eugene SCIENCE CENTER

NEXT GEN STEM

EMPOWERING THE NEXT GENERATION OF STEM INNOVATORS

MEET THE NEXT GEN STEM INNOVATORS:

MEET DR. JESSICA FAGERSTROM, A MEDICAL PHYSICIST

Jessica works in a field that applies concepts in physics and engineering to questions in medicine. She specializes in radiation therapy physics, which means she helps treat patients who have cancer, using radiation.

Have you ever heard of any superheroes from comic books or movies that got their powers from radiation? It turns out that ionizing radiation, the kind of radiation that can damage DNA, can have some pretty big effects on our health. That's why radiation can be a powerful tool when it comes to treating cancer. Medical physicists working in radiation therapy make sure that radiation is delivered safely and effectively to target tumor cells. And while medical physicists don't work with radioactive spiders or big green hulking heroes, they do perform a very important job to make sure that patients get the care they need.

Dr. Fagerstrom earned her Ph.D. at the University of Wisconsin-Madison, and her previous work took her to Hawaii where she was a clinical physicist at Queen's Medical Center. She enjoys volunteering with young students, encouraging the next generation to pursue a career path in Medical Physics and other STEM professions. She also loves hiking, running marathons, and snorkeling with her husband, family, and friends.

I love my job because I get to use fascinating science and cutting edge technology, to help people who are sick feel better. I also get to work with an absolutely fantastic team of people every day. On a daily basis, I know that our team is making a real difference in people's lives. I definitely recommend Medical Physics as a career for anyone who loves learning and helping people!
- Dr. Jessica Fagerstrom

CLICK TO WATCH OUR INTERVIEW WITH JESSICA

A DAY IN THE LIFE OF A MEDICAL PHYSICIST

Dr. Jessica Fagerstrom is a Medical Physicist who is passionate and committed to treating cancer patients with the highest quality healthcare. Can you find some of the terms she uses in her practice?

T Z R C H Y C E L L S D Y Y X P
Y S T A B E G L W W K R P G E H
T X I N D E A R V M W S A O N Y
E R X C E I A L E C N O R L I S
F A J E I M O M I N A F E O C I
A Y B R Z S T L S N E F H N I C
S S D T I N Y N O T G I T H D S
V Q P R Q X N H I G G C N C E H
S T N E I T A P P O Y E O E M N
Z T Y A E S Z N Z L P A I T H D
S N O T O R P P P D A P T T L H
U Y U M Y F B M S H T C A V T I
M M T E Y P A R E H T O I D A R
S I O N I Z I N G K X D D D V P
Y E I T L R Q O E H K H A W E T
M A L I G N A N T S Q M R D D M

- medical physicist
- radiation therapy
- radiotherapy
- malignant
- cells
- cancer treatment
- technology
- patients
- radiology
- medicine
- beams
- energy
- x rays
- protons
- physics
- ionizing
- drs office
- appointment
- healing
- safety

Please note: some words are found when spelled backwards!

MODELING RADIOACTIVE DECAY

Medical Physicists use radiation therapy to help cancer patients.
In this activity you will explore an important concept in radiation science: **radioactive decay.** You can follow along with Jessica as she models radioactive decay by visiting [eugenesciencecenter.org/nextgenstem.](eugenesciencecenter.org/nextgenstem)

Materials:

- 50 M&M's (can be substituted with 50 pennies or 50 puzzle pieces)
- Cup large enough to hold your 50 M&M's
- Tray or flat surface to spread out your M&M's
- Pencil
- Data Collection Sheet from this workbook

Procedure:

1. Put 50 M&M candies into your cup. The 50 M&M's are recorded as Trial 0 on the Data Collection Sheet. All of the M&M's are radioactive.
2. Shake the cup and spill out the M&M's onto a flat surface.
3. Pick up ONLY the candies with the "m" showing - these are still radioactive. Count the "m" candies as you return them to the cup. Move the candies that are blank on the top to the side - these have now decayed to a stable state. (If using pennies or puzzle pieces, count the pennies that are 'heads-up' or puzzle pieces that are 'picture-up.')
4. Record the number of "m" candies you returned to the cup under Trial 1 in your Data Collection Sheet.
5. Shake the cup with the radioactive M&M's. Spill them onto a flat surface.
6. Pick up ONLY the candies with the "m" showing - these are still radioactive. Count the "m" candies as you return them to the cup. Move the candies that are blank on the top to the side - these have now decayed to a stable state.
7. Record the number of candies you returned to the cup under the next Trial.
8. Repeat steps 5 through 7 until all the candies have decayed or until you have completed Trial 7.
9. Plot the results as a line graph on your Data Collection Sheet.
   Is the line straight or curved?

