THE ENGINEERING ADVENTURE

ACTIVITY BOOK

VCU College of Engineering

The Engineering Adventure Activity Book
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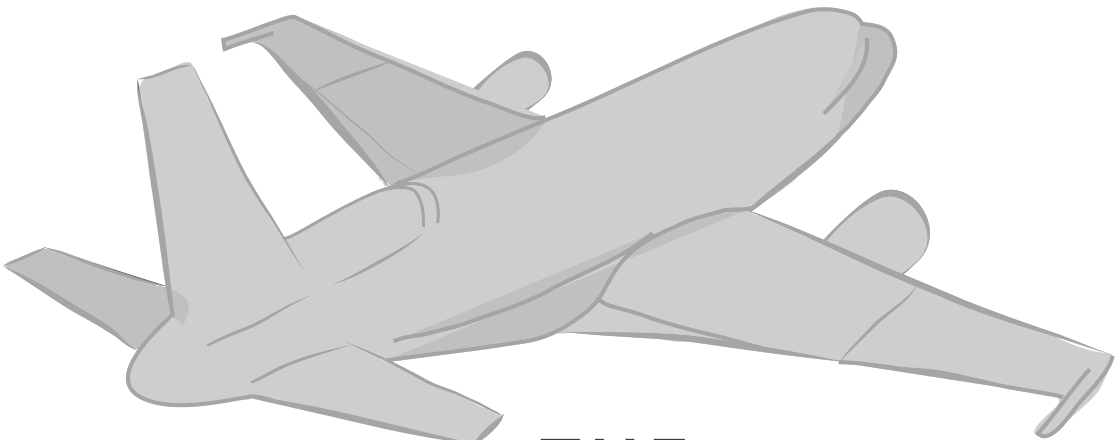


THE ENGINEERING ADVENTURE

ACTIVITY BOOK VERSION 2

Biomedical
Engineering

Chemical and Life Science
Engineering

Computer
Science

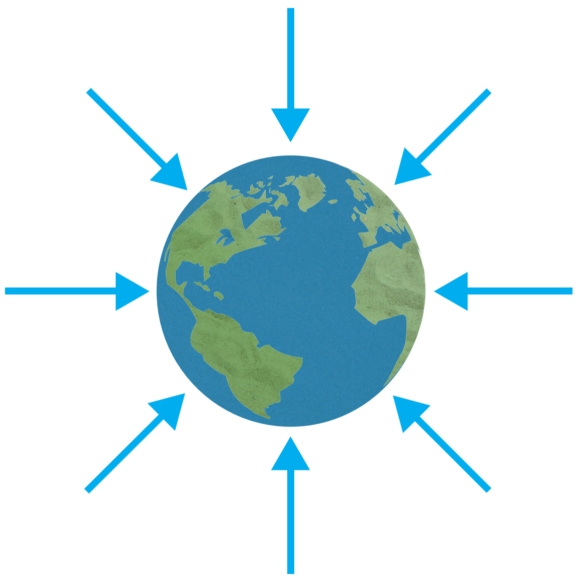
Electrical and Computer
Engineering

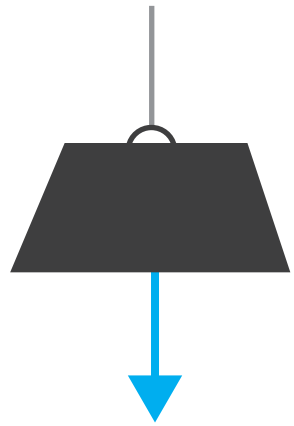
Mechanical and Nuclear
Engineering

Contents

Gravity

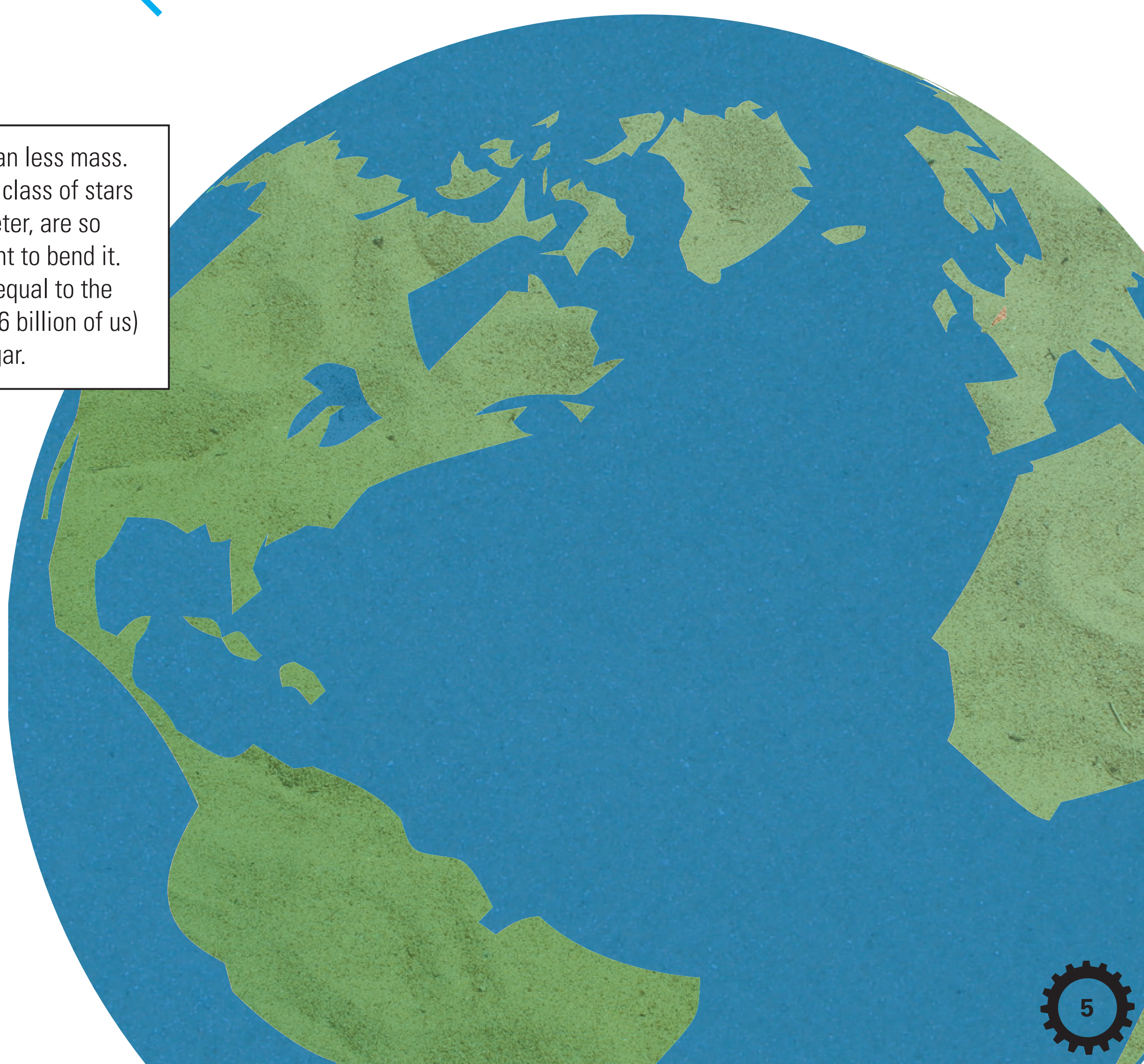
Everything in the universe is pulling on you. Anything made of matter (the stuff that makes up everything) pulls on everything else around it. This is because of one of the four fundamental forces, called gravity. All matter has mass, and the more mass something has the stronger its gravitational pull. While you're pulling on this activity book, its mass is pulling you. Gravity doesn't care how far away something is, just how much matter it has. That's what keeps you from falling off the side of the earth and why the planets revolve around the sun.





Fun Fact

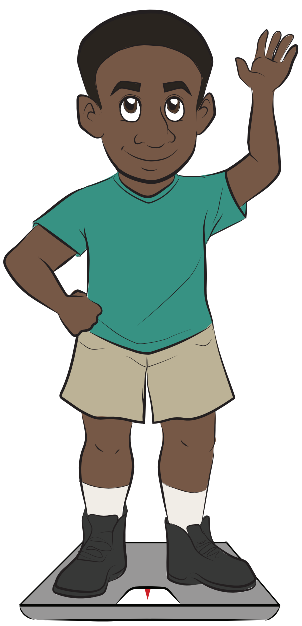
Smaller doesn't always mean less mass. Neutron stars, the smallest class of stars at around 18 miles in diameter, are so dense their gravity pulls light to bend it. One neutron star's mass is equal to the mass of every human (all 7.6 billion of us) squeezed into a cube of sugar.



Weigh In!

Although gravity is constant across the universe, weight isn't. Gravity gives objects weight, and mass gives objects gravity. If someone weighs 100 pounds on the Earth, they'll weigh 16 pounds on the moon and over 230 pounds on Jupiter! It's not the person's mass that has changed, just the amount of gravitational pull.

Let's take DJ for example, who weighs 50 lbs. on Earth. How much will he weigh in outer space, the sun, and Jupiter? Use a calculator if you need to.



	Mass	x Gravity	= Weight
Earth	50 lbs	1	50 lbs
Outer Space	50 lbs	0	
The Sun	50 lbs	28	
Jupiter	50 lbs	2	

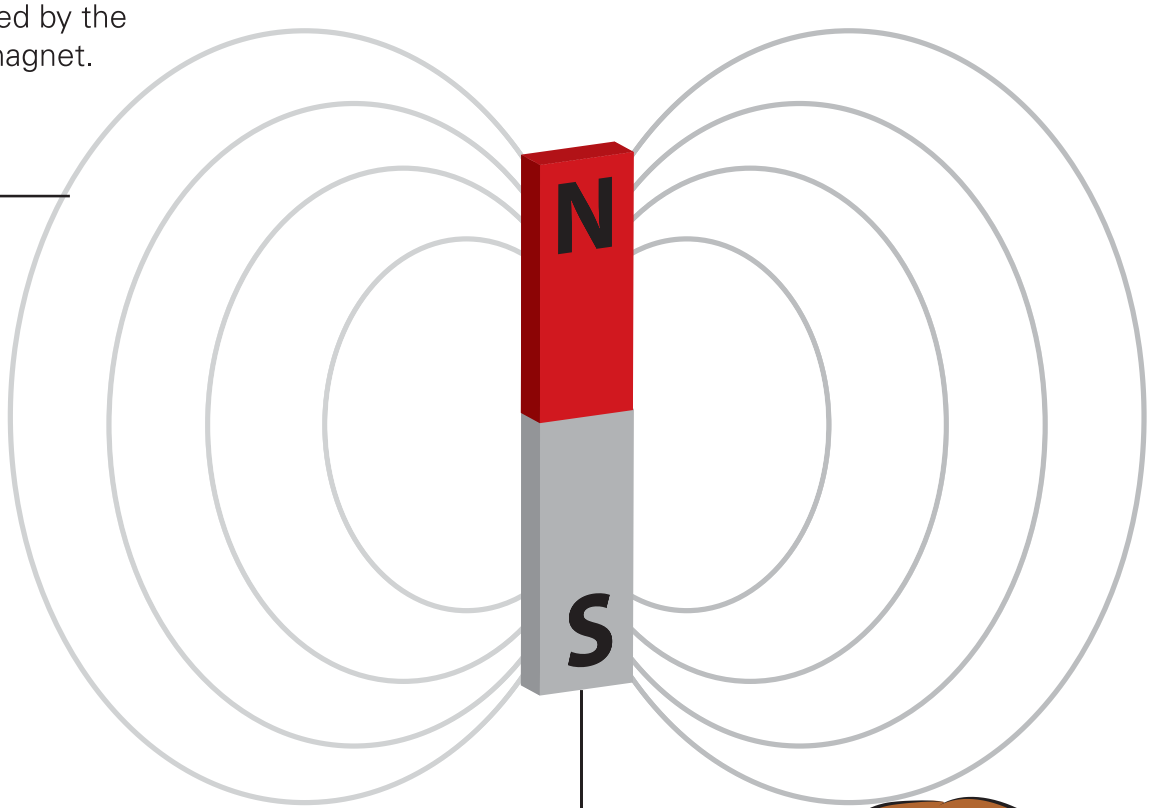
Now you try it.
Weigh yourself on Earth and then calculate your weight on other planets!

	Mass	x Gravity	= Weight
Earth		1	
Outer Space		0	
The Sun		28	
Jupiter		2	

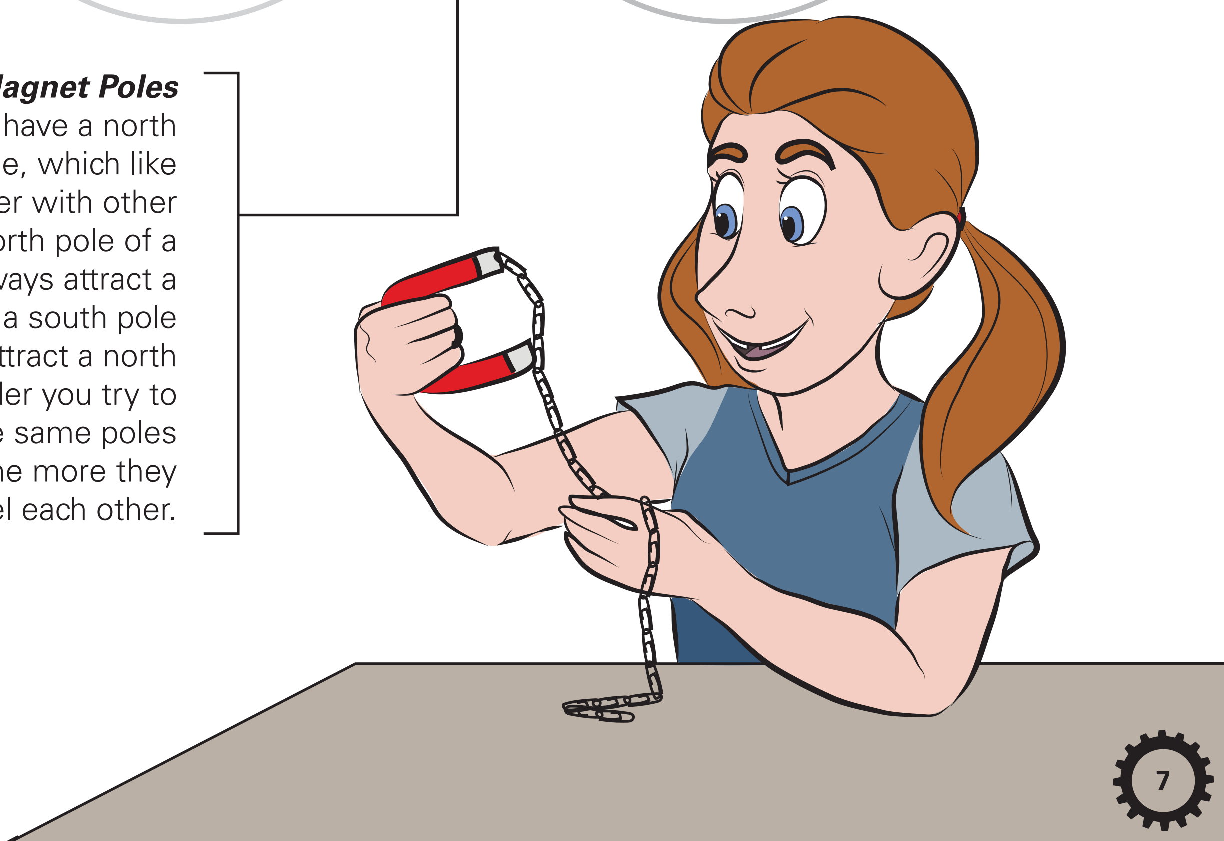
Magnets

Magnets are metals that can be found in nature, or made in a lab. Magnets create an invisible force called a magnetic field, which interacts with other magnets by attracting or repelling them.

Magnetic field lines
These lines show the magnetic field created by the bar magnet.



Magnet Poles
All magnets have a north and south pole, which like to get together with other magnets. The north pole of a magnet will always attract a south pole, and a south pole will always attract a north pole. The harder you try to force two of the same poles together, the more they repel each other.



Magnetic Word Search!

Can you find all 8 words?

