
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR		PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 8

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT	X	ENTIRE	X
CIRCULAR	X	RAISED		ULDINATE	
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR		PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 9

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT		ENTIRE	X
CIRCULAR	X	RAISED		ULDINATE	
FILAMENTOUS		CONVEX	X	FILAMENTOUS	
IRREGULAR		PULVINATE		LOBATE	
RHYZIOD		UMBINATE	X	EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 10

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT	X	ENTIRE	
CIRCULAR		RAISED		ULDINATE	X
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR	X	PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 11

FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT	X	ENTIRE	X
CIRCULAR		RAISED		ULDINATE	
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR	X	PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

COLONY MORPHOLOGY — SAMPLE 12

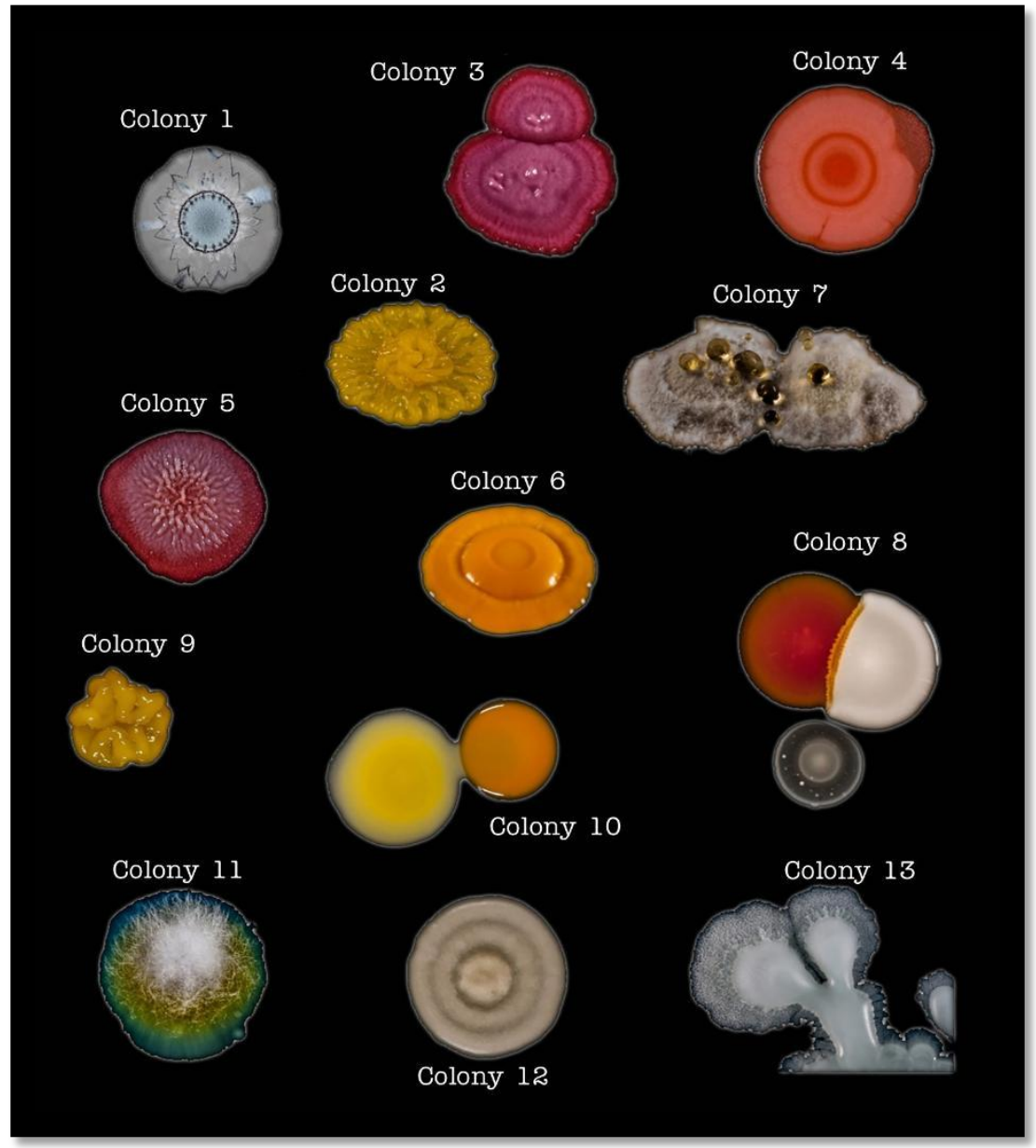
FORM		ELEVATION		MARGIN	
PUNTIFORM		FLAT		ENTIRE	
CIRCULAR		RAISED	X	ULDINATE	X
FILAMENTOUS		CONVEX		FILAMENTOUS	
IRREGULAR	X	PULVINATE		LOBATE	
RHYZIOD		UMBINATE		EROSE	
SPINDLE				CURLED	

ANALYSIS A & B

MARGIN	COLOUR	ELEVATION	TEXTURE	SHAPE
Curled	Orange	Raised	Slimy, moist	Round
Entire (smooth)	Red or pink	Umbonate	Matte, brittle	Punctiform
Filamentous	Black	Flat	Shiny, viscous	Rhizoid (root-like)
Undulate (wavy)	Brown	Convex	Dry, mucoid	Filamentous
Lobate	Opaque or white	Pulvinate (Cushion-shaped)	Translucent	Irregular
Erose (serrated)	**Milky**	**Growth into culture medium**	**Iridescent (changes colour in reflected light)**	**Spindle**

Source: MicroDok

I USED THIS CHART AS A GUIDELINE TO CLASSIFY MY FINDINGS.



ABOVE IS AN EXAMPLE OF DIFFERENT TYPES OF COLONIES.