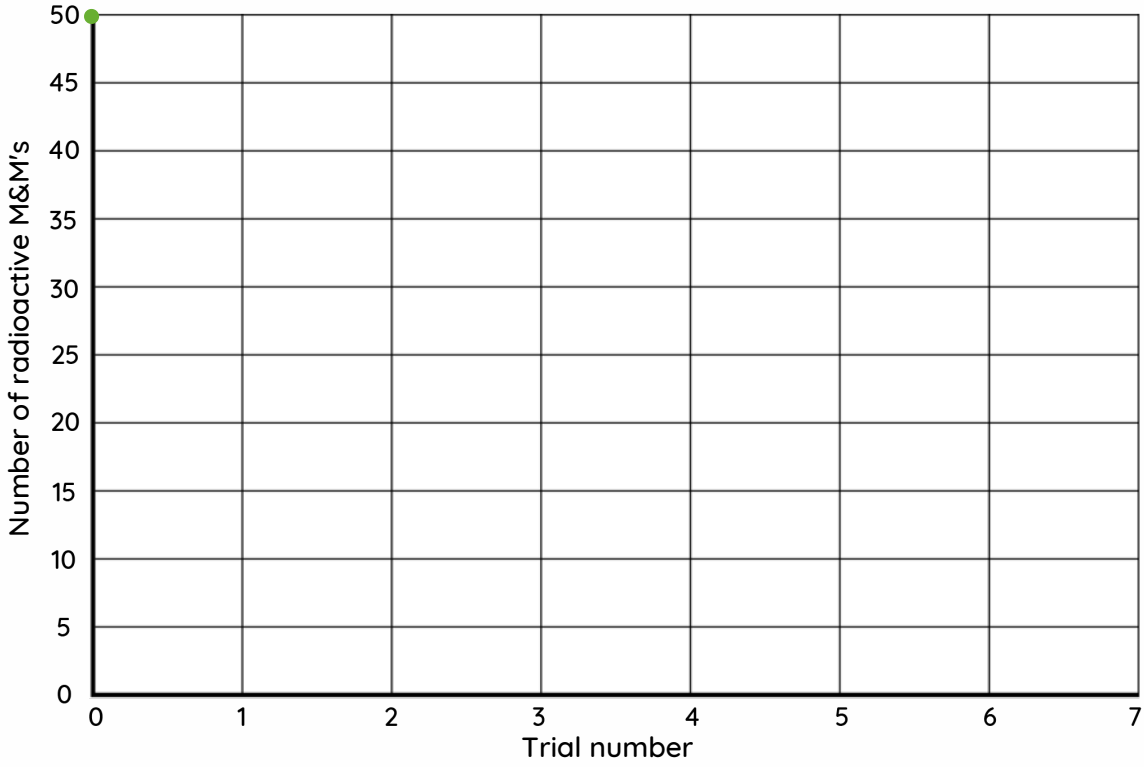
DATA COLLECTION SHEET: MODELING RADIOACTIVE DECAY

Record the number of M&M's with the "M" showing

Trial 0	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7
50							

Plot your results on a line graph below. Is the result a straight or curved line?

MODELING RADIOACTIVE DECAY OF M&M'S



If you were to repeat this experiment, do you think you would see similar results? Why or why not?

_____

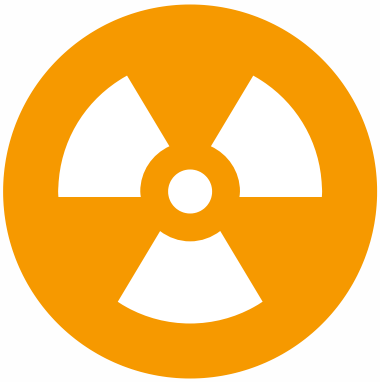
_____

_____

Still Curious? Try researching these topics:

- Carbon-14 Dating
- Radiation therapy
- Nuclear energy
- Exponential population growth

MODELING RADIOACTIVE DECAY



What's Happening?

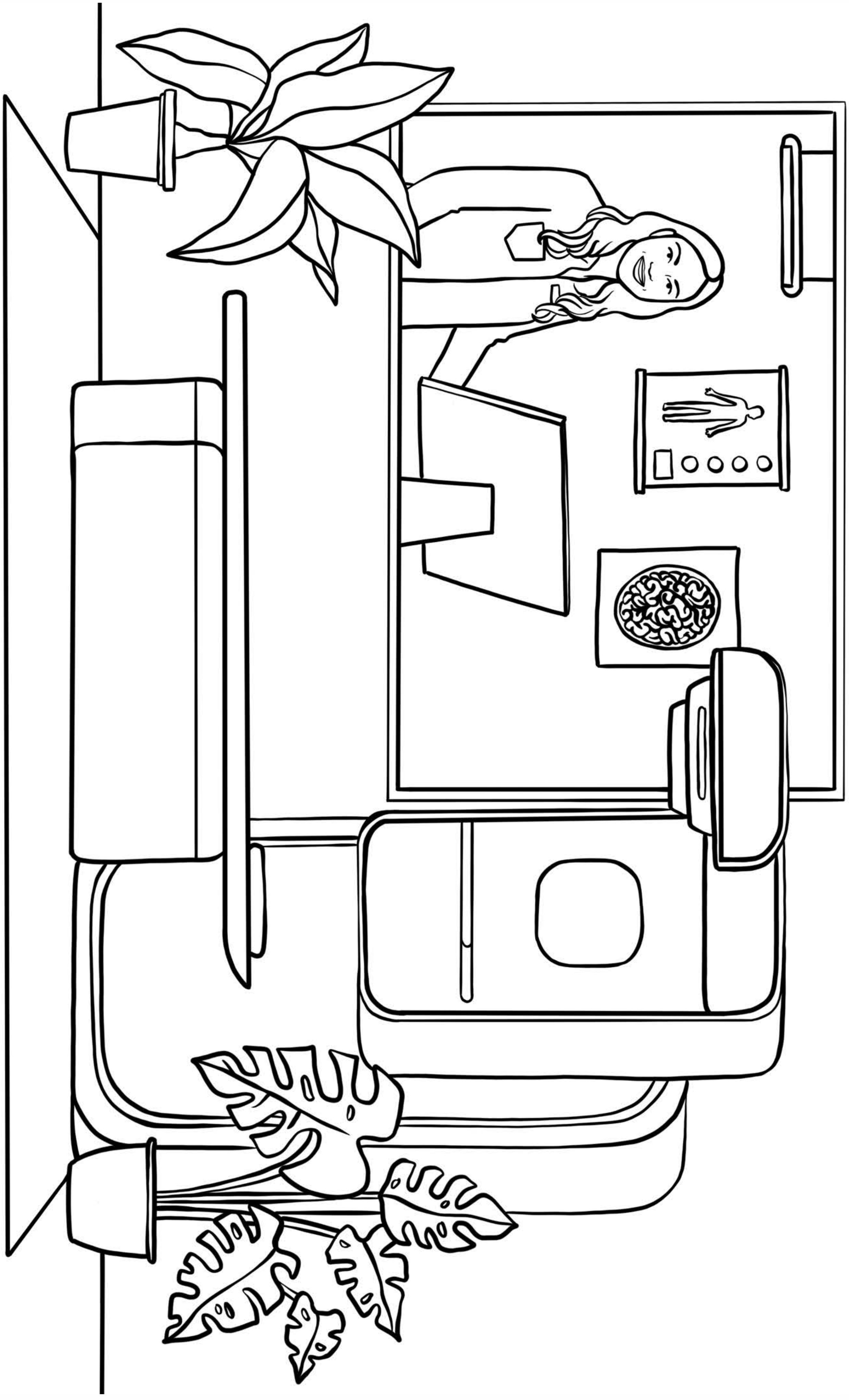
You may have noticed that about half of your M&M's decayed to a stable state while the other half stayed radioactive during each trial. This phenomenon models what happens to radioactive material over time.

Radioactivity is a feature of certain types of matter. All matter is made of chemical elements, and elements are made of atoms. Most atoms are stable. That is, they do not change over time. Radioactive atoms, however, do change over time. Small particles and energy fly out of them naturally. The particles and energy that are released are a form of radiation.