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

Magnets Attract Repel North Poles
South Field Compass Force Metal

Cells

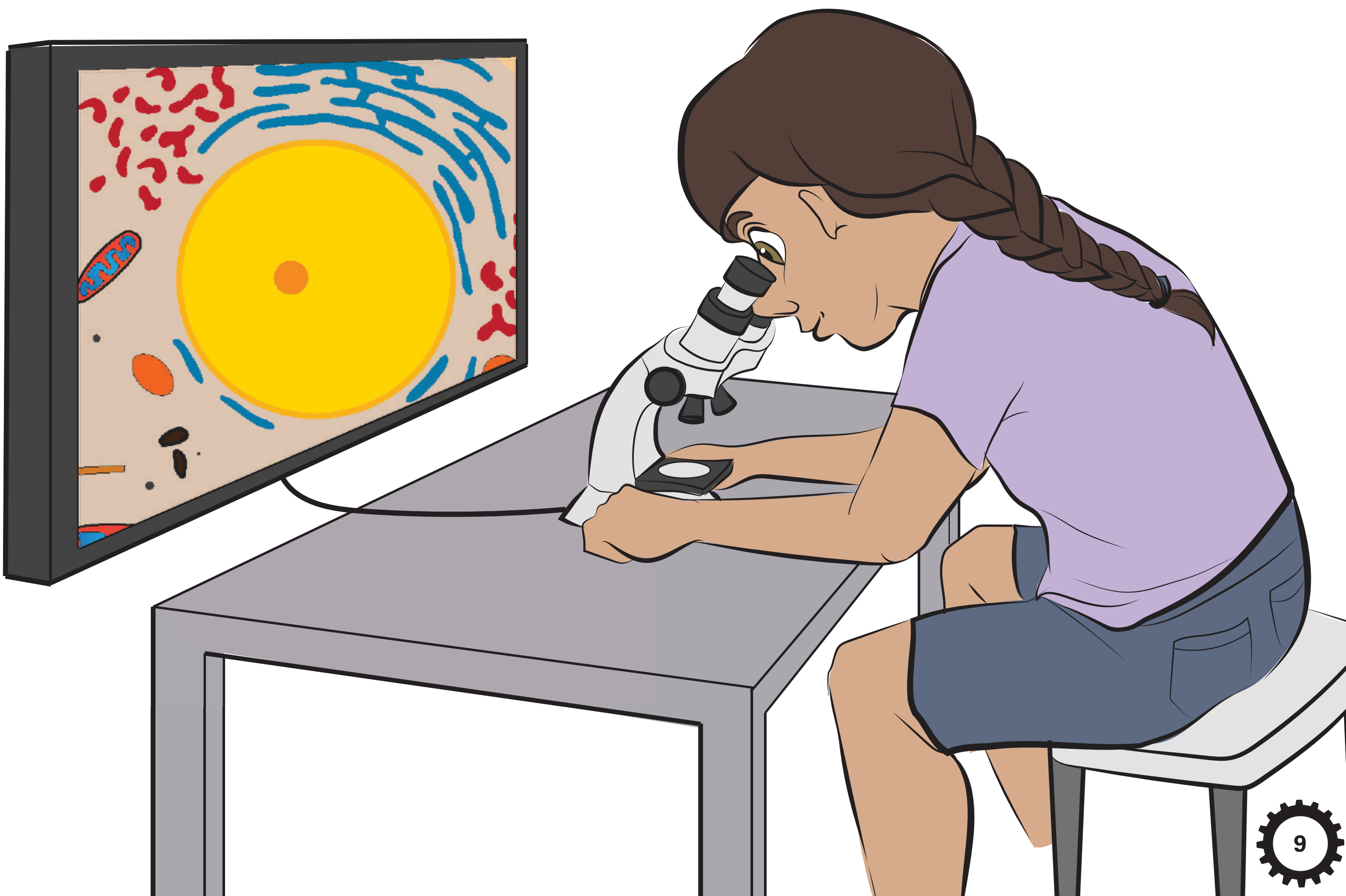
Cells are the smallest form of life we know. One cell can be an entire organism (a living thing) or work with trillions of other cells to keep an organism alive.

Not all cells are the same. Every cell is specialized for its environment or job. Some cells, like E. coli (a nasty bacteria), make us sick. Others, like white blood cells, eat bacteria to keep us healthy! Every living thing is made of cells, from bones and hair to your eyes or skin. Different types of cells make up all the structures that make up you.

Our cells communicate by using a tiny brain called a nucleus. The nucleus is packed with DNA, which holds the instructions for each cell. The cells then "read" the information and work together to complete tasks requiring millions of workers.

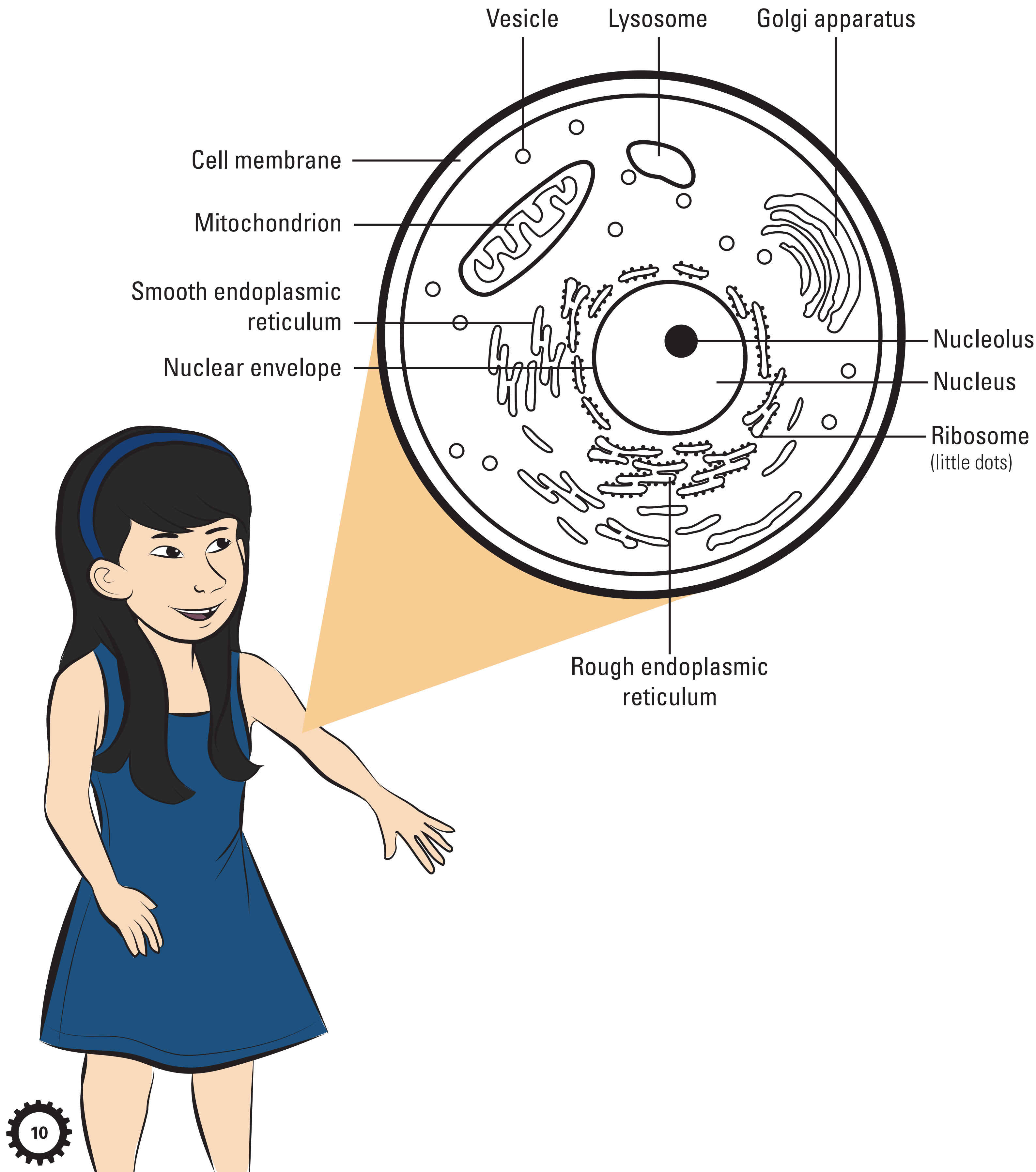
If cells make up everything, what makes up them?

Cells are specialized to fit their job perfectly, but all cells share some characteristics. Each cell has organelles, which are tiny structures similar to our own organs. Organelles float in a liquid called cytoplasm, which protects the organelles and holds cell waste (cells poop, too). Everything in the cell is packaged in the cell membrane, which acts like the cell's skin by letting waste out, allowing food to enter and helping cells communicate with each other.



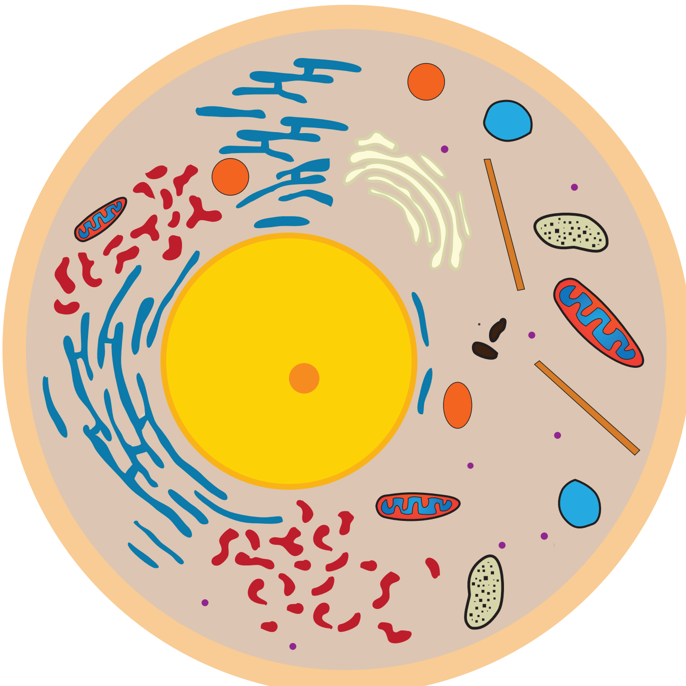
The Human Cell!

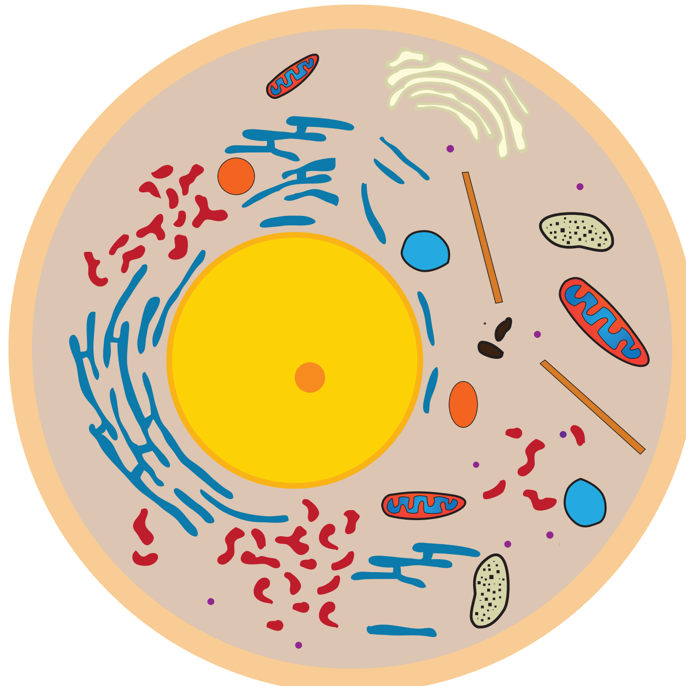
Use your imagination to color the parts of a skin cell.



Spot the Differences!

There are ten differences between the two cells. See if you can spot them all!





Unscramble the following words:

lelc benemmra ______________________________

usnleuoc ______________________________

bsomorie ______________________________

gliog pastuarap ______________________________

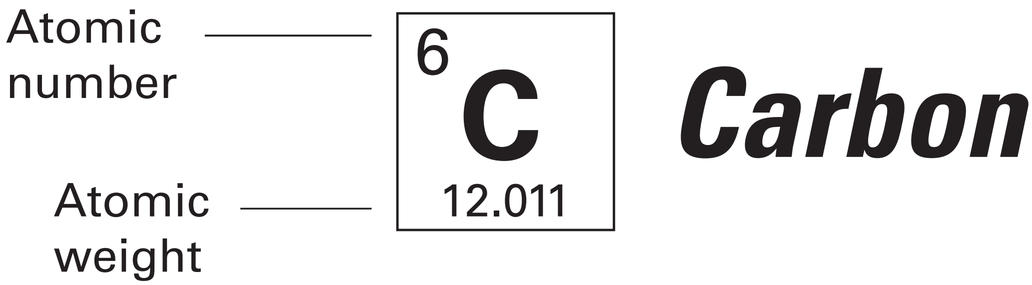
uleacnr vloeenep ______________________________

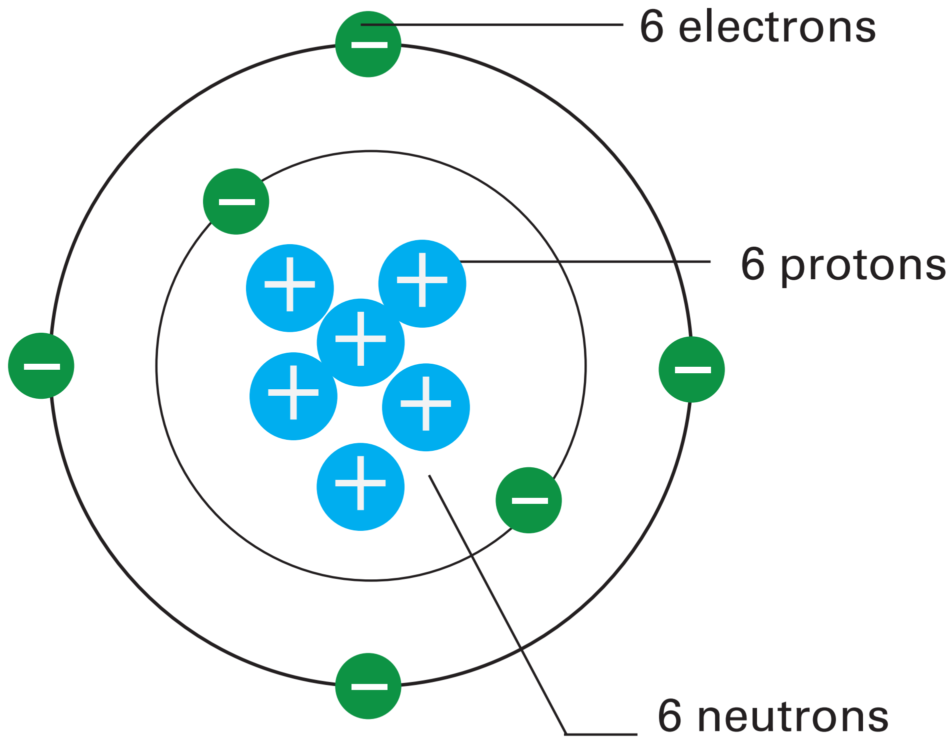
mosolyse ______________________________

noirdnochotim ______________________________

Hint: The human cell diagram on the previous page is the word bank.

Atoms



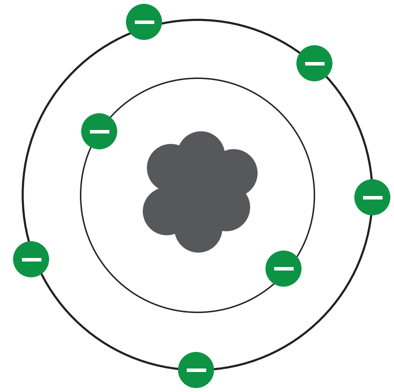


Atoms, or elements, are the building blocks of the universe. Atoms form all matter in the entire universe, from giant stars to the smallest speck of dust. Most atoms (but not all) are made up of three pieces: protons, neurons and electrons. Protons, which are positively charged, and neutrons, which have a neutral charge, have almost the same mass and make up the nucleus, or center, of an atom. Electrons are negatively charged, are a fraction of the mass of their atomic buddies and orbit around the nucleus. Atoms are mostly empty space. In fact, over 99 percent of an atom is empty. If the nucleus of an atom were the size of a kernel of corn, the closest electrons would be one football field away.

Each atom has a positive, negative or neutral charge, depending on how many protons, electrons and neutrons it has. Electrons spin around the nucleus in electron shells, ranging from one to eight electrons in each shell. Atoms like to have their shells filled and will sometimes take, give or share electrons with other atoms, creating reactions and forming all physical matter in the universe.