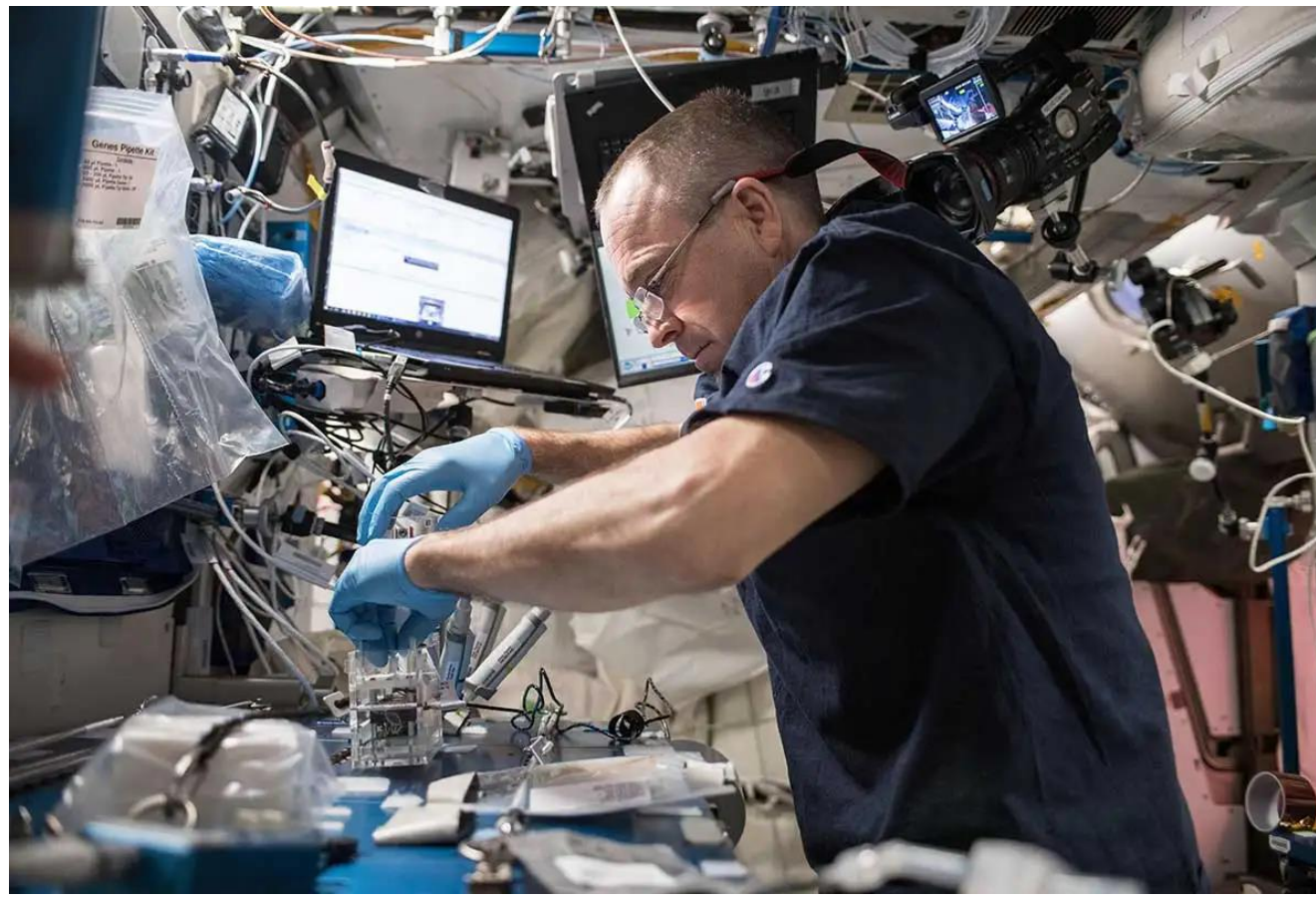
DATA COLLECTION C

COMPARATIVE DATA FOR MICROBIAL BACTERIA GROWTH ON EARTH AND IN SPACE

GERMS IN SPACE COMPARISON CHART		
		DATE
	My Microbial Growth on Earth	Microbial Growth in Space
What do you first notice about the microbial growth?	Early on, I noticed that the growth seemed slow .	The growth occurs very fast in space.
How large is the microbial growth in general?	It depended on the bacteria present in the petri dishes. Several of them rapidly covered	In space, the bacteria forms biofilms which is a protective mode of growth. This allows them to survive in hostile environments and to colonize in new areas.
What colors are the microbes?	The colors vary	Colors vry.
Describe the shape of the colonies	The colony growth patterns varied based on the samples collected.	The colonies stick together forming biofilms.
What do you notice about the arrangement of the microbes?	Many of the microbes grew in circular patterns then they spreaded out.	The colonies stick together forming biofilms and groups.
How does your microbial growth compare with the microbial growth in space?	My microbes grew slower than the microbes in space.	According to research conducted on the ISS, 8 areas were sampled for bacteria. The data showed that there were no significant differences in the amount of bacteria found. They also found some bacteria that was genetically different than any know bacteria on Earth.
What do you expect to change? Do you expect any changes?	I expected to see steady growth over time.	I expected to see the bacteria grow slower in space.
What else do you notice?	Some of the samples were 100% covered in bacteria in a very short period of time. The colony took over and likely consumed all of the nutrients. Nothing else grew within the dish.	Most of the bacteria found on the ISS resembled bacteria found on animal skin surfaces so this means the bacteria comes from humans.
	No Data	Staph and Entero bacteria was found on the ISS.