The atoms are changed a little bit each time they release something. They keep giving off particles and energy until they are changed into a stable form. That process is called **decay**. The amount of time that each type of atom takes to decay varies greatly. It can be less than a second or millions of years. The measure of that rate is called a **half-life**. A half-life refers to the time required for one half of a group of atoms to decay into a stable form.

When scientists show radioactive decay in a line graph, it always shows the same shape of a curved line. This type of curve on a graph is called **exponential decay**.

This activity is adapted from one designed by the American Nuclear Society.



MEET DR. ARLYNE SIMON, A BIOMEDICAL ENGINEER

Dr. Arlyne Simon is a Biomedical Engineer, Inventor, Author and Entrepreneur from Dominica, a small Caribbean island, and now resides in Portland, Oregon. When she was five, Arlyne fell in love with science after conducting her first messy experiment at home, which fueled her curiosity and set her on a path to become a biomedical engineer.

Arlyne holds a Ph.D. in macromolecular science and engineering from the University of Michigan and an undergraduate degree in chemical & biomolecular engineering from Georgia Tech. She became the first person in her family to get a Ph.D., and graduated with an invention to her name! Recognized as a trailblazing female innovator by the United States Patent and Trademark Office, Arlyne invented a blood test that detects when cancer patients reject bone marrow transplants.

Her passion for healthcare has led her to design syringes, train clinical laboratory technologists in Kenya, help build supercomputers, and now design medical imaging equipment at Intel. Eager to inspire more girls to become inventors, Arlyne founded Timouns - a multicultural children's products company that creates picture books for kid inventors. Arlyne is also the author of the Abby Invents picture book series, which stars a girl inventor who invents unbreakable crayons and more! Arlyne hopes to challenge everyone to explore science and encourage them to be among the greatest of inventors, too!

You were born to be an inventor. Yes, you. If we are going to create a kinder world, a healthier world, a more sustainable world, then you need to share your creativity.
- Dr. Arlyne Simon

CLICK TO WATCH OUR INTERVIEW WITH ARLYNE

A DAY IN THE LIFE OF DR. ARLYNE SIMON

Arlyne is a Biomedical Engineer, Inventor, Author and Entrepreneur and is committed to creating next-generation technologies that transform medicine. Can you find some of the terms she uses in her practice?

U E D Y T I V I T A E R C D E N E F G B
P N U R N B M Y U B I O M E D I C A L G
X G N Y W O A U K N N M W X B F X W L B
K I S E I R E S K O O B C Q S A X R A M
D N I T V I T E T J V Q G S U K B G I E
U E B B V P S U R Z U K P U S H A X C D
R E T F L L X G A T T I U P T T V R I I
S R I N T E L L I G E N C E A U T K F C
L A K W E E E V L J C V A R I S L N I A
A B U T J V Q Y B B H E K C N T M F T L
B A D T C F A K L K N N V O A N T Q R I
O U Y S H K D V A P O T W M B E D N A M
R J T I O O J U Z Y L O A P I V A O Z A
A Q I V T T R D E H O R T U L N Q S F G
T W S K E B F N R M G W L T I I O H A I
O S O I I E A A F O Y Q E E T Y Y A N N
R H I E G D U D N K S P U R Y B Q U V G
Y L R Y A P A T E N T P K S L B P R P J
C Z U A D E R A C H T L A E H A T O M S
K P C E N T R E P R E N E U R L H C W O

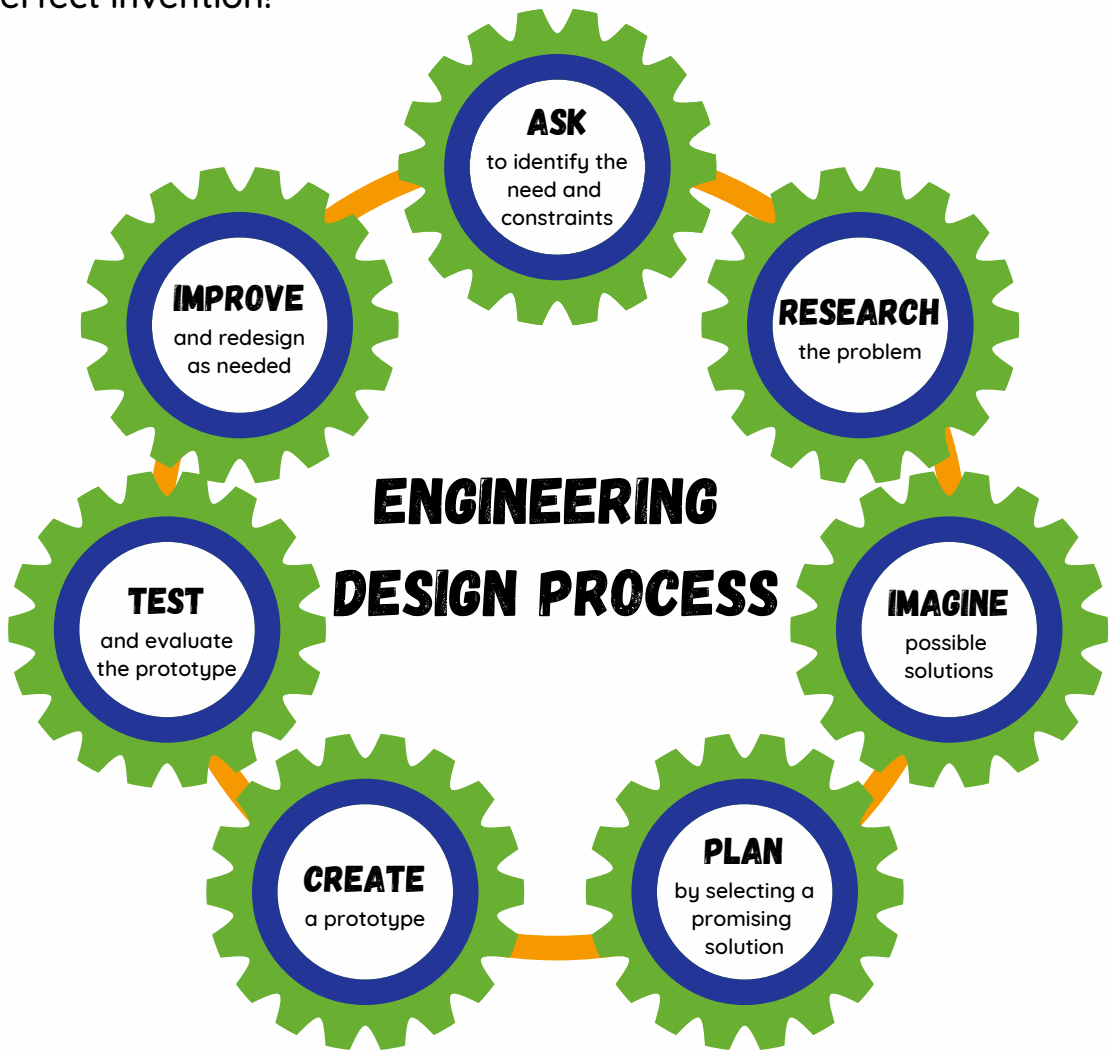
- STEAM
- inventor
- author
- entrepreneur
- curiosity
- biomedical
- engineer
- patent
- healthcare
- sustainability
- supercomputers
- Abby Invents
- artificial
- intelligence
- medical imaging
- trailblazer
- creativity
- book series
- technology
- laboratory