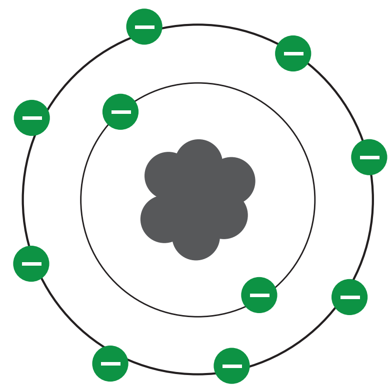
Elemental Matchup!

Draw a line matching the element to its diagram.
The atomic number (top left of box) equals the number of electrons.



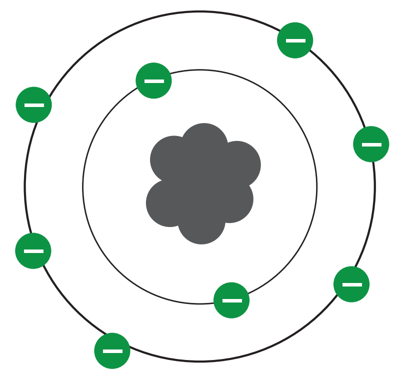
6
C
12.011

Carbon



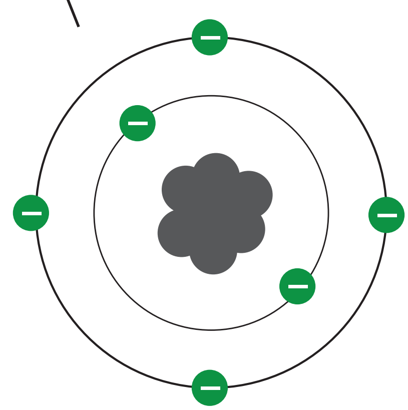
7
N
14.007

Nitrogen



8
O
15.999

Oxygen



10
Ne
20.180

Neon

Computers

Almost everyone uses computers every day, but what is a computer? Computers range from ultra-complex machines to simple calculators. Every time you give a computer an instruction, it translates it into a series of commands, which are then sent to the different parts of the computer.

So, what makes a computer?

Central Processing Unit (CPU) - This acts like the logic center of the computer's brain. Its job is to take instructions and translate them into specific commands, for the other parts of the computer.

Motherboard - This is where most of the computer's parts live. Each part is attached to the motherboard and connected by circuits.

Hard Drive - This is the part of the computer's brain that stores important and permanent information the way your brain stores long-term memory.

Random Access Memory (RAM) - Just like your brain, RAM remembers some information and then forgets it. This is used for information that doesn't need to be stored permanently.

Video Card - Like the part of your brain that takes information and turns it into what you see, the computer's video card reads data and presents it on the computer's monitor so you can see what you're doing.

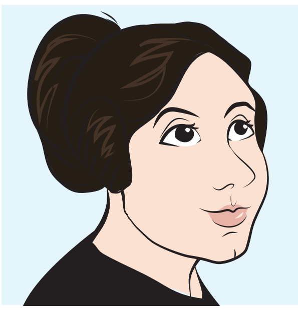
Power Supply - Like your blood brings oxygen to your muscles and cells, a computer's power supply brings electricity to all of its parts.

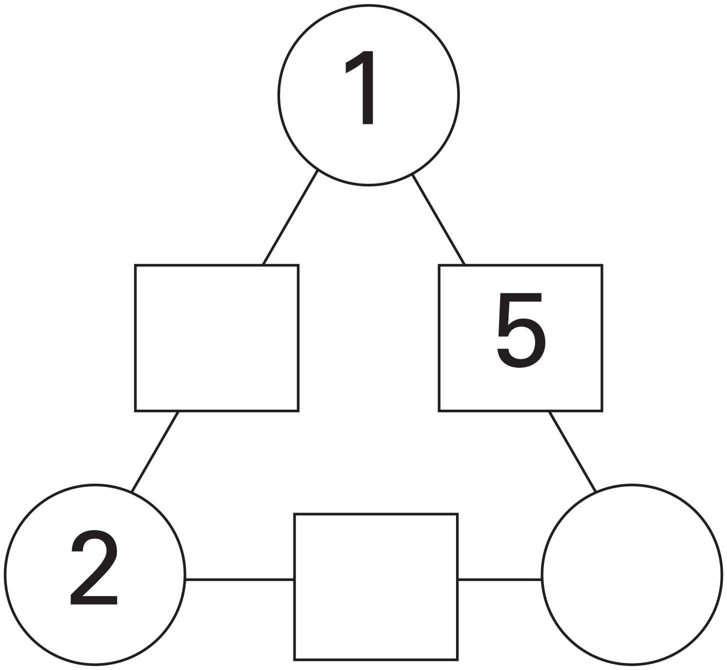
Compute This!

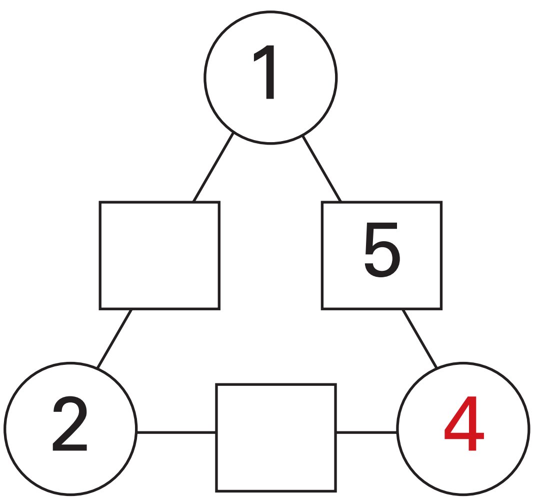
It's time for you to be the computer! The sum of the numbers in the circles produces the number in the squares that connect them.

Fun Fact

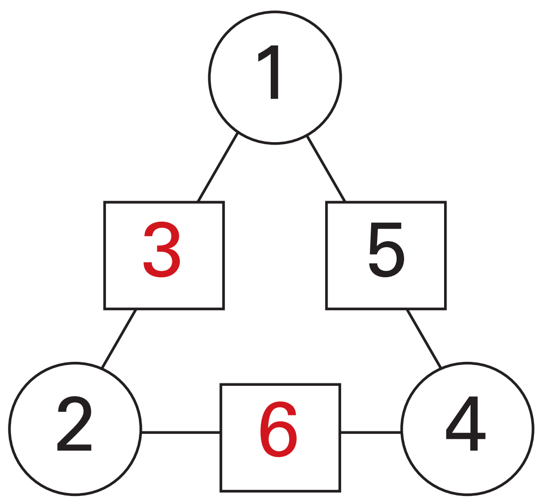
The world's first programmer was Ada Lovelace, daughter of the famous English poet Lord Byron.







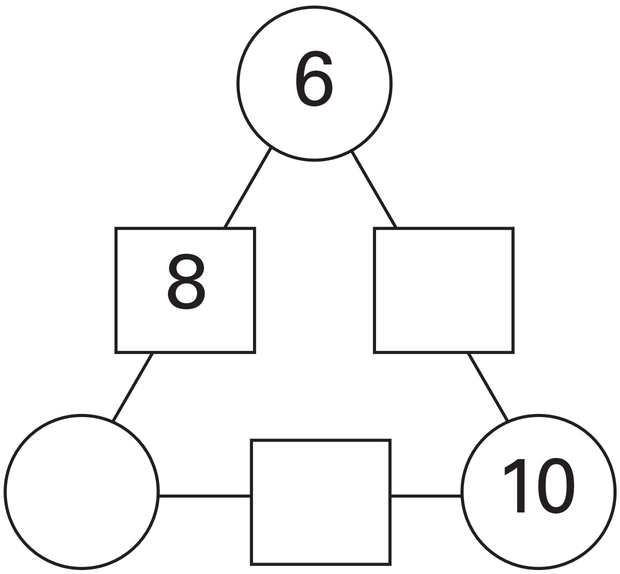
Step 1: Subtract circle from the connecting square to find the missing circle. (5 - 1 = 4)

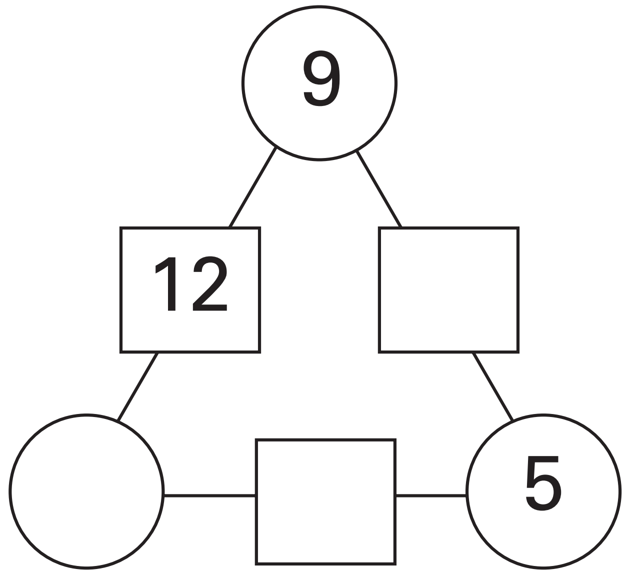


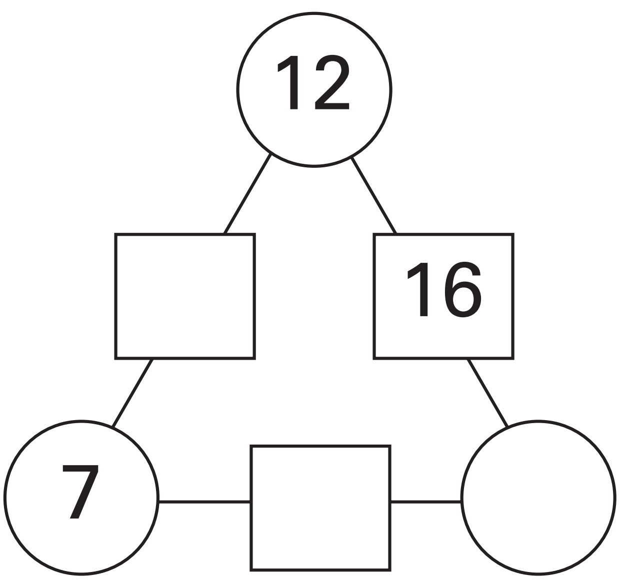
Step 2: Add circles to find the missing squares.

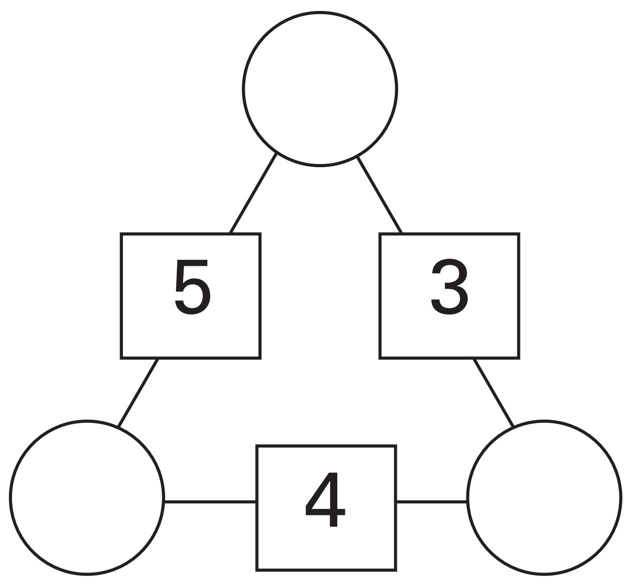
Try it yourself!

See if you can figure out the missing numbers.



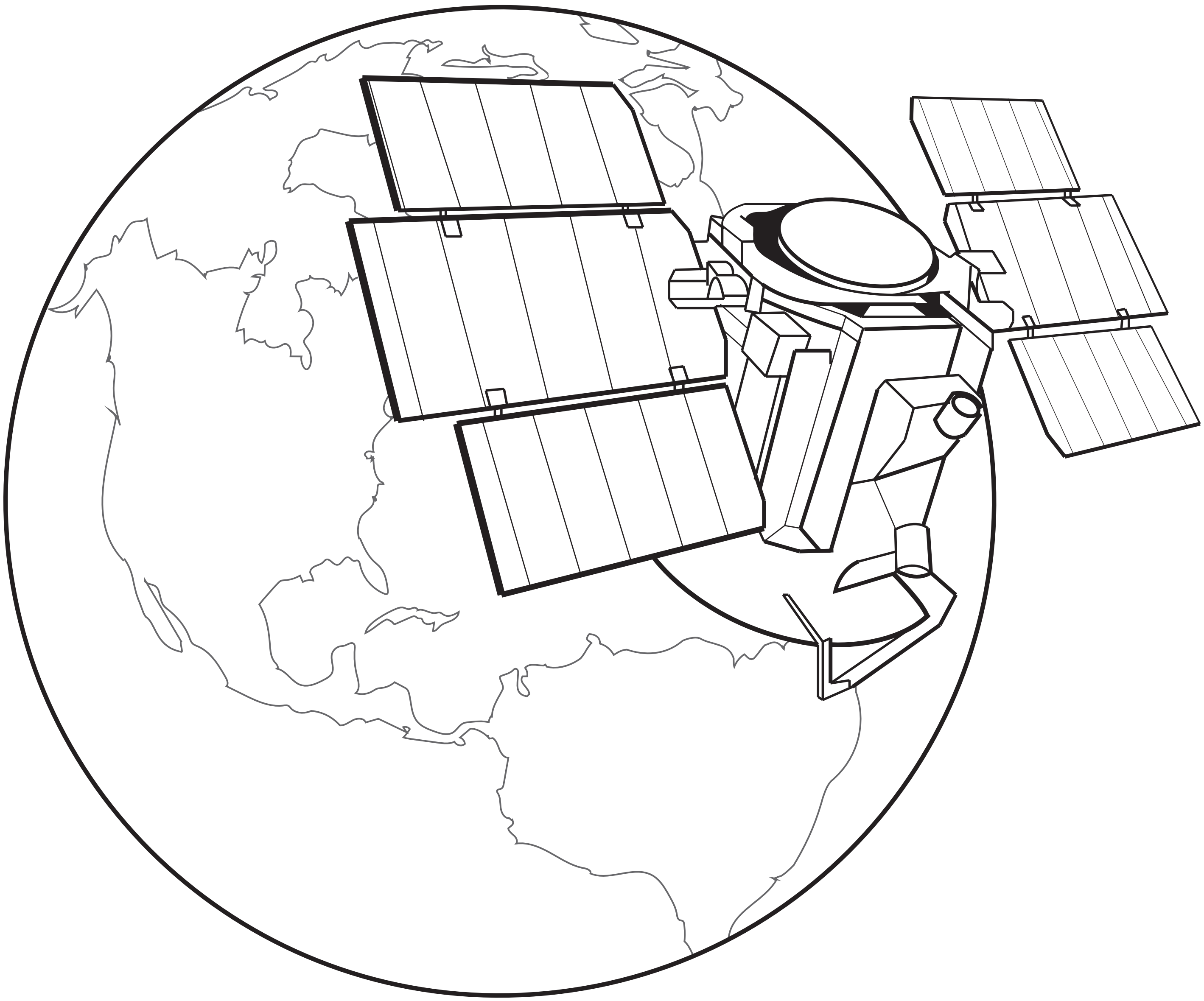






See it in action!

Use your imagination to color in the following illustration.



There is a train in space, orbiting the Earth as you read this. It's called the "A-Train," and it doesn't need tracks, switches, or conductors. In fact, it's made out of five satellites, in a sun-synchronous orbit, 690 kilometers above the Earth.

This space train is called the "A-Train" because it crosses Earth's equator at 1:30 pm. The "A" stands for afternoon— get it? Engineers aren't really known for coming up with creative names— maybe you'll change that!

Each of the satellites orbits just a few minutes behind the previous one, so NASA is able to build high-definition 3D images of Earth's atmosphere, continents and oceans.