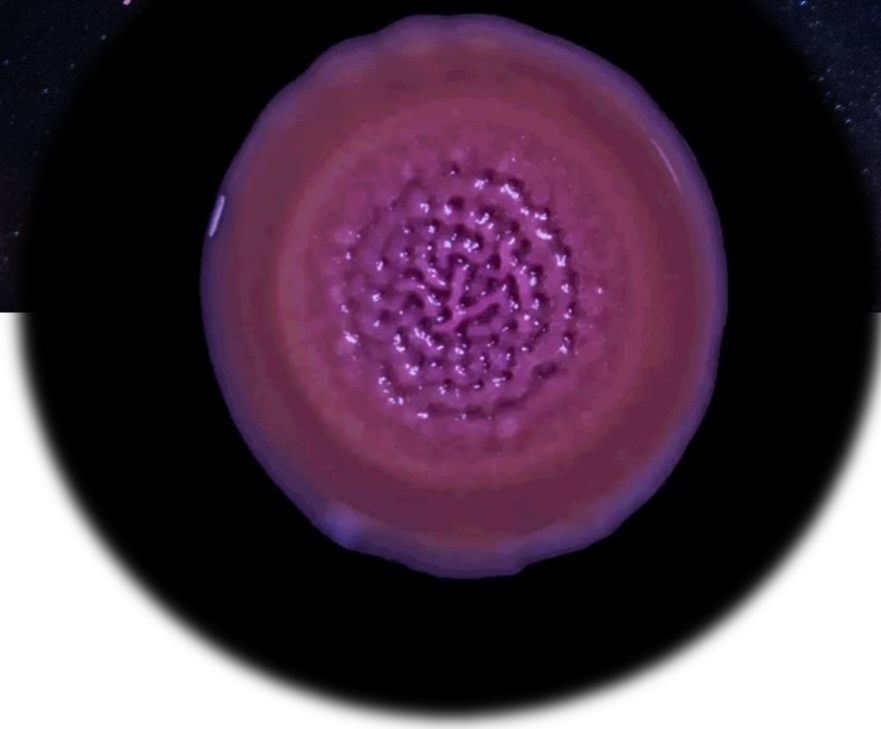
ANALYSIS C

Observation based findings in comparison from observation data collected from a similar experiment conducted on the International Space Station (ISS).



ISS Experiment Data provided by DreamUp & found through a literature review.

ANALYSIS D



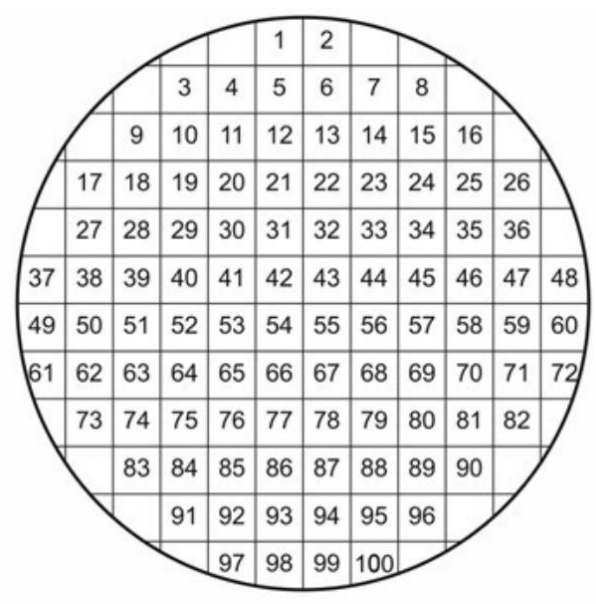
I collected quantitative data by using a grid to gather data to calculate percent coverage.

There were 100 squares that each petri dish covered.

I counted the number of squares with bacterial growth.

Number of Squares Filled With Bacteria

I estimated the growth rates based on the samples and the experiment days.