Please note: some words are found when spelled backwards!

CREATE YOUR OWN INVENTION!

Inventors are problem solvers. They notice something about the world that could work better - if only we had the right tool.
The first question to ask yourself as an inventor is: What need is not being met? Who experiences this problem, and in what setting?

Next, comes research. Has someone else already invented this solution? If so, their design may have a patent. A **patent** is a legal document that records how an invention works, what makes it original, when it was first invented, and who owns the rights to it. Does a tool to solve the problem already exist? Maybe it needs improvements. Many inventions are actually created as improvements to an existing item - like inventing a smaller, faster computer. Once you are sure a need exists, you can use the **engineering design process** to guide you on your journey to the perfect invention!



The most important thing about being an inventor is to never give up! Learning from mistakes is how the best inventions are created.

PLANNING MY NEW INVENTION

- What problem do I want to solve? Who will my invention help?

- Can I improve something that already exists in order to solve this problem? What existing things can inspire my new invention?

- What is unique about my invention? How will it be used?

- What materials do I need? How much do they cost?

- Describe your invention. Consider the size, weight, shape, color, smell, movements, and sounds it makes.

- How does my invention work? Use the next page to brainstorm!

MY GREAT INVENTION:

Name of my invention: _____

Use this page to sketch and then label the parts of your invention.
Try showing how it looks when someone uses it.

MEET GRACIE ERMI, A RESEARCH SOFTWARE ENGINEER

Gracie is a research software engineer in Seattle, Washington, who writes code to aid wildlife conservation. She holds both a B.S. and an M.S. in computer science from Western Washington University. Every day Gracie gets to write code that makes it easier for wildlife experts to do their job.

Gracie works at Vulcan Inc., where she builds machine learning technology - training computers to do the most tedious aspects of conservation work so that experts can focus on more critical tasks. Her work focuses specifically on saving endangered animals and preserving ocean health. A super exciting project she has been working on recently is helping to protect endangered killer whales.

SeaLife Response, Rehabilitation, and Research (SR3) is an organization that researches sea-life and then uses that research to aid and advocate for those animals. Gracie and her team are the ones building new technology to try to make SR3's work easier for them. Specifically, they are working on technology that can assist SR3's scientists as they use drone images to do health check-ups on killer whales without disturbing the animals at all. This new technology will automatically do some parts of the health check-up, like identifying individual whales in the images, and will allow scientists to more quickly learn information about the whales to then share with governments to make better laws to protect these amazing animals.

CLICK TO WATCH OUR INTERVIEW WITH GRACIE

Anyone can be a software engineer! If you are interested in solving big problems, not only is software engineering a fun and attainable job, it can also help save the world!
- Gracie Ermi

A DAY IN THE LIFE OF GRACIE ERMI

Gracie is a research software engineer and is part of a team who creates technology and software to aid in wildlife conservation!

Can you find some of the terms she uses everyday?

S R Y X E L O S R G H H K Y G E

L M S R H N O R N C T K G E N C

R U E K E F G I C L H O Q F I N

K E W T T G D I A A L B V I V E

I Q S W S O A E N O S G O L R I

L B A E C Y H M N E U C G A E C

L R E B A L S H I J E Z B E S S

E S Z O A R C G K A U R S S E R

R T Q M O E C Z N D R O I D R E

W O I V T Q H H I I M U N N P T

H N C O N S E R V A T I O N G U

A V U L C A N I N C O A C I H P

L E F I L D L I W P K I R M S M

E P L T N G L G E D G K H E N O

G N H G N I M M A R G O R P P C

H W B B J D P V M T U G J A R O

- Animal Health
- Coding
- Computer Science
- Conservation
- Droid
- Engineering
- Imagery
- Killer Whale
- Ocean Health
- Operating Systems
- Orcas
- PNW
- Preserving
- Programming
- Research
- Sea Life
- Software
- Technology
- Vulcan Inc
- Wildlife

Please note: some words are found when spelled backwards!

ENCODING LANGUAGE

Coding, sometimes called computer programming, is how we communicate with computers. Code tells a computer what actions to take, and writing code is like creating a set of instructions. By learning to write code, you can tell computers what to do or how to behave in a much faster way. Computers don't speak our language, but we can convert information into a simple alphabet every computer can read: **binary**.

Binary is a way to represent information using only two options. A computer uses the options "off" and "on" as wires send it information in the form of electricity. Information can also be stored in binary - DVDs store information as either reflective or non-reflective. How can we convert real-life things that we want to store in a computer into binary?

Let's start with letters in the alphabet. Explore the **American Standard Code for Information Interchange**, or ASCII, to see how the English alphabet is encoded into a series of eight boxes with two options: colored in or not colored in.

ASCII ALPHABET ENCODER

A	■□■■	■■■□	N	■□■■	□□□■
B	■□■■	■■□■	O	■□■■	□□□□
C	■□■■	■■□□	P	■□■□	■■■■
D	■□■■	■□■■	Q	■□■□	■■■□
E	■□■■	■□■□	R	■□■□	■■□■
F	■□■■	■□□■	S	■□■□	■■□□
G	■□■■	■□□□	T	■□■□	■□■■
H	■□■■	□■■■	U	■□■□	■□■□
I	■□■■	□■■□	V	■□■□	■□□■
J	■□■■	□■□■	W	■□■□	■□□□
K	■□■■	□■□□	X	■□■□	□■■■
L	■□■■	□□■■	Y	■□■□	□■■□
M	■□■■	□□■□	Z	■□■□	□■□■

YOUR NAME IN BINARY

Create a necklace or keychain that spells your name in binary.