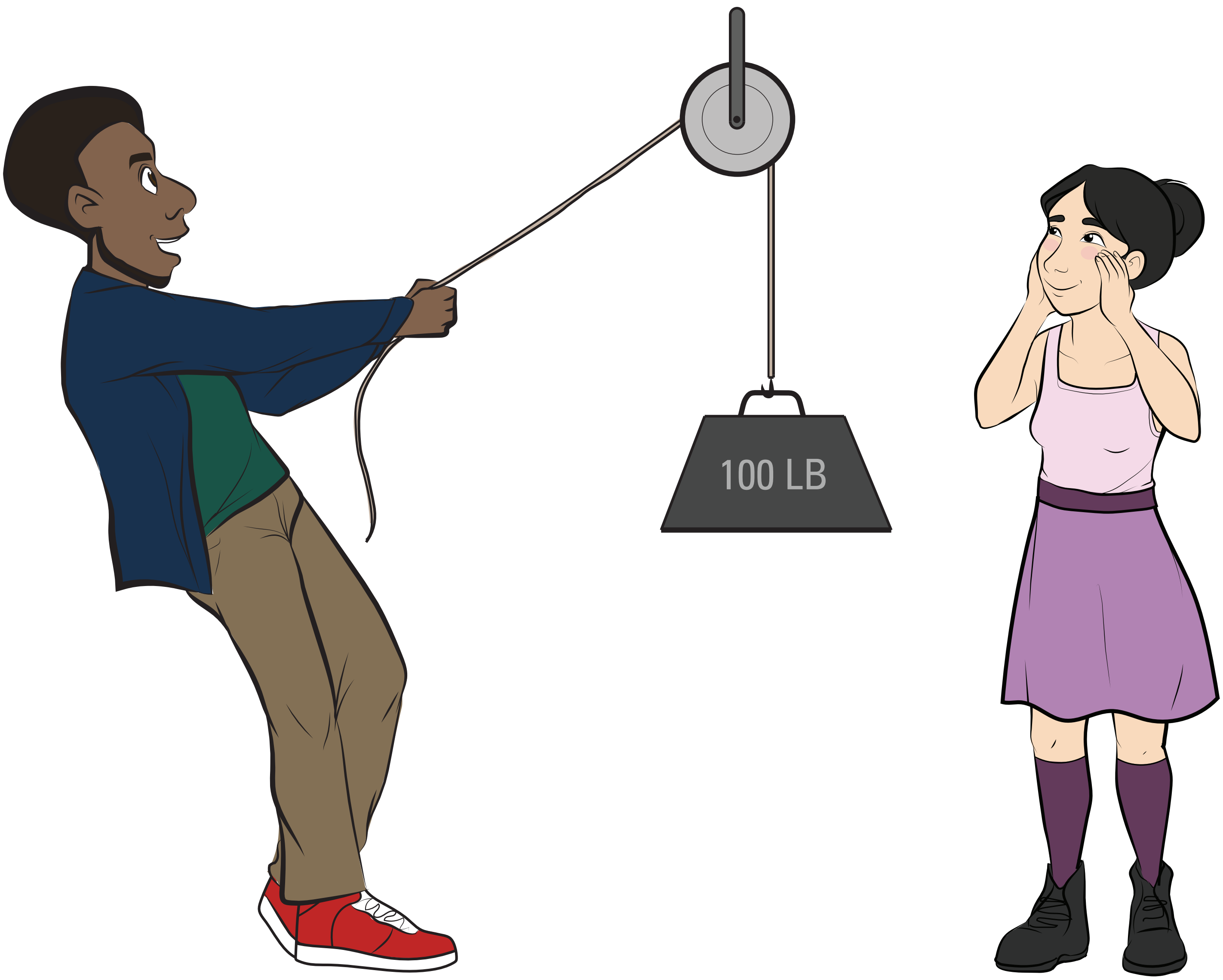
Mechanical Systems

Ever wonder how ancient engineers lifted heavy blocks before machine-powered cranes?
Pulleys and gears.

A pulley is a simple machine with grooved wheels and a rope to raise, lower or move a load.

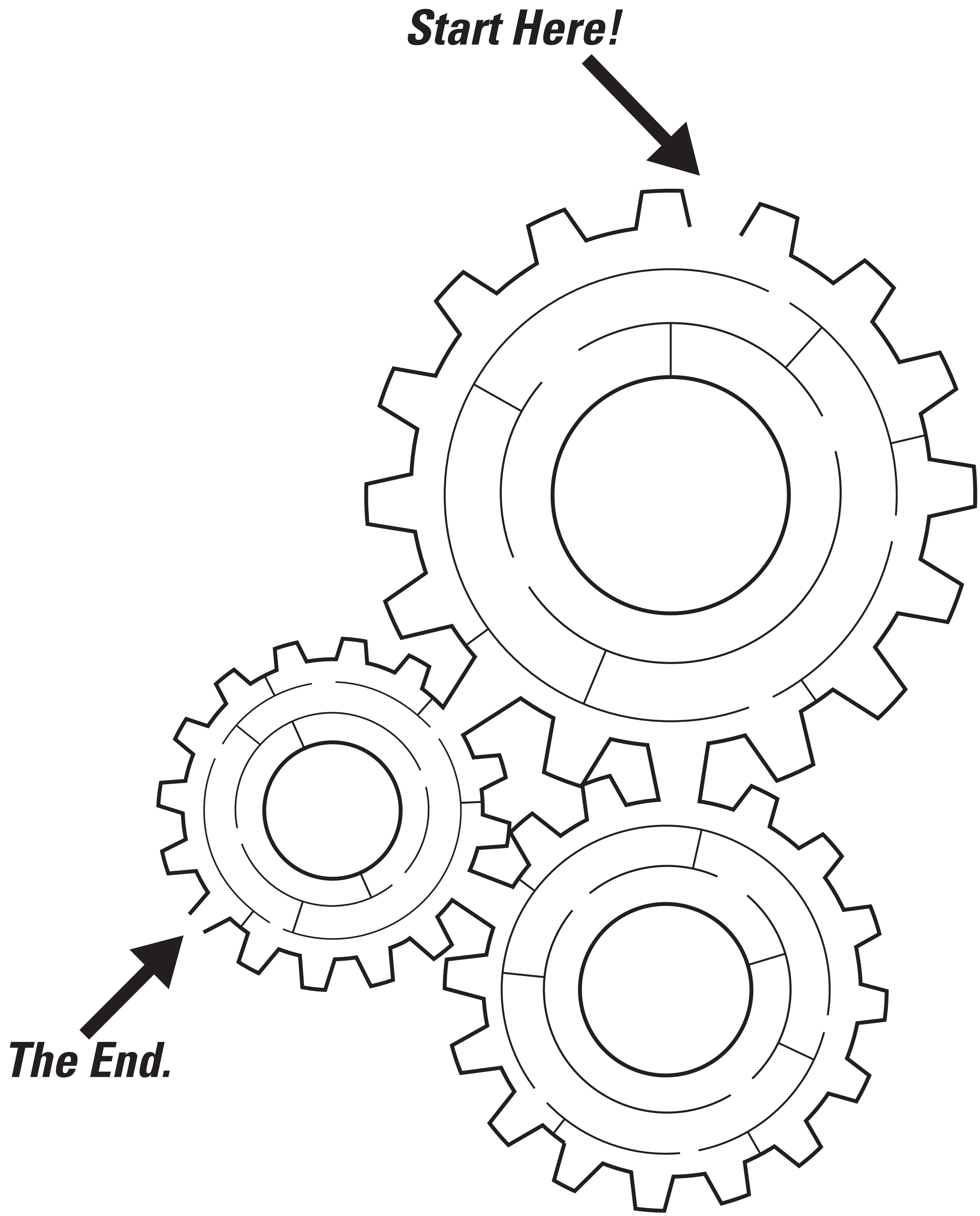
Here's how pulleys work:
Say you have one wheel and one rope with a weight attached, just like in the picture below. If you pull the rope down, the weight lifts up. To lift a 1pound (1lb) weight, you have to pull down with a 1pound (1lb) force. If you want to raise the weight 1 meter (1m) in the air, you have to pull the rope an equal distance of 1 meter (1m).

With just one wheel, a pulley changes the direction of the force. By adding two or four wheels, you can use even less force to move the weight.



Mechanical Maze!

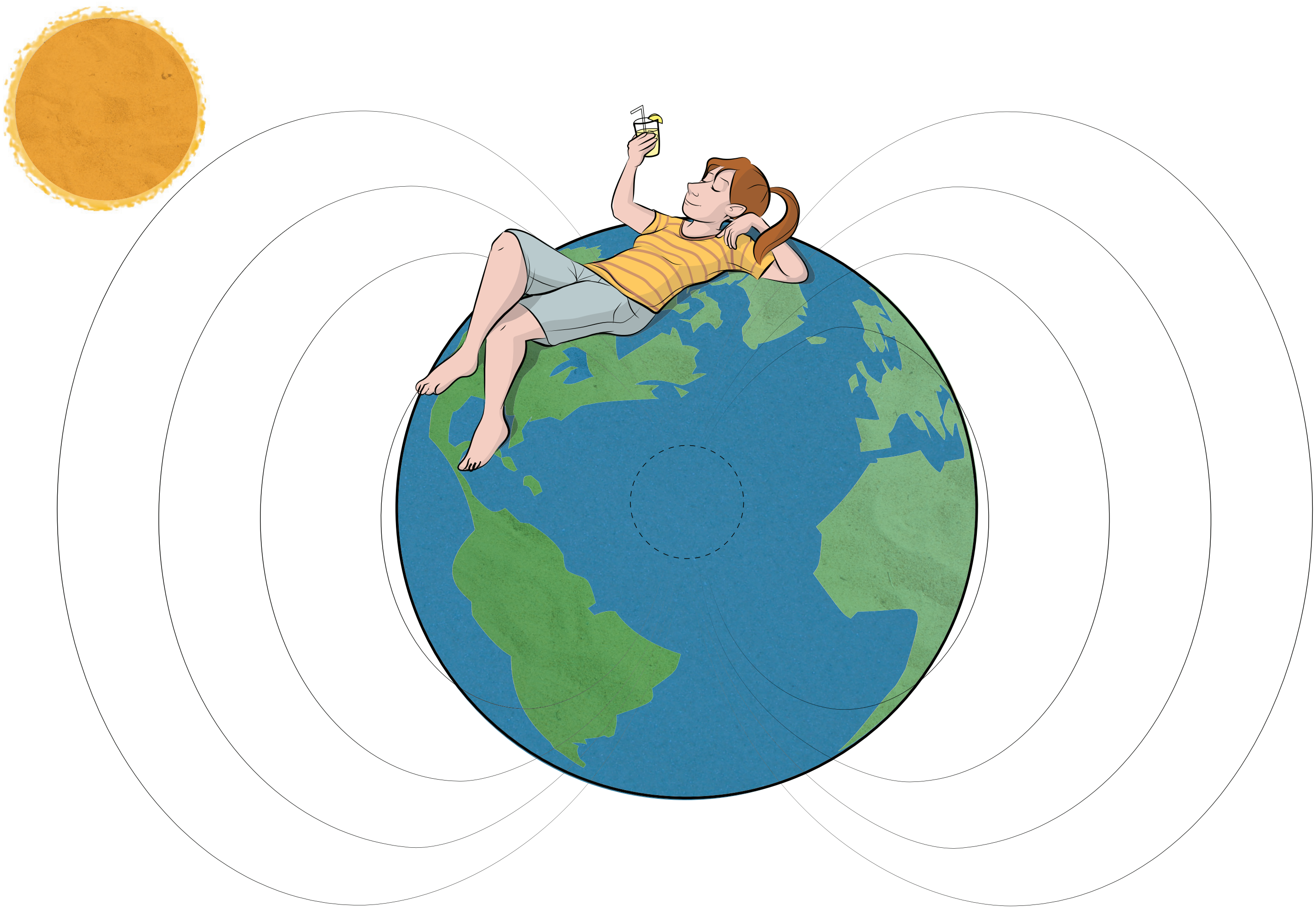
Trace your way through the system of gears to get the machine working again.



Electromagnetism

If electrons are zipping around a nucleus, why don't they fly away?
Electromagnetism is responsible. Each atom has its own magnetic field, created by the opposing forces of negatively charged electrons spinning around the positively charged protons.

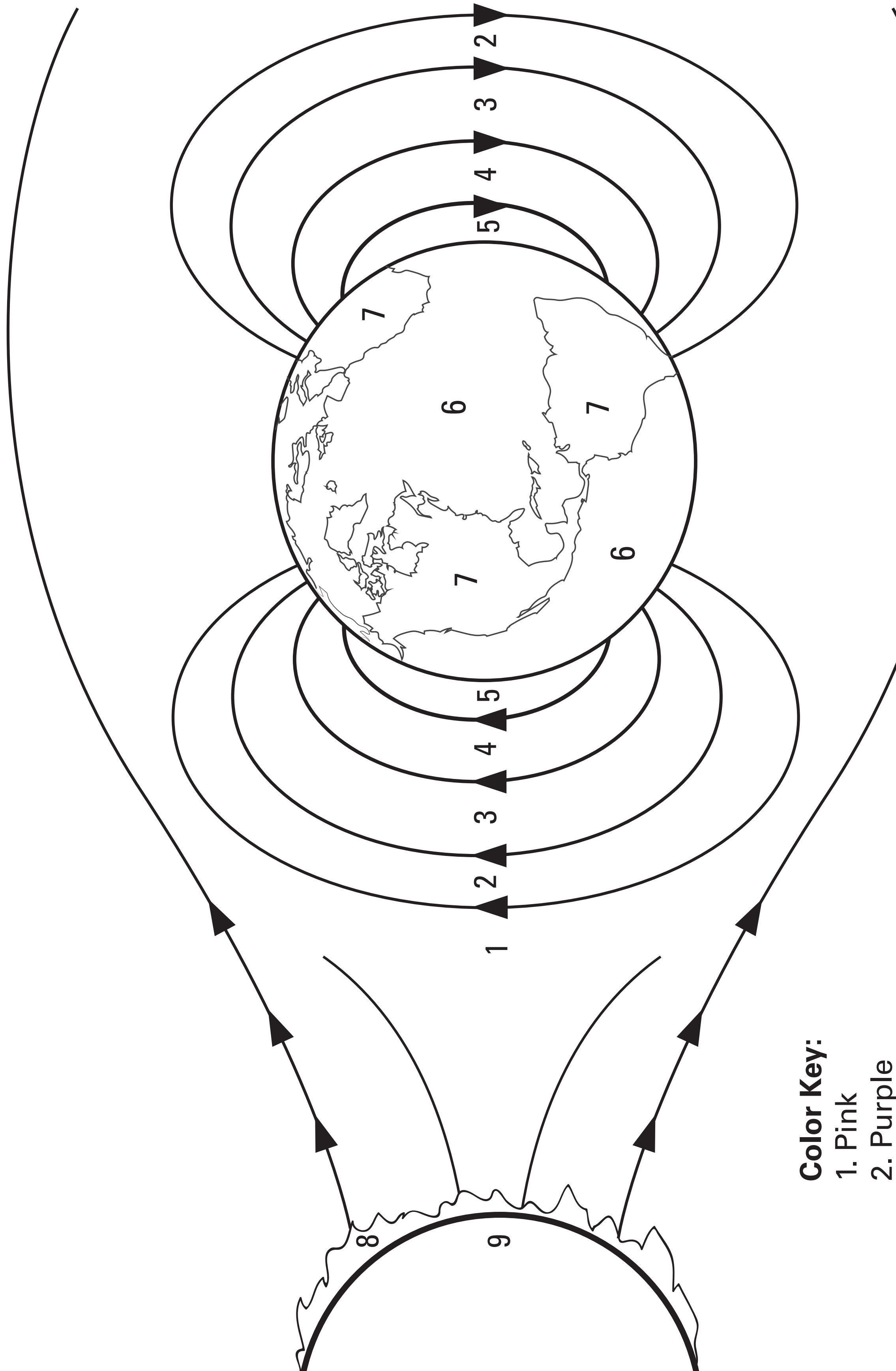
The electromagnetic field of atoms adds up and creates some of the most powerful forces we can observe in our universe. The molten iron core of the earth, for example, creates a magnetic field so strong and large it protects our planet from the sun's harmful radiation.



Animals have evolved to sense the Earth's magnetic field. For example, a magnetic sensor in migratory birds' beaks lets them know which way is south. Sharks can sense the magnetic field produced by their prey.

Electromagnetism by Numbers!

Turn the page sideways and color the illustration based on the numbers to see how Earth's magnetic field protects the Earth from solar flares.



Fun Fact

Electromagnetism is so strong that the Earth's core produces a magnetic field that reaches into outer space! This field is what compasses use, and animals sense it to migrate. It does more than just that, though - it also acts as a force field from the massive amounts of radiation the sun sends out into space, and even deflects.