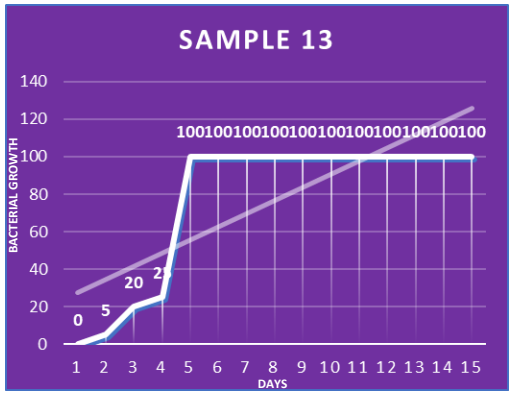


DATA COLLECTION D

BACTERIA PROPOGATION OVER TIME

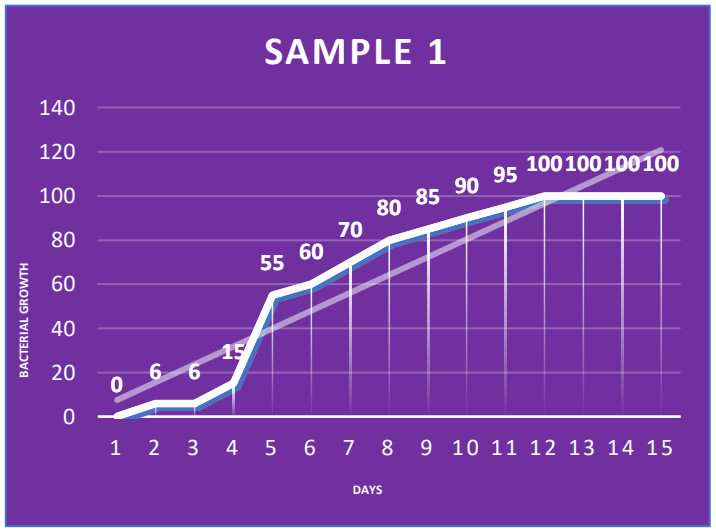
(Sample Number)*

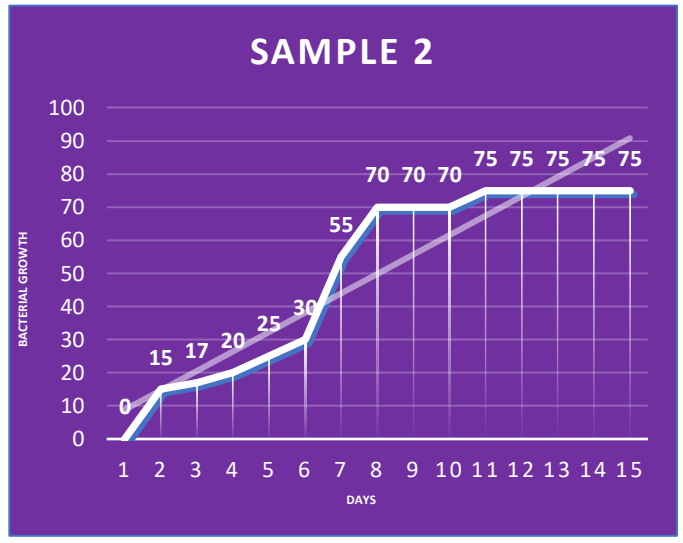
(Day)	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	6	15	5	50	100	1	100	100	0	0	1	1	5
3	6	17	11	60	100	9	100	100	8	80	1	1	20
4	15	20	13	70	100	10	100	100	9	85	100	95	25
5	55	25	30	75	100	20	100	100	25	95	100	95	100
6	60	30	40	75	100	30	100	100	30	95	100	95	100
7	70	55	50	79	100	35	100	100	45	95	100	95	100
8	80	70	60	80	100	40	100	100	55	96	100	95	100
9	85	70	75	90	100	50	100	100	60	98	100	95	100
10	90	70	75	90	100	50	100	100	75	98	100	95	100
11	95	75	80	90	100	55	100	100	80	98	100	95	100
12	100	75	80	90	100	55	100	100	80	98	100	95	100
13	100	75	80	95	100	60	100	100	80	98	100	95	100
14	100	75	80	95	100	60	100	100	85	98	100	95	100
15	100	75	80	95	100	60	100	100	85	98	100	95	100

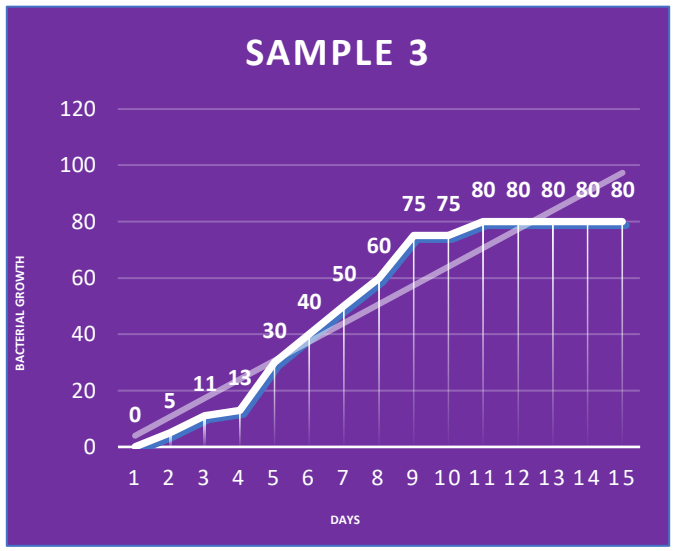


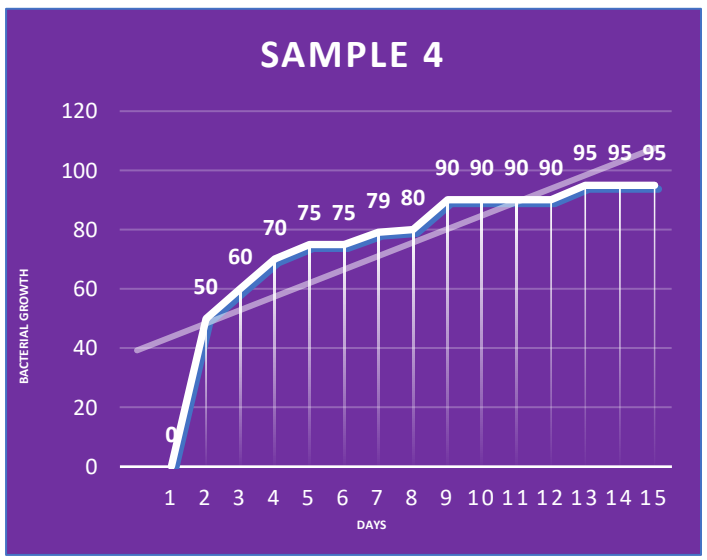
Notice that many of my samples grew rapidly and filled all 100 squares within the first 5 days.