Materials:

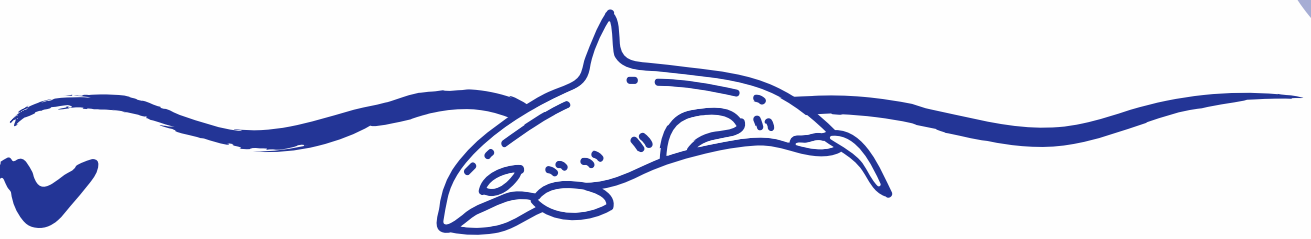
- String
- Pony beads (two different colors)
- Pencil
- ASCII Alphabet Encoder

1. Find the letters of your name on the Alphabet Encoder and copy the 8 digit binary code for each letter into the boxes below. Use a pencil to color in the squares.
2. Tie a knot on one end of your string.
3. Choose two colors of beads, and assign one color of bead to the filled in squares and the other color to the blank squares.
4. String beads in order of the code, one letter at a time, until you spell your name.
5. Tie the other end of your string so the beads cannot fall off.
6. Enjoy your name in binary as a necklace or keychain.

LETTER:	BINARY CODE:
_____	
_____	
_____	
_____	
_____	
_____	
_____	
_____	
_____	
_____	
_____	

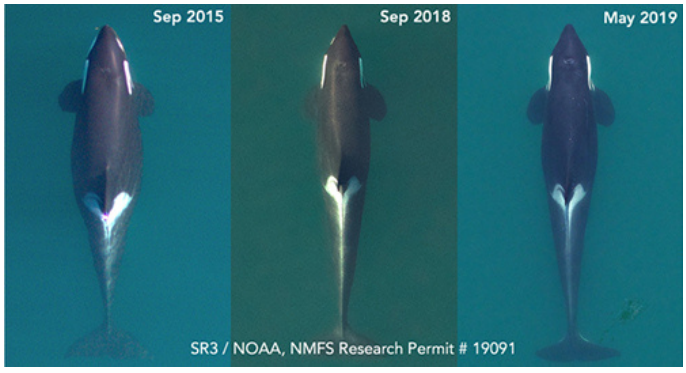
This activity is adapted from the code.org "Binary Bracelets" lesson

RESEARCHING WHALE HEALTH



Researchers at SeaLife Response, Rehabilitation, and Research (SR3) have been collecting aerial images of orcas, or killer whales, over the past twelve years, shifting from **manned aircraft** (e.g. helicopters) to **unmanned aerial vehicles** (UAVs), or drones in 2014. After the aerial images are collected, they are analyzed by scientists to identify individual whales from unique saddle patches on their backs. This allows the scientists to link measurements to whales of known age and gender. Then, using these aerial images, researchers can estimate the size and monitor growth and body condition of each whale, without disturbing them, to track their health over time.

Performing this analysis manually, while valuable and accurate, is also very time intensive. It can take up to several months for annual updates, which makes it difficult to quickly take action for killer whales who need it the most. In order to help streamline this process, Vulcan Inc. is working on developing **machine learning**, the study of finding patterns in data, to automate some of the labor-intensive work of processing these images. The goal of this work is to help scientists at SR3 work even faster as they take action to improve killer whale health.



Just how each of us has a unique thumbprint, Orcas have a unique **saddle patch**. This white marking on their back helps scientists identify each whale. Thanks to technology, we are able to track the whale's health, as shown in these photos of the same whale spanning four years.

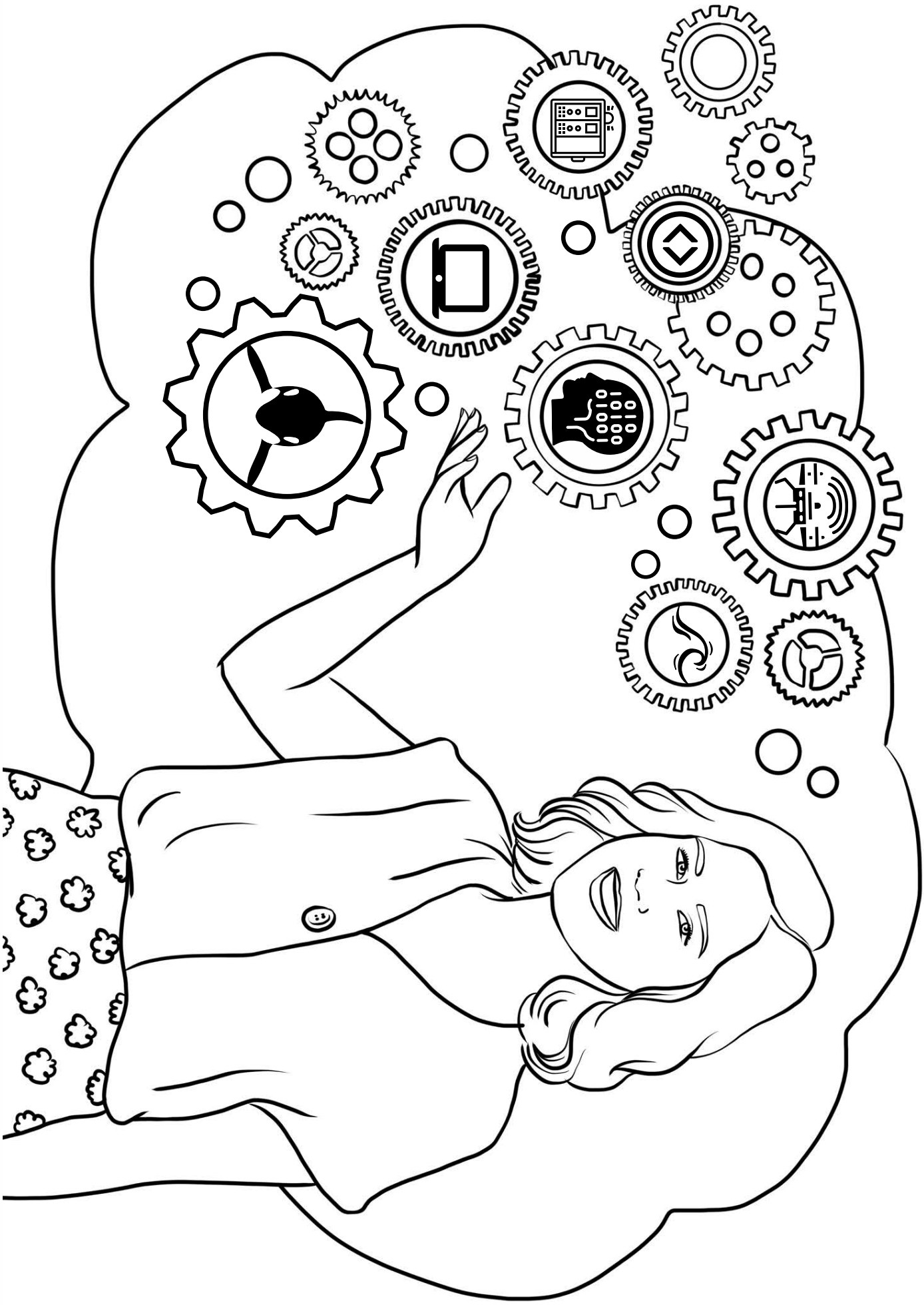
Want to learn more? Visit these Links!