Color Key:
1. Pink
2. Purple
3. Orange
4. Brown
5. Silver
6. Blue
7. Green
8. Red
9. Yellow

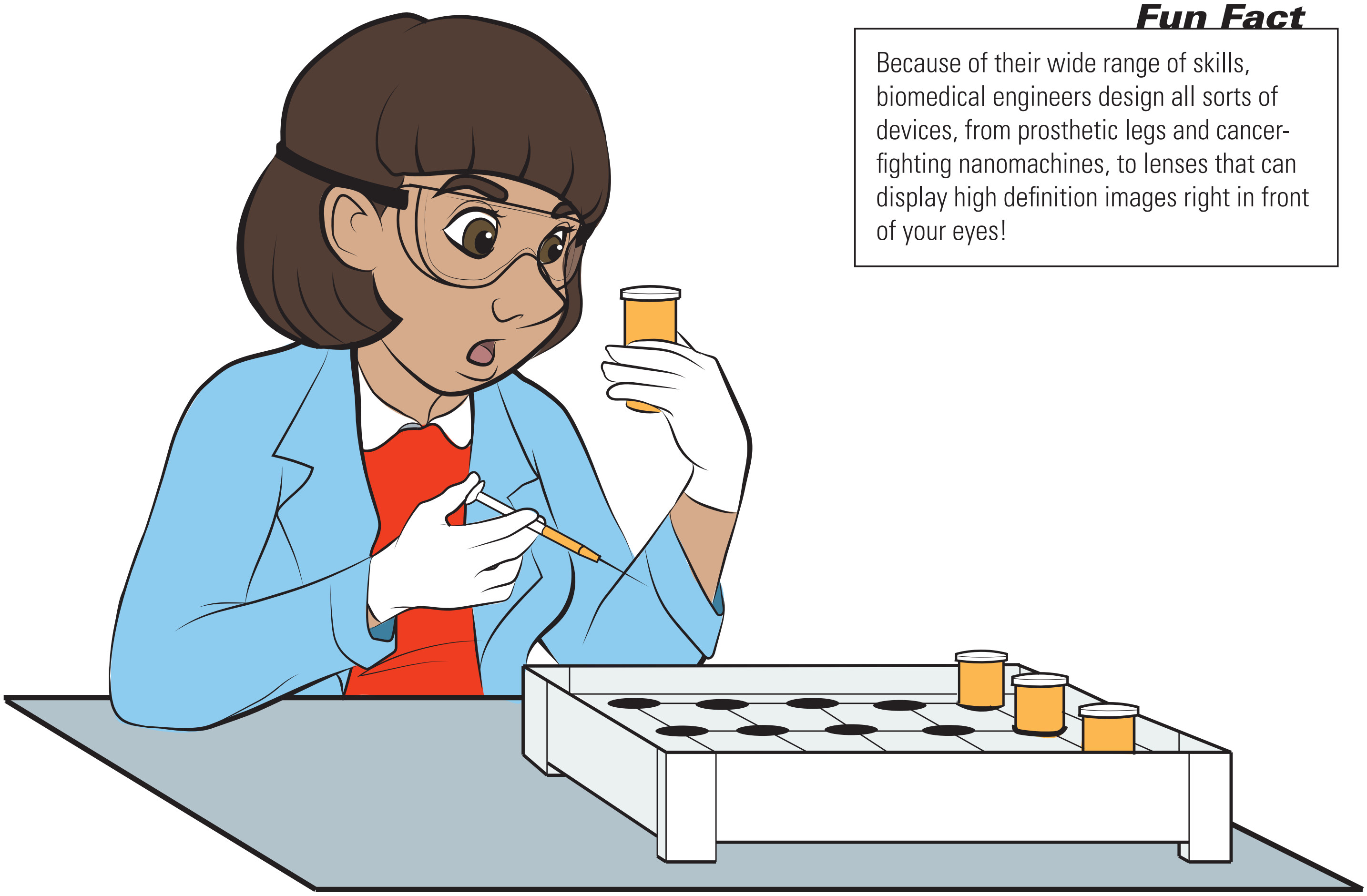
Biomedical Engineering

Biomedical engineering is one of the fastest developing fields engineers are exploring. Biomedical engineers are creating new devices that did not exist twenty, or even ten, years ago.

These engineers make things our bodies interact with, like artificial hearts and electrodes implanted on the brain to help cure blindness.

Fun Fact

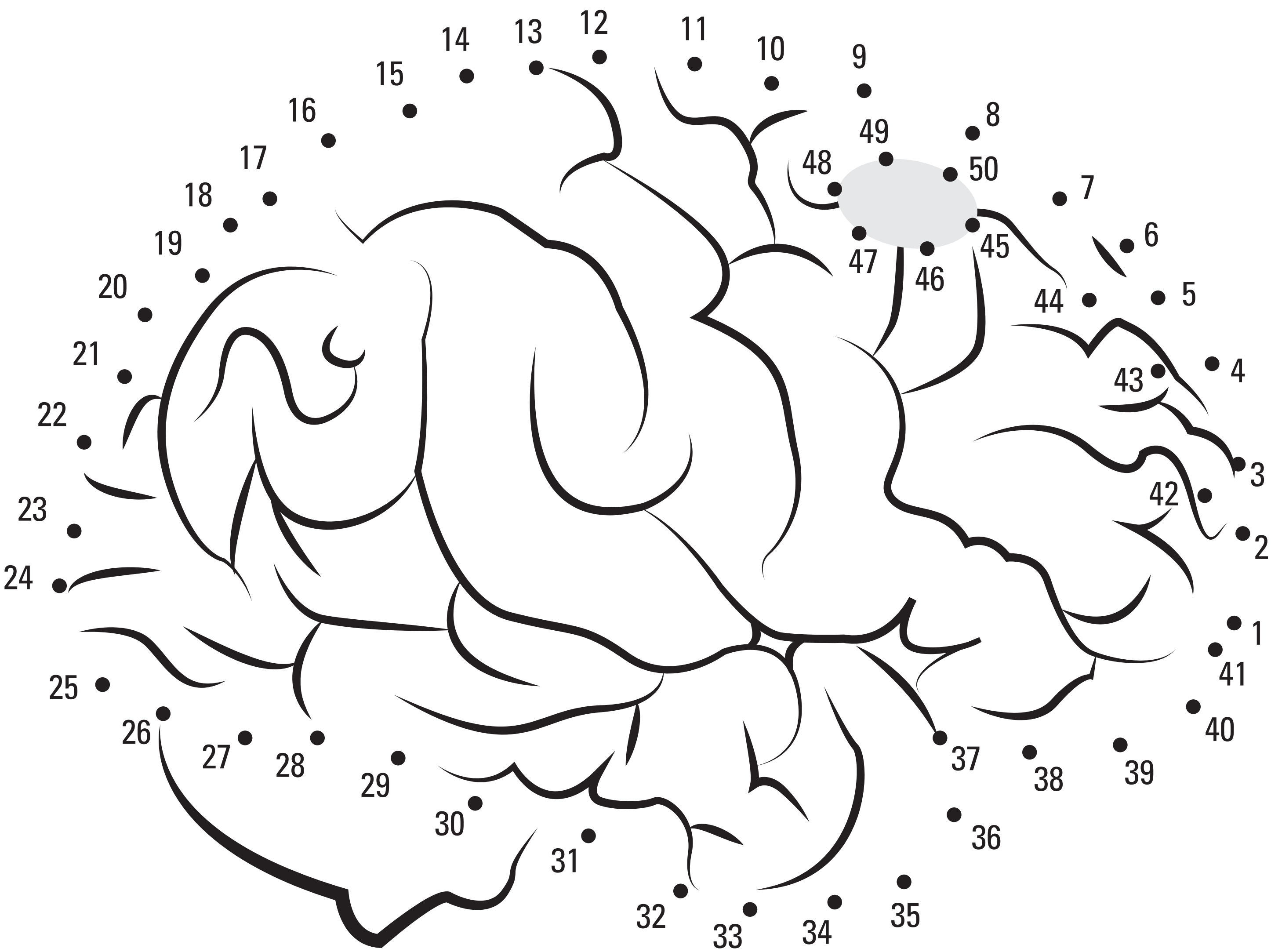
Because of their wide range of skills, biomedical engineers design all sorts of devices, from prosthetic legs and cancer-fighting nanomachines, to lenses that can display high definition images right in front of your eyes!



Imagine wearing contact lenses that display an HD image on your eye. You could be anywhere— at school, home, or with your friends— and see what time it is, or find out the temperature in New Delhi. Right now, these lenses only work with glasses, but in a few years, you'll be able to surf hands-free.

Keep it Functioning!

Connect the dots to keep the brain functioning with an electrode implant. Then color it with crayons or markers to make it healthy.



Fun Fact

Electroencephalography, or EEG, is the recording of the electrical activity in your brain. Whenever your brain tells you to do something, it fires an electrical signal between neurons. These signals can be recorded by electrodes and either placed on the scalp, or sometimes directly on the brain. These electrodes can be used to diagnose diseases like epilepsy or sleep disorders.

Algorithms

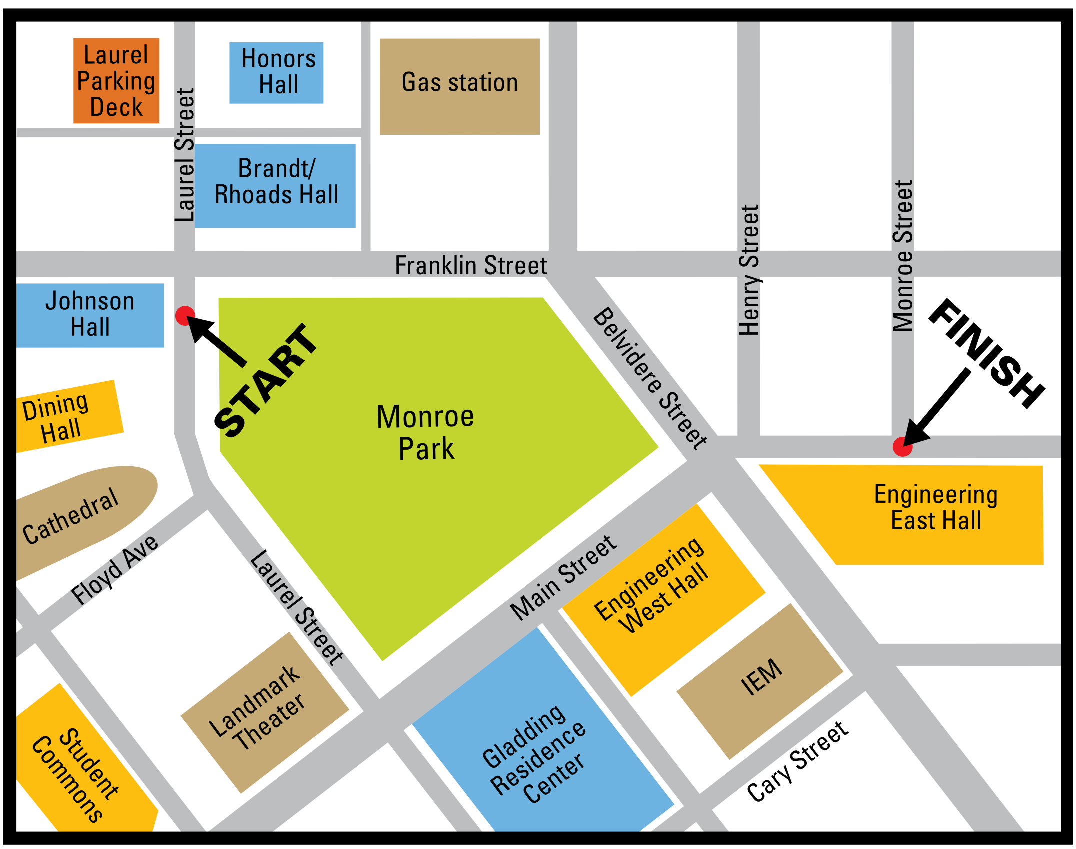
The last time we talked about computers we mentioned that everything you do on the computer is sent as instructions. How do these instructions work? They use algorithms, which are just step-by-step lists of what to do, very much like your favorite recipe.

Let's try some algorithms for getting from one place to another, using the map below.

Example: Edward lives in Gladding Residence Center and wants to visit DJ in Honors Hall. How does he get there?

- Go left on Main Street
- Go right on Laurel Street
- Honors Hall is on the right

Try it yourself! Amy lives in Johnson Hall and needs to get to class in Engineering East Hall. How does she get there? Write an algorithm below (there is more than one correct answer).



1.

2.

3.

4.

Algorithmic Mix-up!

Oh no! Edward's hard drive is malfunctioning and all of his algorithms are scrambled. Match the number to the letters in the box to unscramble the algorithm. Can you guess what this algorithm is for?

STEP 1 16 5 24   10 22 26   5 20 3 22 9 10 5 9 20 19

STEP 2 16 5 24   25 9 19   5 20 3 22 9 10 5 9 20 19

STEP 3 15 17 22 9 2 10   5 20   17 2 20

STEP 4 7 2 6 9   2 19   Π ∫ Σ

STEP 5 19 9 15 19   25 5 19 1   4 13 22 6

STEP 6 22 9 16 13 23 9   4 22 13 16   13 23 9 20

STEP 7 12 9 19   5 19   8 13 13 12

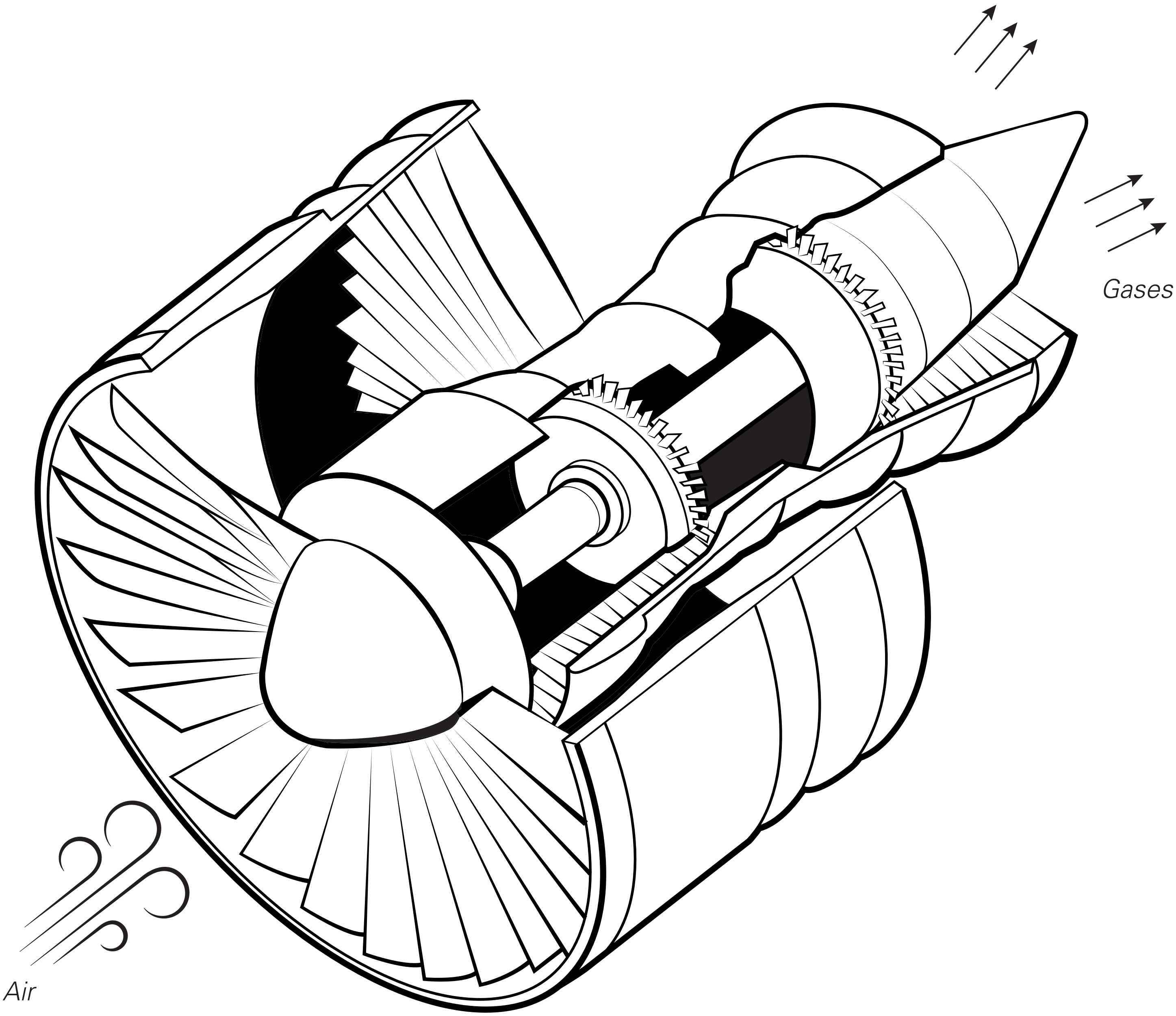
STEP 8 9 2 19

Key:

2	7	8	10	9	4	3
A	**B**	**C**	**D**	**E**	**F**	**G**
1	5	11	6	12	16	20
H	**I**	**J**	**K**	**L**	**M**	**N**
13	17	18	22	15	19	21
O	**P**	**Q**	**R**	**S**	**T**	**U**
23	25	24	26	14	◊	∫
V	**W**	**X**	**Y**	**Z**	**1**	**2**
∞	Π	Σ	Ω			
3	**4**	**5**	**6**			

See it in action!