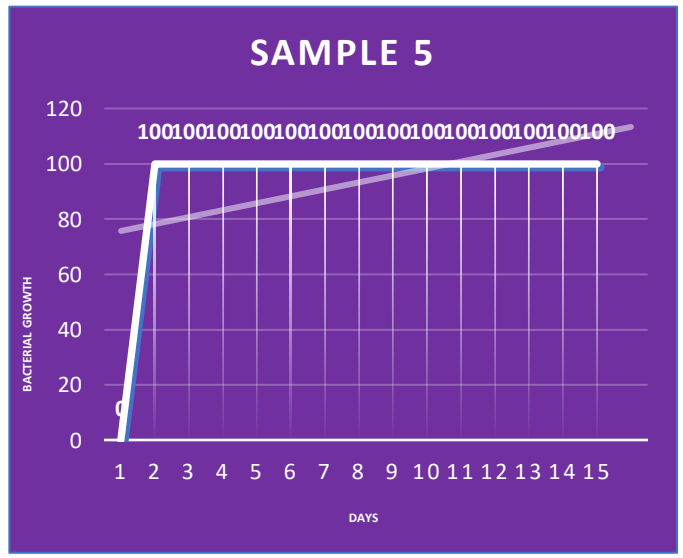
DATA COLLECTION D

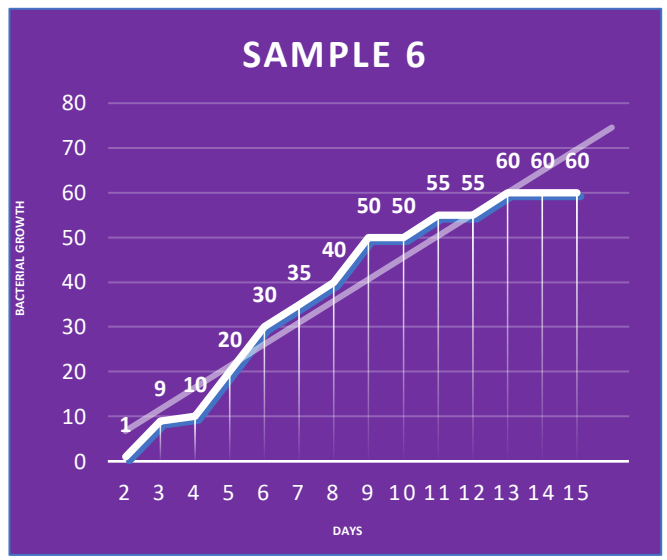






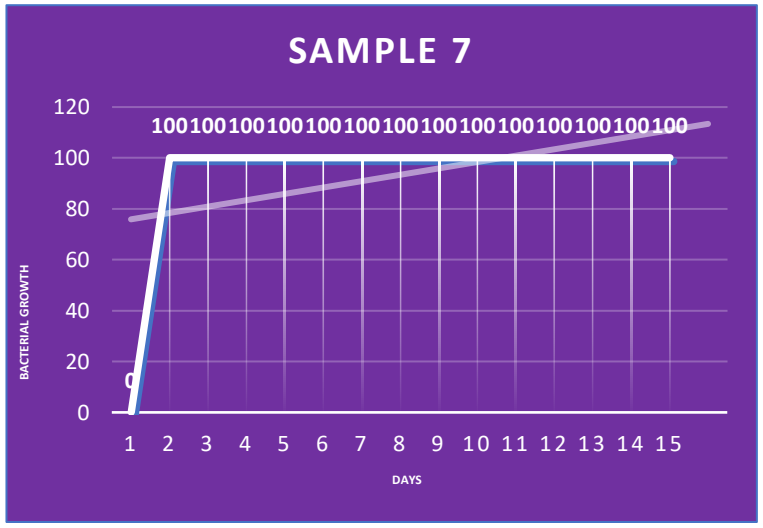


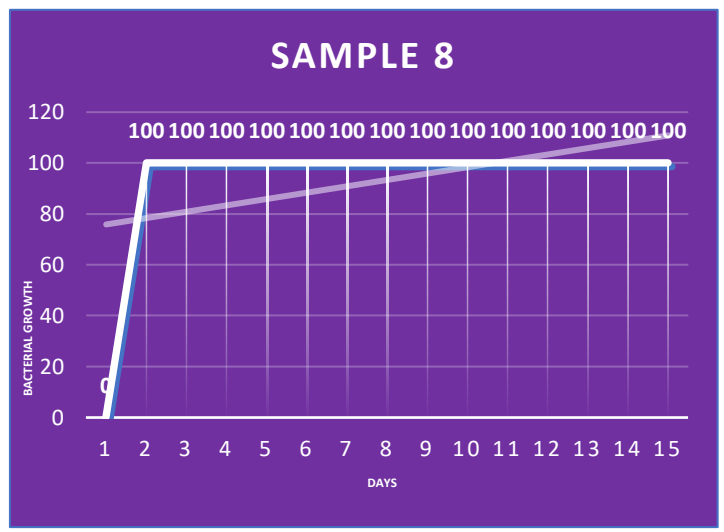


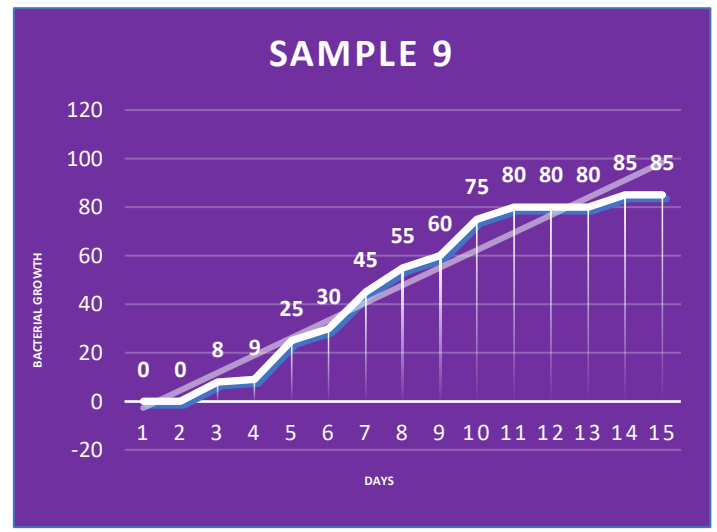


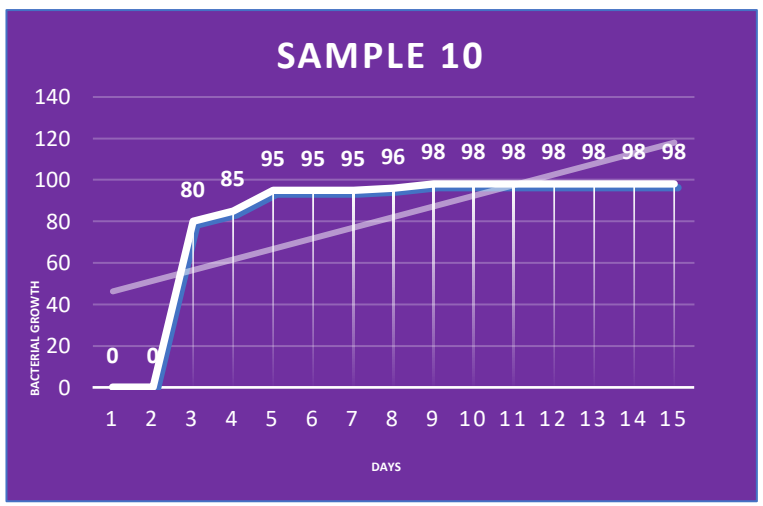
These charts represent the sample growth over a 15 - day time period.

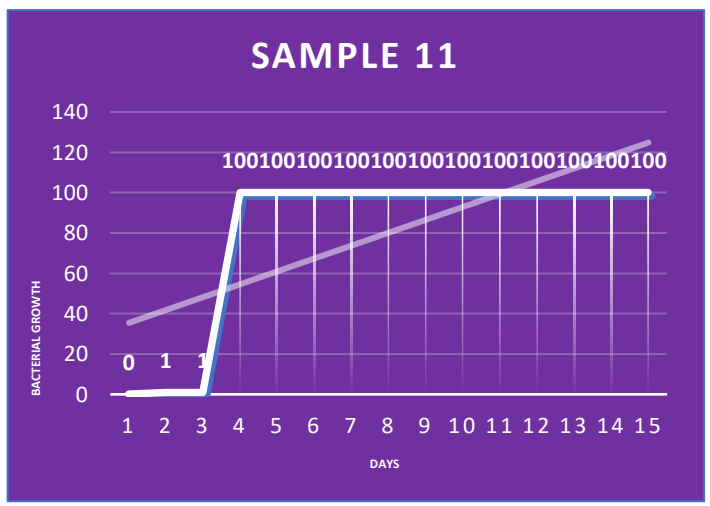
DATA COLLECTION D

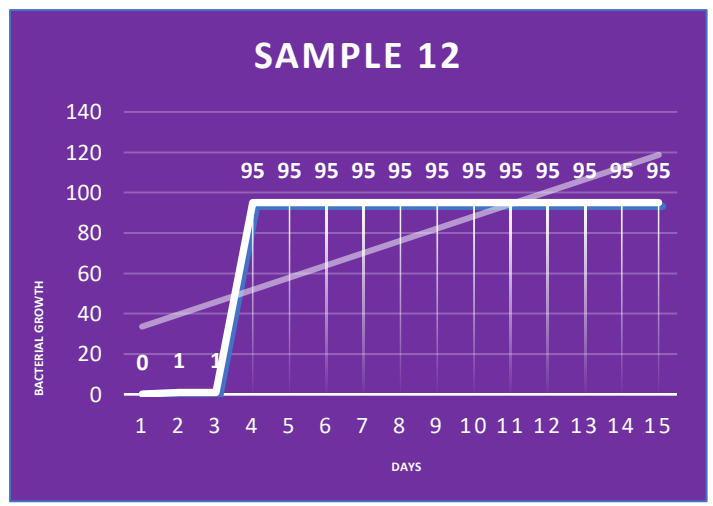












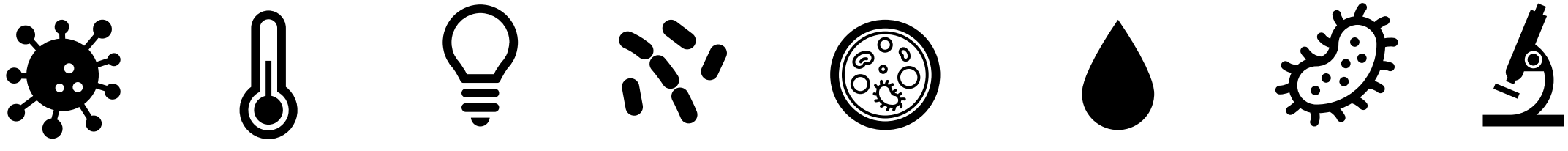
These charts represent the sample growth over a 15 - day time period.

VARIABLES

INDEPENDENT VARIBLES

- Light Duration & Intensity
- Moisture
- Temperature
- Nutrients

- **DEPENDANT VARIBLES**
- Rate of Growth
- Size of bacteria
- Shape of Bacteria
- Shape of Bacterial Colony



INFORMATION

- **I conducted a literature review of several germ growth articles relating to experiments conducted in space.**
- **I conducted a few informational interviews with NASA experts that have been involved in space germ growth experiments.**
- **I used actual ISS experimental data via DreamUp for my comparative analysis.**

Interviews & Expert Discussions

INTERVIEW 1

ASTRONAUT DR. SIAN PROCTOR

DATE: 11 October 2021

I had a discussion with Astronaut Dr. Sian Proctor about her recent trip to Space with SpaceX in September 2021.

We discussed her biological research conducted in space regarding germs and how after a period of time some germs have been known to swap from individual to individual.

Individual swabs were collected for analysis and study upon the crew's return to Earth.

Interviews & Expert Discussions

INTERVIEW 2

ANONOMOUS NASA SCIENTIST

DATE: 24 October 2021

We discussed data collection methods and data analysis methods.