[Video] How Can Coding Save Orca Whales?: youtu.be/jIuE0x4hK88

[BLOG] Learn more about Vulcan Engineering: engineering.vulcan.com/blog

Learn more about how SR3 helps Sea Life and how you can help: www.sealifer3.org

Information adapted from Vulcan Inc. and SR3 publications.



MEET DANA BOLLES, A SPACE SCIENCE COMMUNICATOR

Dana began working for a space agency in 1995. The first 13 years of her career were as an engineer in **regulatory compliance**, which means she ensured her agency followed state, federal, and local laws and regulations before being allowed to launch. She worked in payload safety, fire protection, and environmental protection. Dana was also the Lead for the logistics team, providing services to payload teams sending experiments to the International Space Station. Dana has worked at three installations of her space agency on both the east and west coast.

Her most recent opportunity is communicating about the exploration of life beyond Earth. Dana's diverse work experience has given her a great appreciation not only for the programs/projects side of her agency but also for the mission support functions. She is responsible for web resources to help others learn about the search for life and she also leads a team of web developers and editors that maintain the space agency's website for the public.

Having been born with no legs, Dana rides an electric wheelchair to be independent. During her education, Dana focused on studying engineering. She thought, "if I can't find useful equipment to help me with activities, I can design it as an engineer." Dana went on to get a Bachelor of Science degree in Mechanical Engineering.

CLICK TO WATCH OUR INTERVIEW WITH DANA

> **There were many times along my path when having that dream job seemed unreachable, but with hard work and determination, I achieved my goal... to work for a space agency.**
> **-Dana Bolles**

A DAY IN THE LIFE OF DANA BOLLES

Dana has worked in various areas and programs at her space agency, from engineering in regulatory compliance, to strategic communications. Can you find terms she has used throughout her career?

C Y T E F A S L Q M N A Q T N J

O Y H W Z I W F D Q O U A O B G

M S K T M H K B Z U I S I S C L

M W E A T H E R P A T T E R N S

U M I C R O B E S R A R E E S E

N R P K U B D M O C R M R T P A

I E S M N P I B U S O R E R A R

C V F L K S I D E T L E T A C C

A O U K S O E T E T P S N U E H

T R Y I L L I S C S X E E Q S F

I Y O O A L E H R E E A C D T O

O N G B E N I A T A E R E A A R

N Y O T S X M S K R C C C E T L

G L A I N A S A S K A H A H I I

G S N D X M Z C I Q P E P M O F

N G E T M A R S I K S Y S U N E

- Astrobiology
- Communication
- Earth
- Global Education
- Headquarters
- ISS
- Mars
- Microbes
- Mission
- Remote Sensing
- Research
- Rover
- Safety
- Satellites
- Search For Life
- Space Station
- Space Center
- Space Exploration
- Weather Patterns

Please note: some words are found when spelled backwards!

THE SEARCH FOR LIFE

Recently, Dana has been helping her agency best communicate efforts in the Search for Life. Many missions are exploring the habitability of other worlds in our solar system and around other stars. Each mission has research teams made up of engineers and scientists with diverse interests and expertise, including computer engineers, mechanical engineers, aerospace engineers, biologists, astrophysicists, atmospheric scientists, and planetary scientists.

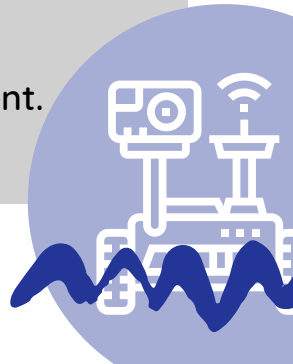
We don't yet have scientific evidence for life in other parts of the universe, but there are some exciting possibilities in the Milky Way galaxy— and even our own solar system! Astronomers have found many potentially habitable planets in the Milky Way using NASA's Kepler telescope. These "Goldilocks" planets are just the right distance from the stars they orbit—not too close and not too far—to allow liquid water to exist on their surfaces, a critical ingredient for life as we know it.

Astrobiology is the study of the origin, evolution, distribution, and future of life in the universe. Astrobiologists use our knowledge about plants, animals, and other living things on Earth to make predictions about what life might be like elsewhere in the universe. They also investigate extreme environments on Earth to develop predictions about where else in the universe we might find life, and what forms it could take. This information gives them clues about where and how to search for life beyond Earth.

On the next page, you can explore some of the adaptations living organisms on our planet have used to survive in extreme environments - places where humans cannot live! Then you can design your own world with an extreme environment, along with an alien life form adapted to survive there.