Use your imagination to color the aircraft turbine.



Here's how it works:

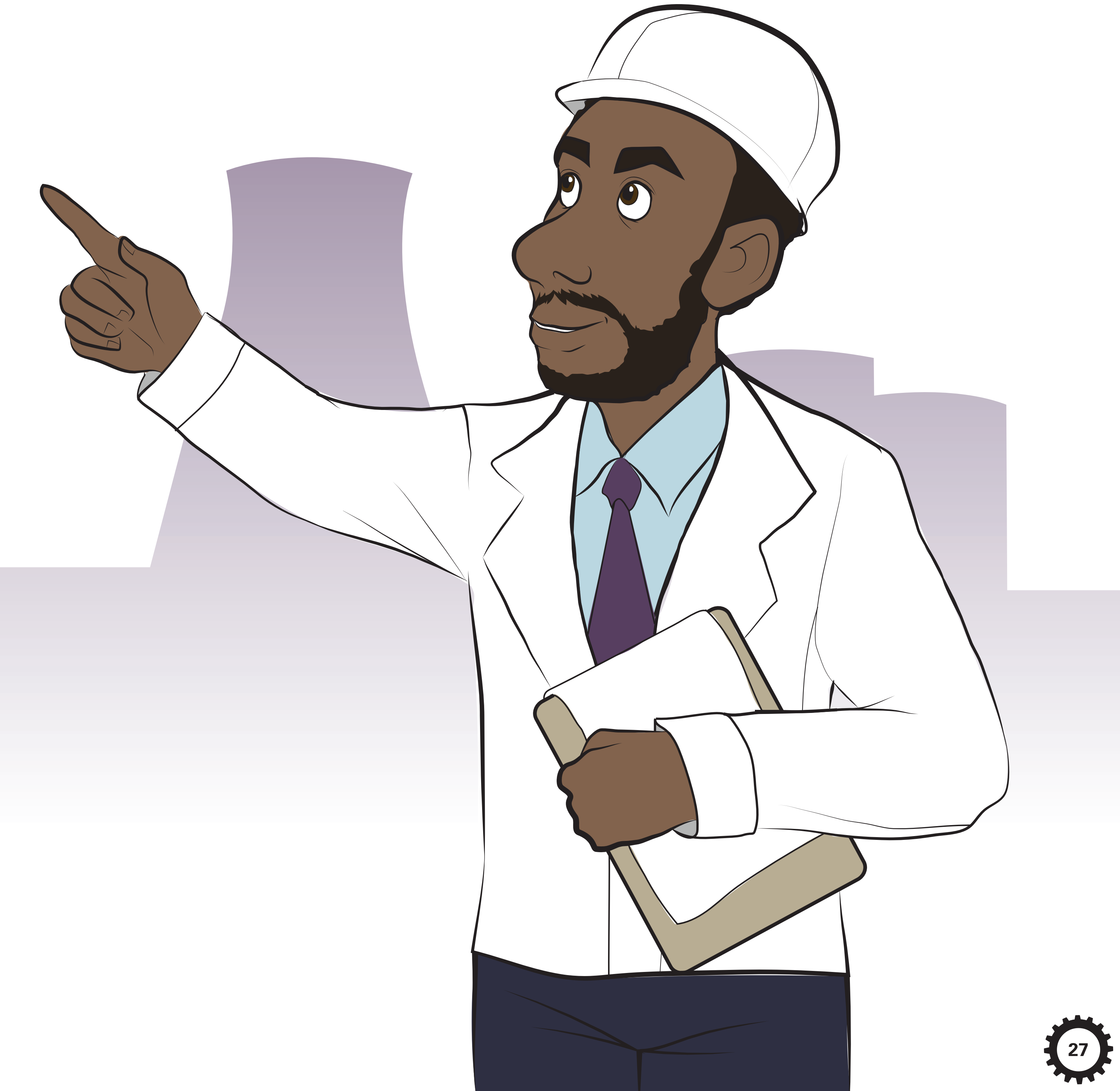
Air is drawn in at the front of the engine and compressed. Fuel is added and the mixture is combusted. This combustion increases the volume of the gases. The gases then exit out of the rear of the engine.

The aircraft can use the power generated from the turbine to race and roar down the runway!

Let's Get *Nuclear*

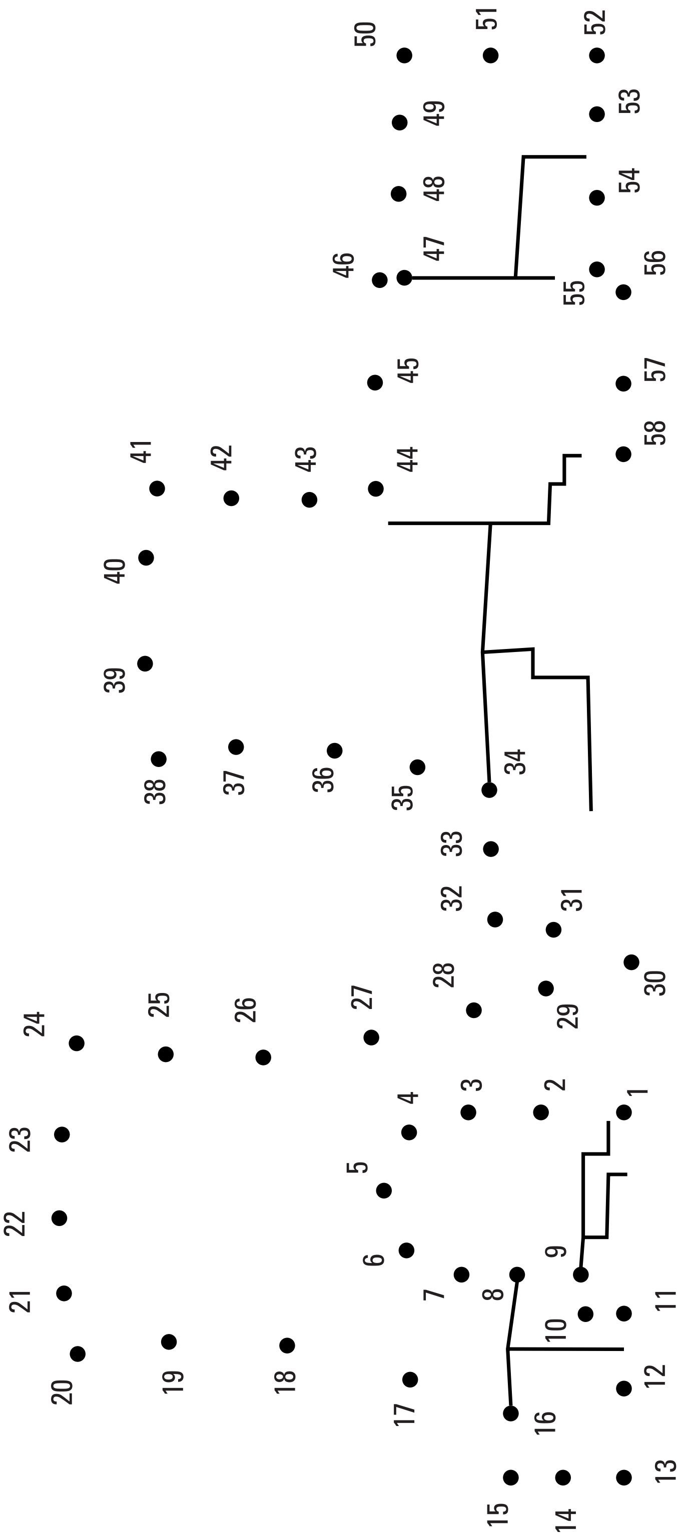
Nucleons are subatomic particles like protons and neutrons found in the atom's nucleus. When these nucleons are smashed together or torn apart, mass is lost or gained, releasing energy. This energy produces extreme heat.

There are many positive uses for nuclear energy. Nuclear power gives people clean energy, and nuclear medicine can help people find diseases and treat them in a safe, painless way.



Power the Plant!

Turn the page sideways and help DJ get the nuclear power plant up and running by connecting all the dots in the right order. Color it with crayons or markers to make it produce even more energy!



Fun Fact

Mechanical engineering is one of the oldest professions around. Mechanical engineering began when the first human-powered machines were invented, like the pulley. Now, mechanical engineers design cars, planes, trains, boats, space shuttles and even things as simple as a toaster. Mechanical engineers also design robots, an emerging technology that will change the future.

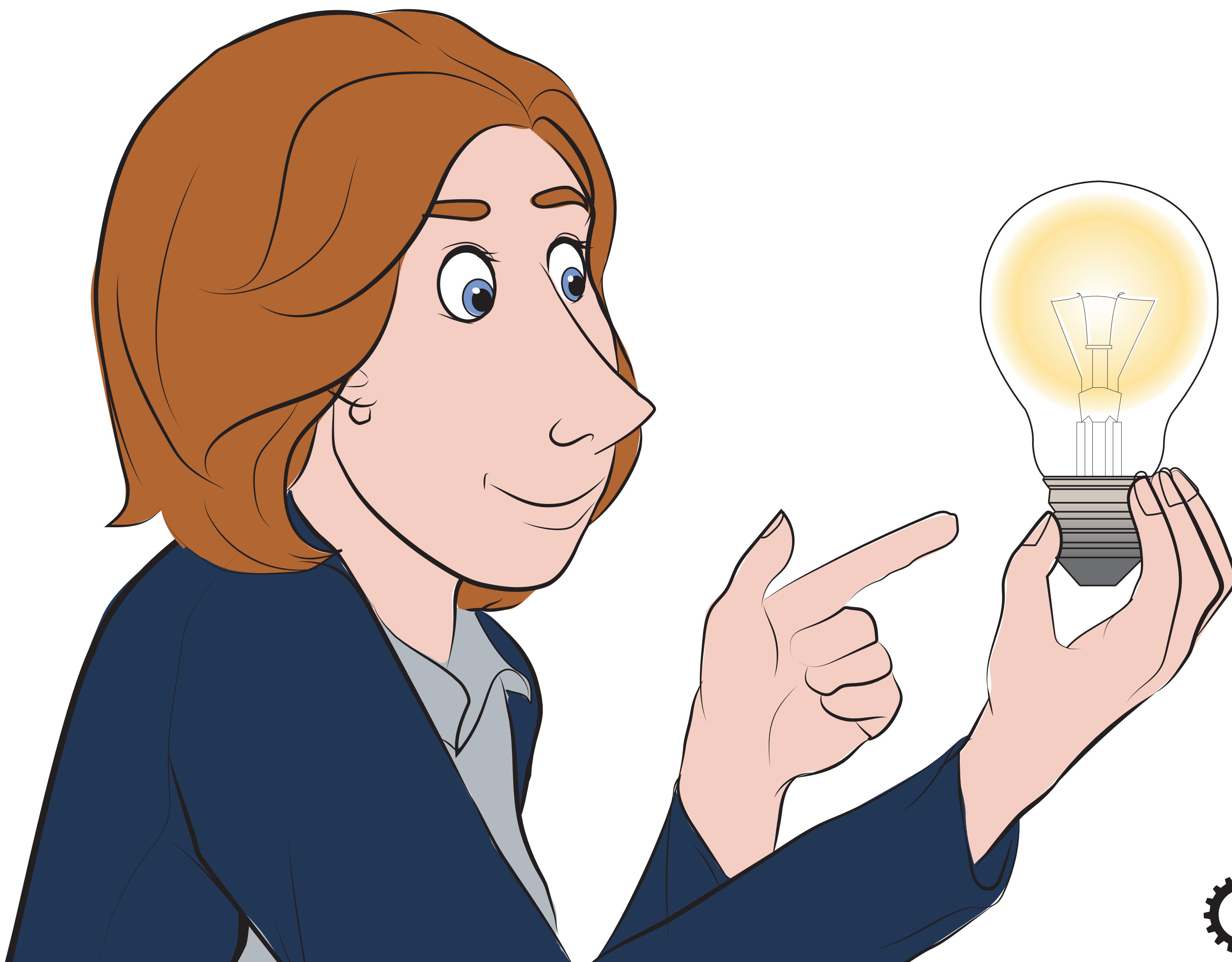
Electricity

What is electricity?

Electricity is a type of energy that can build up in one place or flow from one place to another. Electricity is the reason your iPad works and the power behind how your air conditioner, refrigerator and lights run in your home.

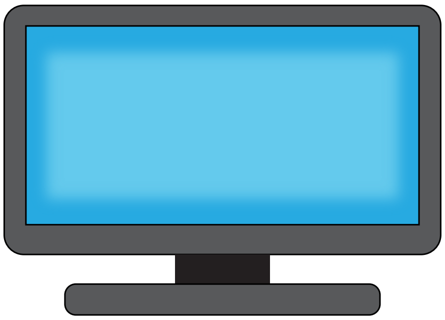
How does electricity turn on a light bulb, anyway? It runs through something called a circuit. All circuits are like racetrack loops giving electricity an endless path to travel on.

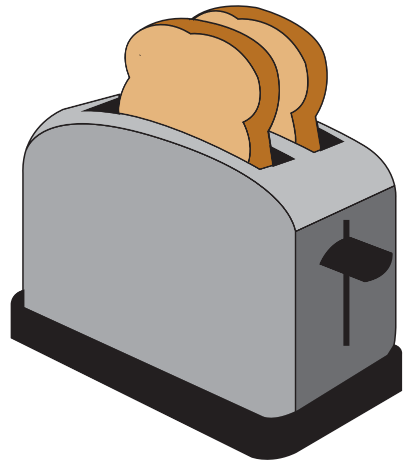
Circuits are made of a voltage source and a resistor (a part of the circuit that reduces the flow of electricity through wires). In the light bulb in your room, the light bulb is the resistor, and a power plant is the voltage source. When you flip a light switch, you're connecting the two ends of a circuit together, letting electricity pass through and into the light bulb. If you've ever looked into a light bulb, you've seen a tiny spiral wire in the middle of the glass. That's part of the circuit, and when that wire heats up, it starts to glow, producing the light you use.

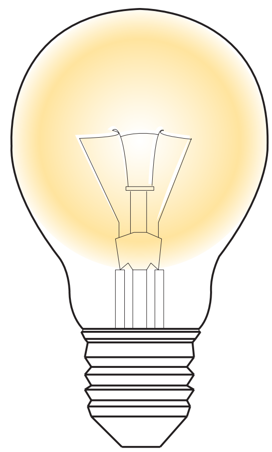


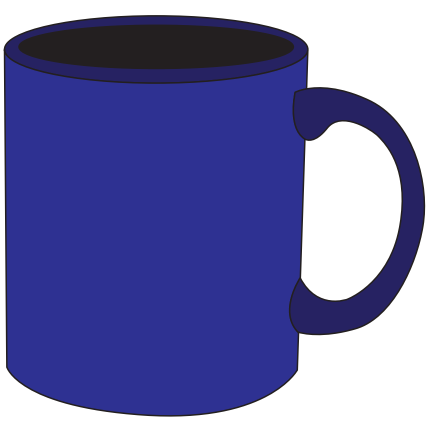
Is it Electric?

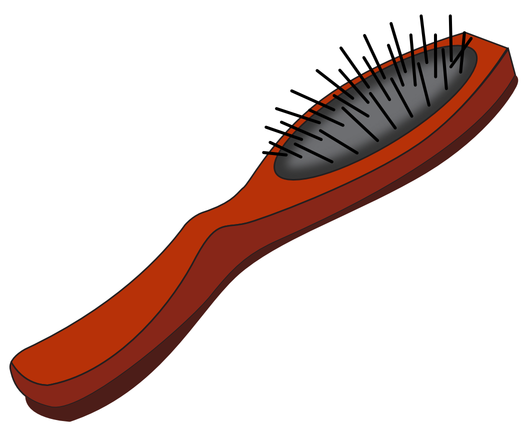
Your city is going through a power outage! You can't use electricity, but that doesn't mean that you can't use everything in your house. Circle the objects below that you can use without electricity.