We discussed how bacteria react in space.

RESULTS & FINDINGS

I assessed my findings and determined that my hypothesis for conducting a comparative analysis with my data and with data from a similar experiment conducted on the ISS was incorrect.

I assumed that the bacteria would grow slower in space. Findings suggest that bacteria and fungi grow faster in space. They both thrive in low gravity environments and often form groups. They form biofilms which is a protective mode of growth. This allows them to survive in hostile environments and to colonize in new and extreme areas. It is important to note that some types of opportunistic microbes were found on the ISS which could pose risks to humans.

Most of the bacteria found on the ISS resembled bacteria found on animal skin surfaces so this means the bacteria more than likely comes from the astronauts on the ISS. This aligns with some of the things that I learned during my informational interview with Dr. Sian Proctor who had recently returned from space.

Its important to note that bacteria were also found outside of the ISS. Specific research conducted determined that they can survive in the harsh space environment for at least 3 years.

The bacteria found in the locations that I sampled on Earth appeared to have all types of bacterial growth from both animals and plants. This finding differed from the ISS findings however this was not surprising.

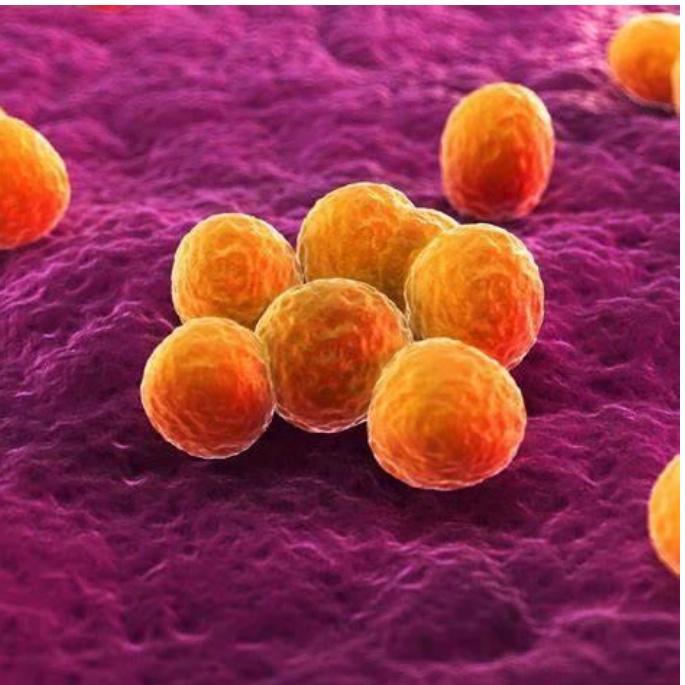
My quantitative data was surprising as several of my samples grew extremely fast. One day there was no growth. The following day, several of my samples were 100 percent covered with growth. It appeared that one specific type of colony consumed all of the nutrients.