Imagine a planet or moon with an environment too harsh for people. Is it too hot? Too cold? Too acidic? Color in your landscape and make it look like the environment you imagine.

Now draw a life form that could survive in your imaginary environment. It can be one you see on the example organisms or one you invent!



EXTREME ADAPTATIONS

These organisms live in extreme environments on Earth where humans cannot survive. Could alien life look something like this?

SNOTTITES

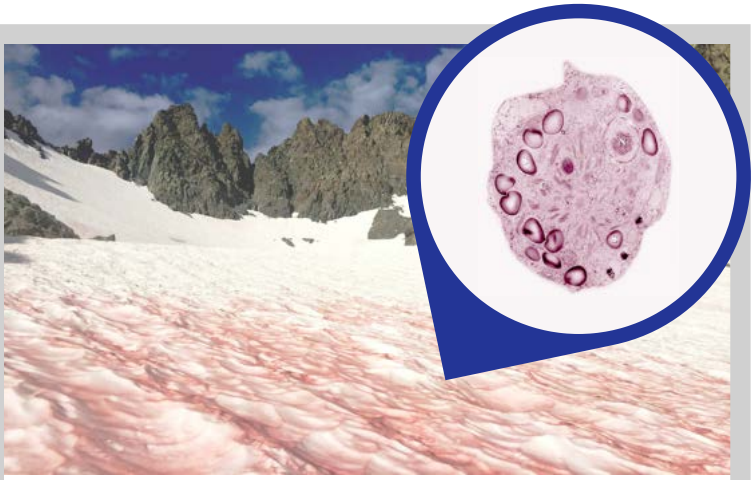
These microbe colonies flourish in very acidic environments. Snottites are single-celled bacteria that live in colonies in dark, wet caves. “Snotties” look like small stalactites but have the consistency of mucus. They get their energy through chemosynthesis of volcanic sulfur, and their waste is highly acidic. Some planets, such as Venus, have toxic clouds and atmospheres. They may be the perfect place to look for life forms that love acidic environments!

RUSHING FIREBERRY

The hotter the better for this organism! The rushing fireberry can survive the burning temperatures of deep-sea volcanoes. It grows best at 100 degrees Celsius, and when conditions are good, it quickly reproduces and increases its population. Some potentially habitable planets in other solar systems (exoplanets) might be closer to their sun than Earth is to ours, so scientists want to learn more about how organisms can survive in extremely hot places.

TARDIGRADE

This eight-legged micro-animal is one of the most durable life forms on Earth. Tardigrades can endure freezing temperatures, high pressure, and very dry air, sometimes by entering a state of suspended animation. As a research experiment, tardigrades were exposed to the radiation and vacuum of space for ten days—and they survived! NASA researchers are studying tardigrades to understand what alien forms of life might be like.



SNOW ALGAE "WATERMELON SNOW"

For many years people thought the reddish color on high alpine snowfields was caused by a mineral, but researchers have discovered that it’s actually huge colonies of algae. Snow algae grow in the freezing water created by melting snow. The algae look and even smell a little like watermelon! Scientists are trying to determine if Jupiter’s icy moon Europa might have the right mix of conditions to harbor forms of life that tolerate cold.

IMAGINE LIFE BEYOND EARTH

Imagine an alien life form that lives on a far-off world.
Where does your alien live? Is it hot or cold, dry or wet?
How is your alien especially well suited to its environment?

When you imagine life on another planet, you're doing a little bit of science! Researchers use our knowledge about life on Earth to make predictions about what a habitable extraterrestrial planet might be like, and what kind of life could survive there.

THE UNIVERSE

MEET DR. YAMINA PRESSLER, A SOIL ECOLOGIST

Dr. Yamina Pressler is a soil scientist, writer, educator, speaker, and artist on a mission to make soil a household name. It wasn't until she took a soil science class that she learned that soils are full of life, wonder, and complexity - not just the brown stuff outside that makes plants grow.

Her research lies at the intersection of **soil biology** (the study of microbial and faunal activity and ecology in soil), **disturbance ecology** (a temporary change in environmental conditions that causes a pronounced change in an ecosystem), and **biogeochemistry** (study of biological, geological and chemical processes in the natural environment) where she explores the role of soil fauna in ecosystem scale processes in response to global change. Her current research focuses on how fire, drought, and management affect soil food webs, organic matter, and carbon cycling. She also studies the mechanisms by which soil fauna and trophic interactions influence soil organic matter formation.

Dr. Pressler shares her enthusiasm for soil science and ecology with her undergraduate students at Cal Poly, San Luis Obispo. She holds a B.S. in Environmental Management and Protection from Cal Poly, and a Ph.D. in Ecology from Colorado State University.

> **Everything I do celebrates soils in an effort to increase our connection to them. If we want to stop treating soils like dirt, we first need to develop the eyes to see them.**
> **- Dr. Yamina Pressler**

CLICK TO WATCH OUR INTERVIEW WITH YAMINA

A DAY IN THE LIFE OF DR. YAMINA PRESSLER

Yamina is a soil ecologist that is passionate about sharing the value of soil. Can you find terms she uses every day in her practice?