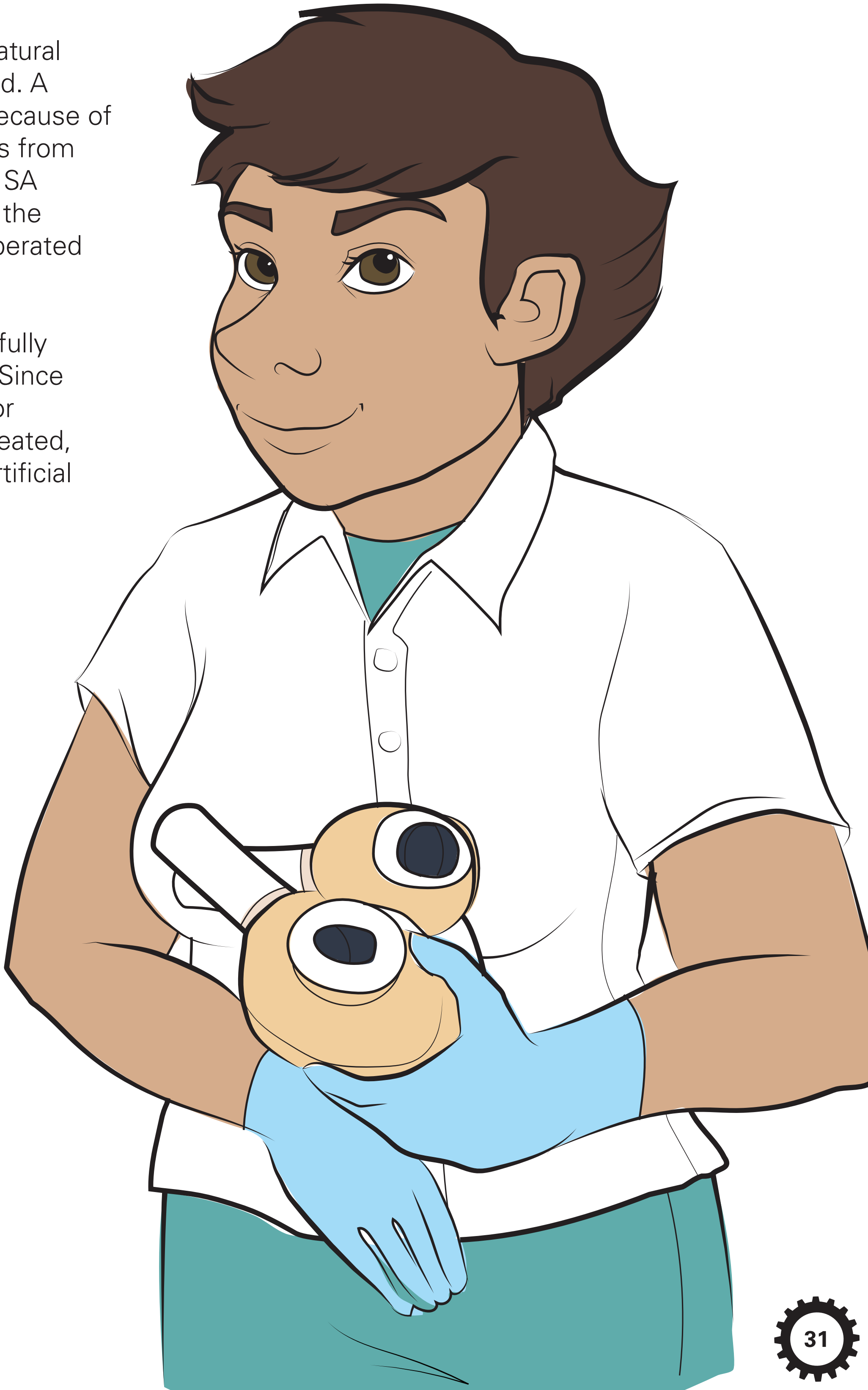
Artificial Hearts

Until recently, doctors weren't able to help patients with a damaged liver or heart. Now biomedical engineers are actually growing organs!

Right now, these human-made organs don't work exactly like the ones you were born with. While biomedical engineers are still figuring out how to grow organs, they are experts at creating artificial ones. Ever heard of an *artificial heart*?

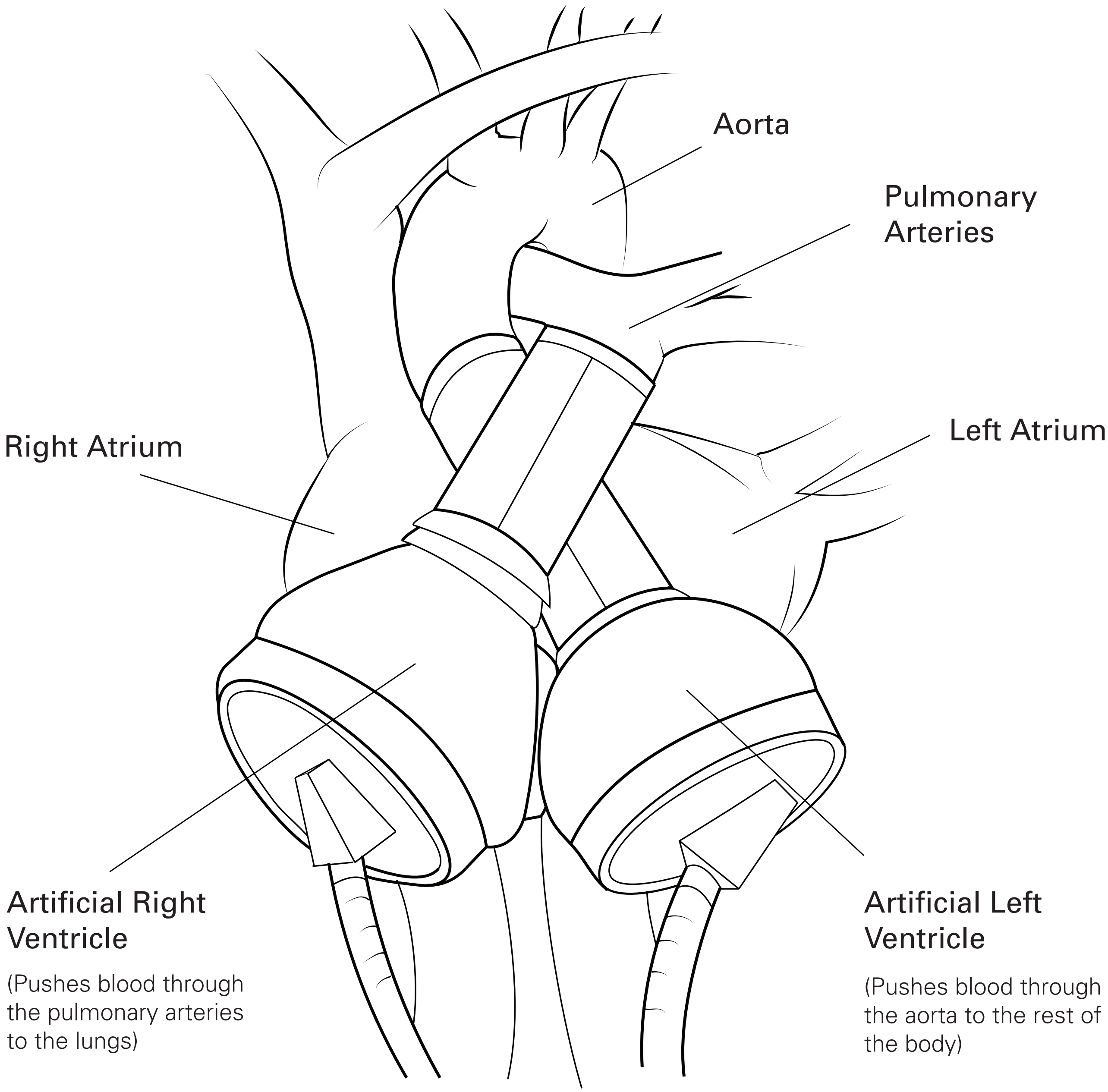
Artificial hearts work just like your natural heart does, but batteries are included. A natural heart knows when to beat because of electrical signals your body produces from a little piece of the heart named the SA Node. An artificial heart beats using the same process, but uses a battery-operated pacemaker instead.

The first artificial heart was successfully implanted in a human in the 1980s. Since then, many artificial replacements for organs and body parts have been created, from robotic legs for amputees to artificial eyes that help people see.



See it in action!

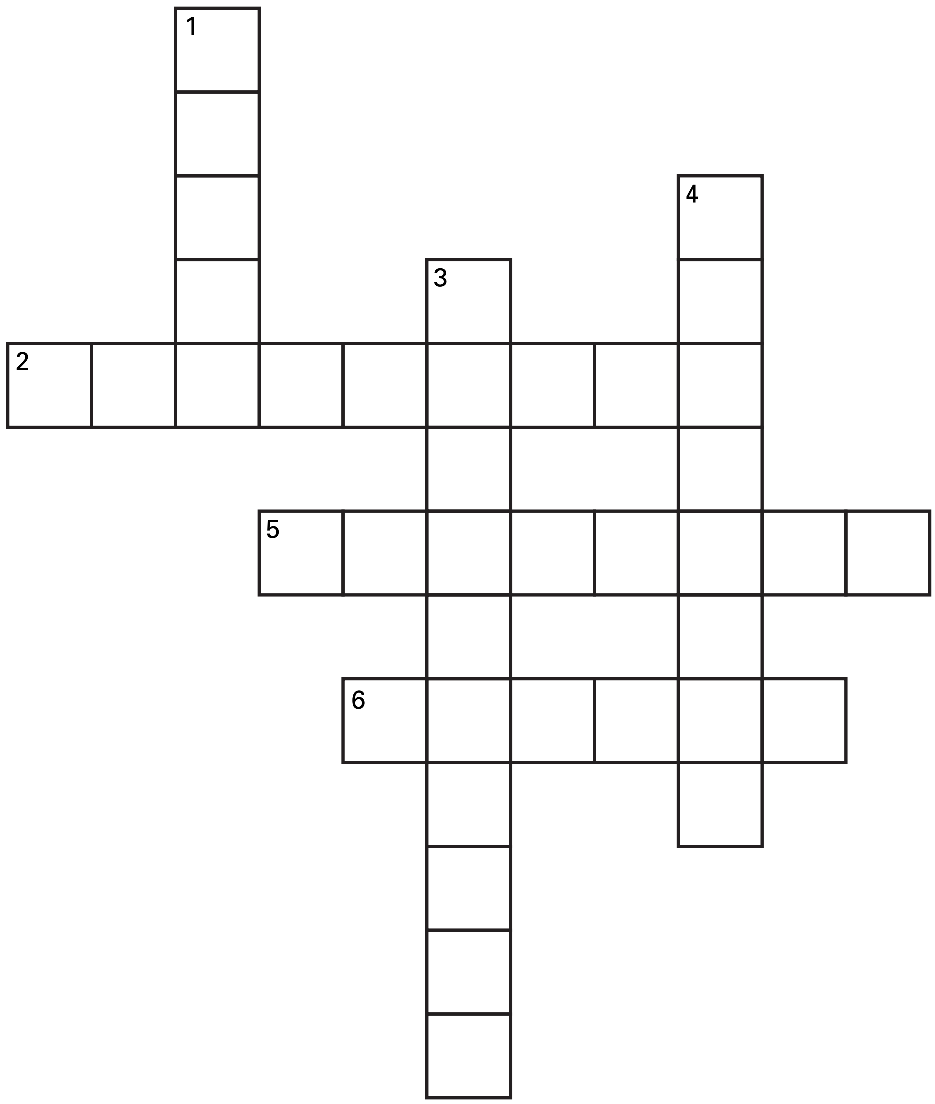
Use your imagination to color the following illustration.



Artificial hearts work just like your natural heart does, but instead of processing electrical signals, the artificial heart uses a pacemaker in order to beat properly.

Biomedical Crossword!

Fill in this Biomedical crossword based on the descriptions below.
Hint: The words are taken from both Artificial Hearts (30) and Cells (6).



Across

2. Protects the organelles and holds cell waste.
5. Millions of these live in our digestive tracts and help break down food.
6. Biomedical engineers are pushing boundaries by growing these.

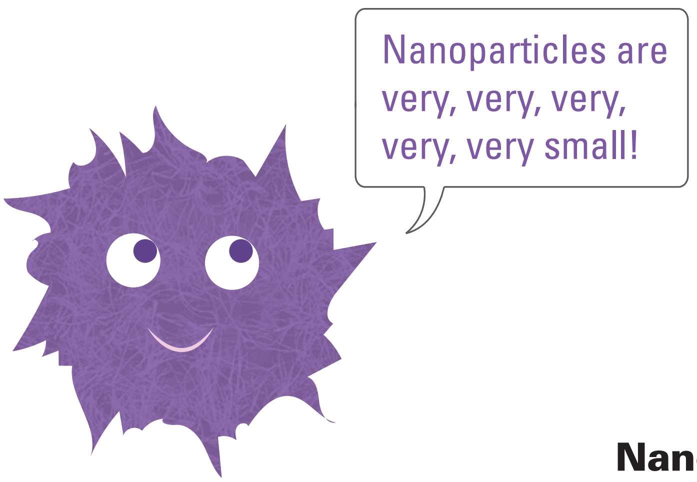
Down

1. Pumps blood through the blood vessels to the various parts of the body.
3. These may be implanted on the brain to partially cure blindness.
4. Skin of the cell

Curing Asthma

Ever had an asthma attack or know someone who has? It's a scary experience, and no matter how hard you try, it feels impossible to breathe in enough air. For years, people have relied on inhalers to stop asthma attacks. Inhalers and some medicines, however, are actually very inefficient.

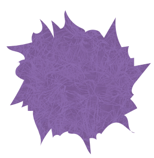
Chemical engineers are working to solve this problem by designing *nanoparticles*. Nanoparticles are tiny. Unbelievably tiny: one billionth (10^{-9}) of a meter to be exact! Chemical engineers are finding ways to make these beyond-microscopic particles carry medicine and connect with cells. Since nanoparticles can be programmed to connect to a specific type of cell in the body, doctors are able to treat disease even better and faster.



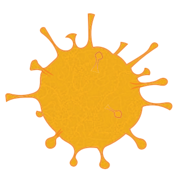
Fun Fact

Chemical engineers manipulate the physical world. They create materials that use chemical properties to change how we interact with the environment and make medicine. Chemical engineers use the three building blocks of atoms (protons, electrons and neutrons) to make new things never seen before!

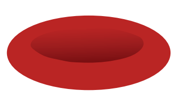
Nanoparticle Size Comparison



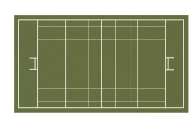
If a nanoparticle was the size of a football…



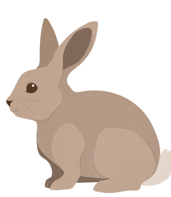
…a virus would be the size of a person.



…a red blood cell would be the size of a football field.