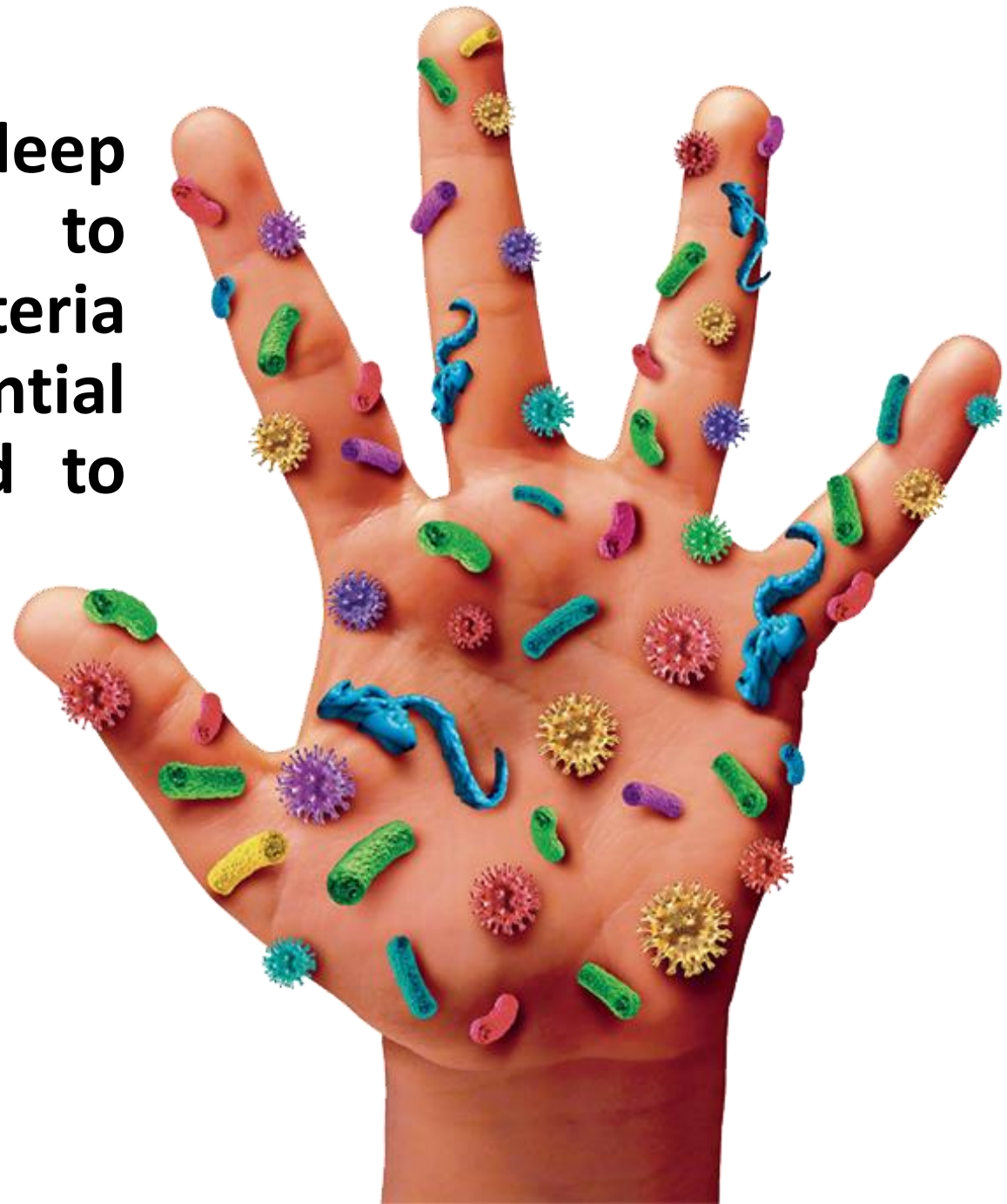
RESULTS & FINDINGS

- **My hypothesis was incorrect.**
- **Germs grow much faster in space.**
- **In space, germs go into a survival mode and form groups and biofilms.**
- **My samples consisted of animal and plant cells.**
- **Bacteria found on the ISS are animal cells – coming from humans.**
- **My quantitative data showed exponential bacterial growth.**

APPLICATIONS

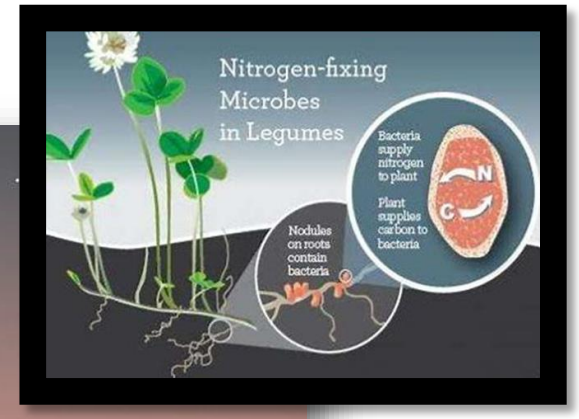
- **There are many applications for my research.**
- **Astronauts who travel into deep space will need to be able to understand the impacts of bacteria and what disinfectants and potential medicines that they may need to bring with them.**





APPLICATIONS

- **Bacteria in space may be able to assist with plant growth in low nutrient environments (Earth and in space).**
- **The discoveries that we make in space, the ones that I hope to make, will benefit life in space and on earth.**



CONCLUSION

KEY POINTS

- **It is important to understand the behaviors bacteria and fungi in the space environment.**
- **This is important for human health, performance and for plant growth. It is also important to understand these behaviors so that we do not contaminate or expose ourselves to harmful environments that we visit while exploring space.**
- **This type of research is important also for extreme environments on Earth. As we understand bacterial behavior more in space, hopefully we can come up with solutions to grow food for populations on Earth that need it.**
- **I intend to carry out research in the future to understand extremophile bacteria and how it can benefit life on Earth.**

RESOURCES & BIBLIOGRAPHY

Bacteria could help 'space farmers' grow plants on Mars. (2021). Bacteria Could Help 'Space Farmers' Grow Plants on Mars. https://www.innovationnewsnetwork.com/

Bacteria in space: Why the International Space Station is riddled with "germs." (2015). Bacteria in Space: Why the International Space Station Is Riddled with "Germs." https://theconversation.com/bacteria-in-space-why-the-international-space-station-is-riddled-with-germs-49827

Bacteria sent into space. (2013). Bacteria Sent into Space. https://www.nasa.gov/centers/ames/news/2013/bacteria-sent-into-space.html

Germs in space iss video. (n.d.). Germs in Space ISS Video. https://www.bing.com/videos/search?q=germs+in+space+ISS&view=detail&mid=368F3EA3A4CF8D516F91368F3EA3A4CF8D516F91&FORM=VIRE

Isolated From the International Space Station. (2021). Isolated From the International Space Station. https://www.frontiersin.org/articles/10.3389/fmicb.2021.639396/full

RESOURCES & BIBLIOGRAPHY

The ISS is crawling with nasty bacteria. (2019). The ISS Is Crawling with Nasty Bacteria. https://www.engadget.com/2019-04-08-iss-bacteria-nasa.html#:~:text=NASA%20scientists%20have%20found%20that%20the%20International%20Space,and%20fungal%20biofilms%20that%20promote%20resistance%20to%20antibiotics.

New bacteria lurking on ISS. (2021). New Bacteria Lurking on ISS. https://www.theguardian.com/science/2021/mar/18/new-bacteria-lurking-on-iss-no-space-oddity-says-scientist

Newly discovered bacteria helps astronauts grow food. (2021). Newly Discovered Bacteria Helps Astronauts Grow Food. https://www.space.com/space-station-bacteria-discovery-grow-food-on-mars

Space station science germs. (2013). Space Station Science Germs. https://www.space.com/19921-space-station-science-germs-worms.html

RESOURCES & BIBLIOGRAPHY

A team analyzing bacteria on the ISS discovered different genes in space bacteria than similar bacteria on Earth. (2020). A Team Analyzing Bacteria on the ISS Discovered Different Genes in Space Bacteria than Similar Bacteria on Earth. https://todayheadline.co/a-team-analyzing-bacteria-on-the-iss-discovered-different-genes-in-space-bacteria-than-similar-bacteria-on-earth/

There are bacteria and fungi all over the space station, and now we know what they are. (2019). There Are Bacteria and Fungi All Over the Space Station, and Now We Know What They Are. https://www.space.com/microbes-fungi-space-station-identified.html

THANK YOU!

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