E C S J W U E M E T A Y L S B C

T C H O Y D I G E G G J M O I I

A J F O I N F L R O G S N I O P

M O F D E L G I L K I O L L D O

I I R R R I C O E N Q G K L I C

L W A D P U C H A L X M U A V S

C L W S L E S G E B D A P Y E O

S R S T G A R X R M J T T E R R

A O U W N O M T G P I V E R S C

M R B D O Z T L I S L S Y S I I

E S R R L A B W O R K A T L T M

D E C O M P O S I T I O N R Y S

B I R E T A W D N U O R G T Y C

M S O I L S A M P L E W K I S L

W R R Y B I D M C P L K V W E A

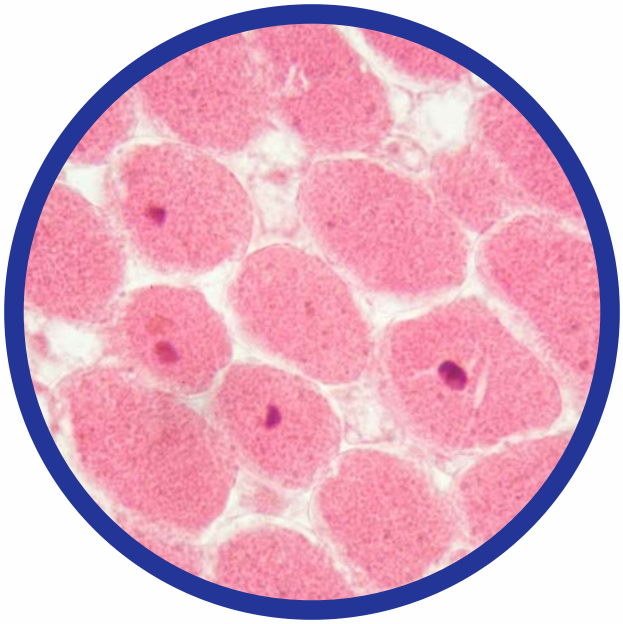
E D O T A M E N S T X Y A G O Y

- agriculture
- biodiversity
- clay
- climate
- decomposition
- ecology
- field test
- groundwater
- lab work
- microorganisms
- microscopic
- minerals
- moss piglet
- nematode
- plants
- sand
- silt
- soil sample
- soil chemistry
- soil layer

Please note: some words are found when spelled backwards!

LIVING SOIL

Billions of organisms can be found in just a teaspoon of healthy soil! Microscopic organisms work together to support the plants we see above the surface. Take a look at some of the organisms found in the soil ecosystem:

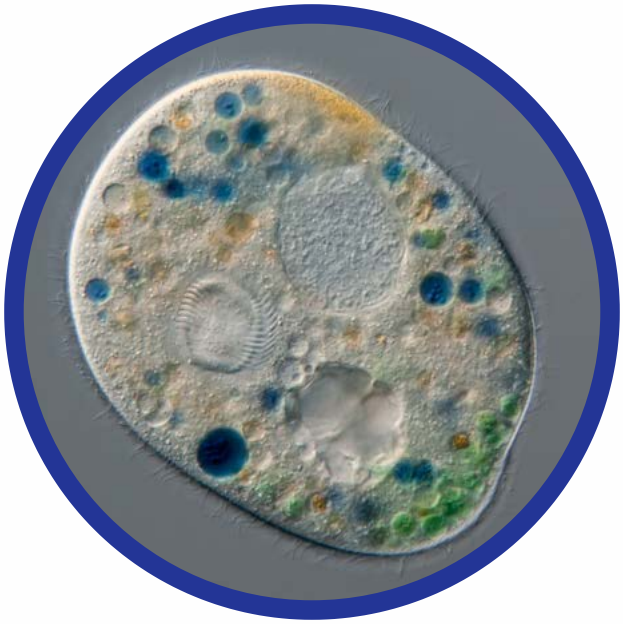


Rhizobacteria

Bacteria that break down organic matter, supply nutrients directly to plant roots, and can even defend roots from disease and drought.

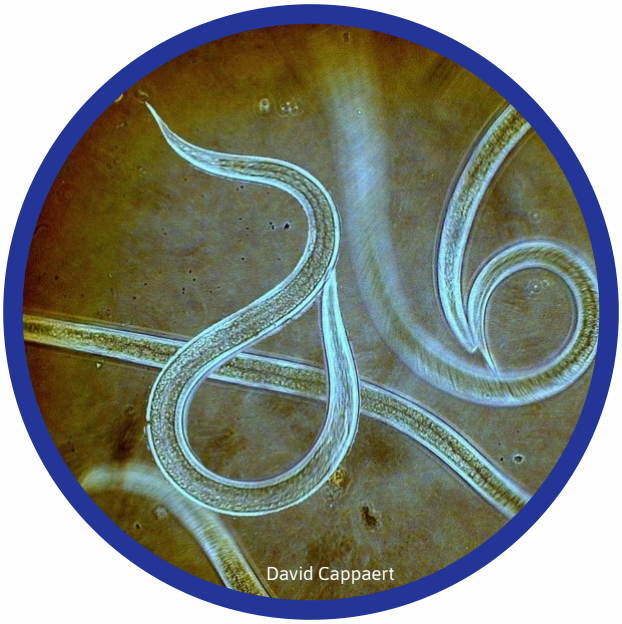
Mycorrhizal Fungi

In return for energy from the plant, these fungi create an absorption and transport system that carries nutrients to the plant's roots.



Protozoa

These microbes consume bacteria, controlling bacterial populations. They provide nutrients & create air pockets & water channels in the soil.



Nematodes

Microscopic predatory worms that live around or inside the plant. They provide nutrients and help control the balance of the soil ecosystem.

COMPOSTING 101

Composting speeds up the natural decay of organic material by providing the ideal conditions for microscopic organisms to thrive. It creates nutrient rich soil that helps plants grow. Try starting your own compost bin or pile with these helpful tips!

While there are plenty of useful options for composting containers, you can also choose to build your own compost pile right on the ground. Start with a base layer of sticks for air flow and water drainage. Then add alternating layers of “brown stuff” and “green stuff” to introduce the right ratio of carbon and nitrogen. The best ratio of carbon to nitrogen is around 25 to 30 parts carbon to 1 part nitrogen, or 25-30:1. Try to use two thirds “brown stuff” and one third “green stuff”. Adding garden soil to your compost introduces helpful microscopic organisms. It’s important to create an ideal environment for these organisms to thrive: warm temperatures, nutrients, moisture, and plenty of oxygen.

"BROWN STUFF"

Brown stuff is high in the element **carbon**. Here are some examples of brown stuff along with their carbon-nitrogen ratio. Some things, like sawdust, are very high in carbon compared to their nitrogen content, while others, like leaves, are not as high.

- **Dried leaves: 60:1**
- **Pine needles: 90:1**
- **Newspaper: 125:1**
- **Sawdust: 625:1**

"GREEN STUFF"

Green stuff contains more of the element **nitrogen** than brown stuff. Examples are fresh, living parts like grass clippings, kitchen vegetable scraps, weeds and other plants. Here are some sources of nitrogen along with their carbon-nitrogen ratio.

- **Food Scraps: 15:1**
- **Grass clippings: 18:1**
- **Coffee grounds: 20:1**
- **Horse manure: 25:1**

MAINTENANCE

Never add meat, dairy, pet waste, or diseased or pesticide treated plants to your compost. Every few weeks, aerate your compost by turning it with a shovel or garden fork. To prevent odors and pests, cover food scraps with a layer of brown stuff right away. Keep the compost moist but not too wet. Over time, dark, healthy soil will form - which you can feed to your plants!


NEXT GEN
STEM