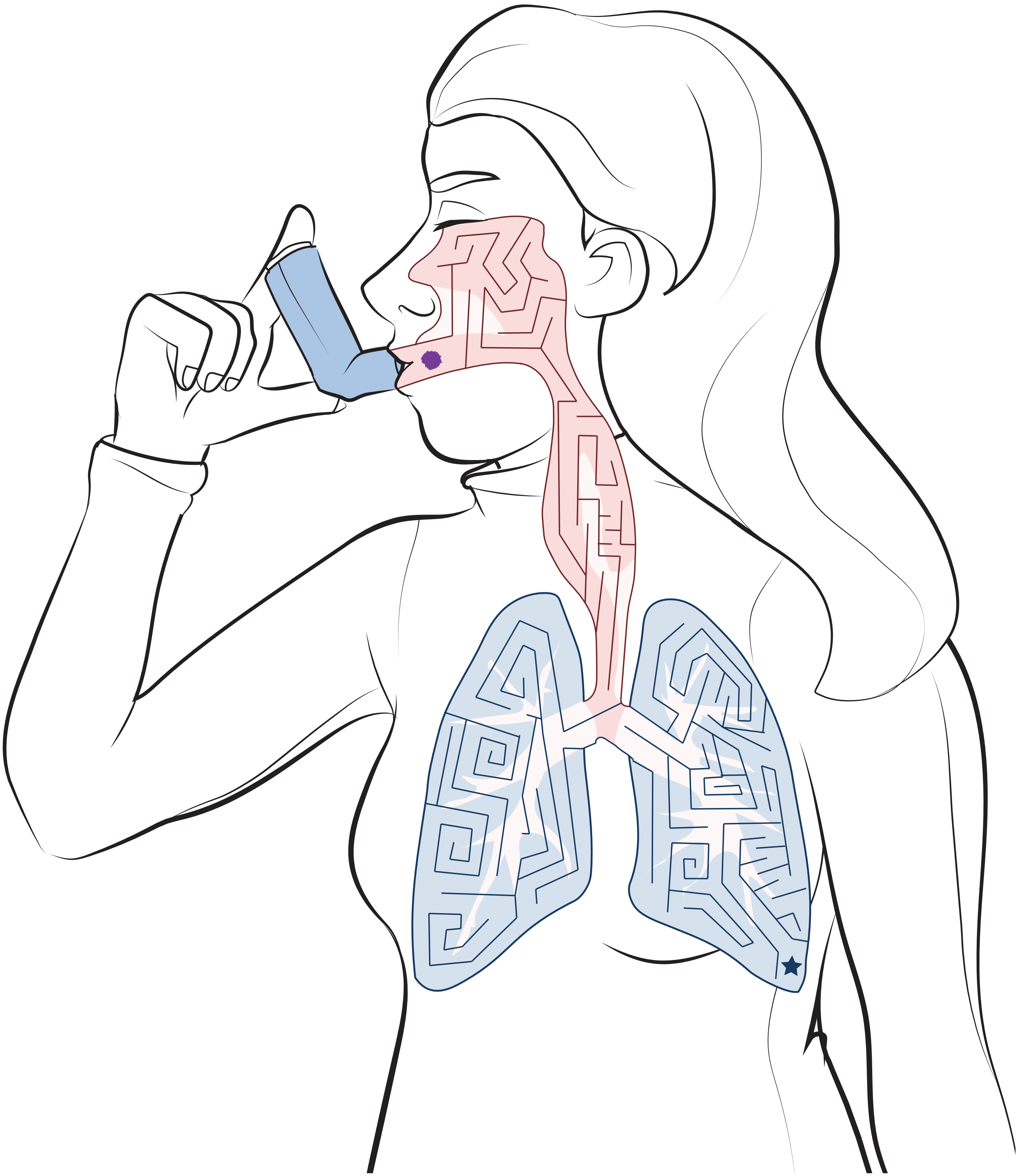
…a doughnut would be the size of New Zealand.



…and a rabbit would be the size of the Earth.

Nanoparticle Maze!

Help the nanoparticle find its way through the maze to the star in the lungs.



Probability

Probability is almost like telling the future. When a coin is flipped, there are two outcomes— heads or tails. Since there are only two ways the coin can land, heads and tails both have a probability of 50 percent. If you flip a six-sided die, you'll have a little less than a 17 percent chance to roll the number you want. If you roll a twenty-sided die, each outcome only has a five percent chance of happening. Adding more options lowers the probability of each outcome and increases the risk of failure. This is why engineers take probability seriously.

Probability can be expressed numerically (a 10 percent chance of snow), or with words (possible, likely, or impossible).

Now, let's figure out how to calculate probability!

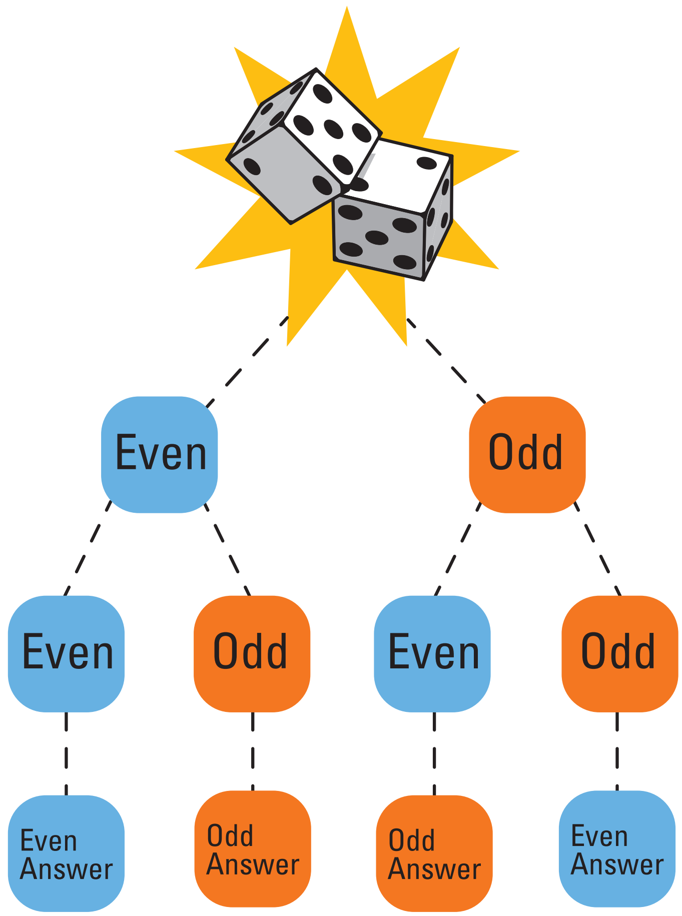
If you roll two six-sided dice, what's the probability you'll end up with an even number?

First, you have to figure out how many possibilities each die has, which we know is six. That means each die has three even numbers and three odd numbers.

Now, we know:

- even number + even number = even number
- odd number + odd number = even number
- even number + odd number = odd number

The first roll doesn't matter. It's only the second die that will change the outcome. With two dice, there are four different paths each roll can follow: even-even, even-odd, odd-even, and odd-odd. This means there are really only two outcomes— either an odd or even number— so we know the probability of rolling an even number is 50 percent.

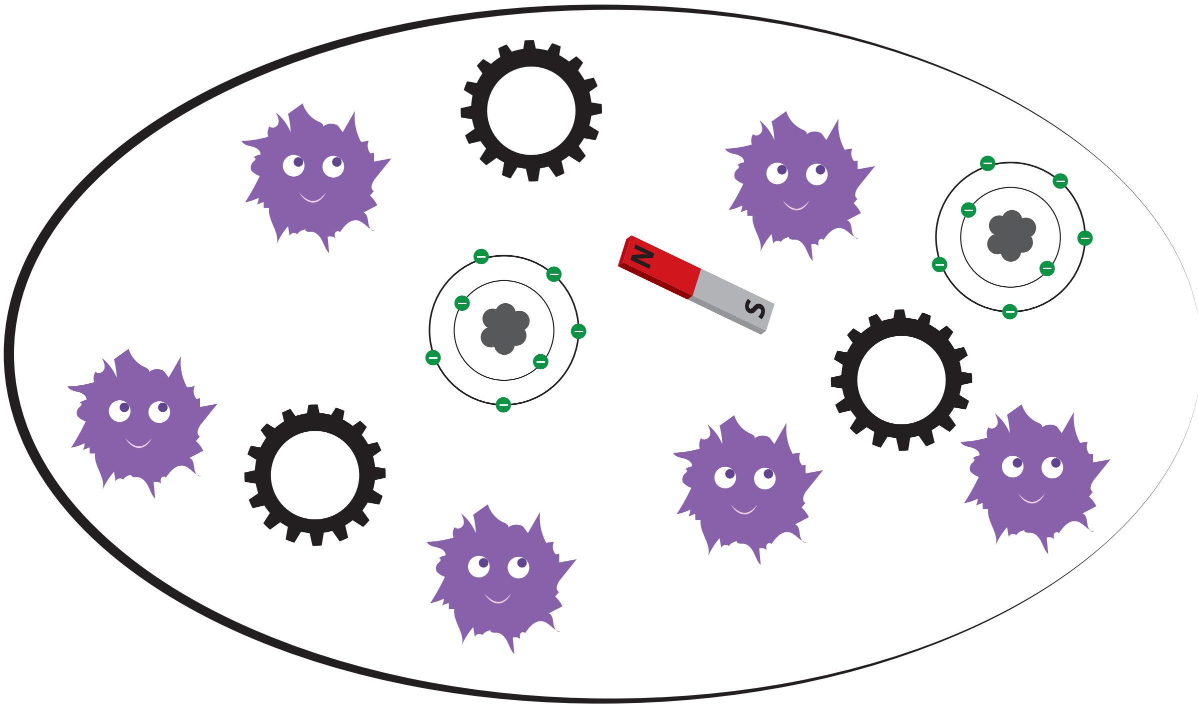


Fun Fact

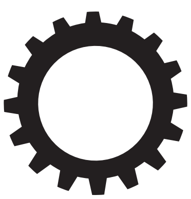
Have you ever played a game of chess with your computer? Did you ever wonder how it predicted your moves? Computers use advanced probability algorithms to measure the probability of each possible move before you do it. After determining this, the computer plays against the most likely move you will make.

What's the Chance?

Imagine that you are reaching into a bag holding the objects in the picture.

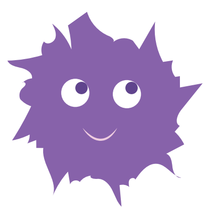


Circle the object you are **more** likely to grab.



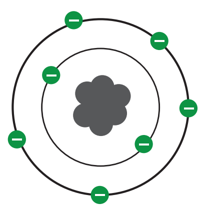
gear

or



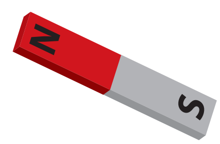
nanoparticle

Circle the object you are **less** likely to grab.



atom

or



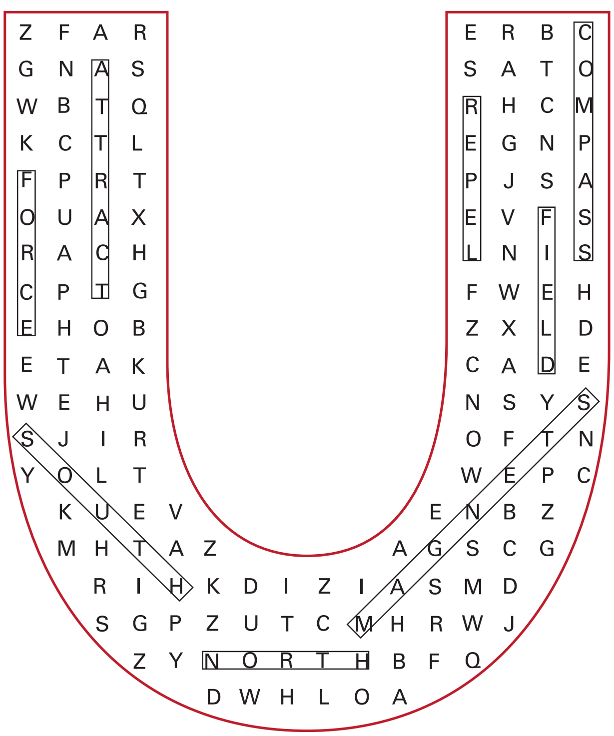
magnet

Answer Key

Page 6

	Mass	x Gravity	= Weight
Earth	50 lbs	1	50 lbs
Outer Space	50 lbs	0	0 lbs
The Sun	50 lbs	28	1400 lbs
Jupiter	50 lbs	2	100 lbs

Page 8



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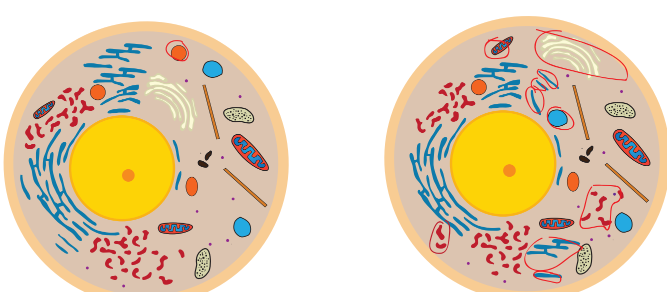

Page 11

1. cell membrane
2. nucleolus
3. ribosome
4. golgi apparatus
5. nuclear envelope
6. lysosome
7. mitochondrion

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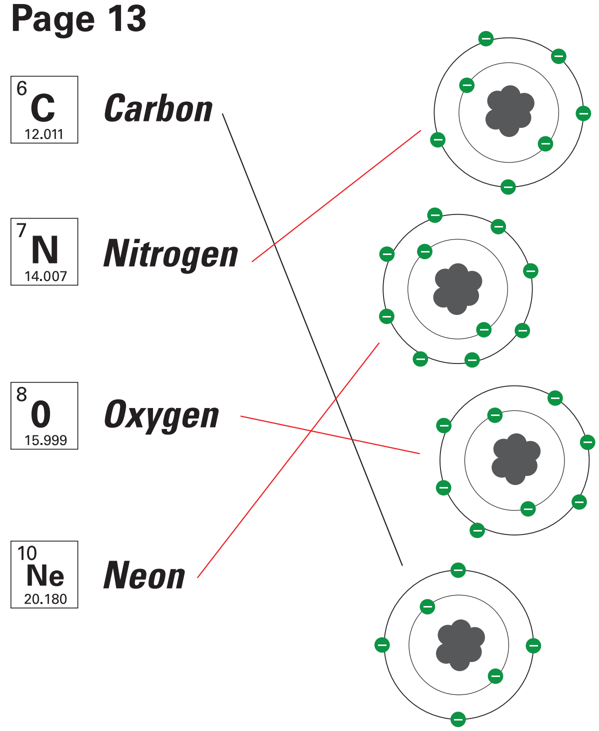

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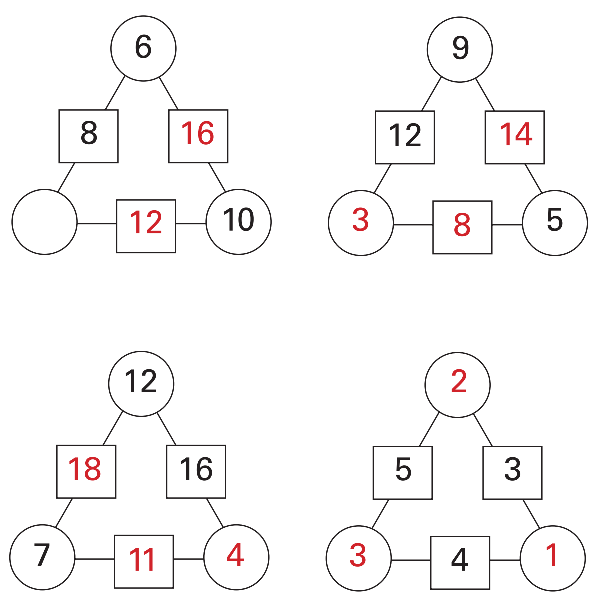

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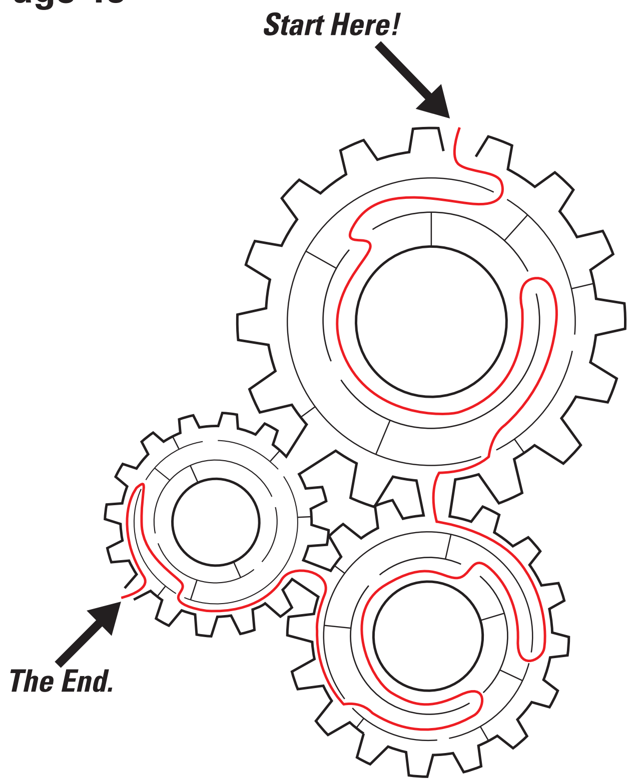

Page 25

1: Mix dry ingredients
2: Mix wet ingredients
3: Spread in pan
4: Bake at 425
5: Test with fork
6: Remove from oven
7: Let it cool
8: Eat

Page 30

Page 33

1. Heart
2. Cytoplasm
3. Electrode
4. Membrane
5. Bacteria
6. Organ

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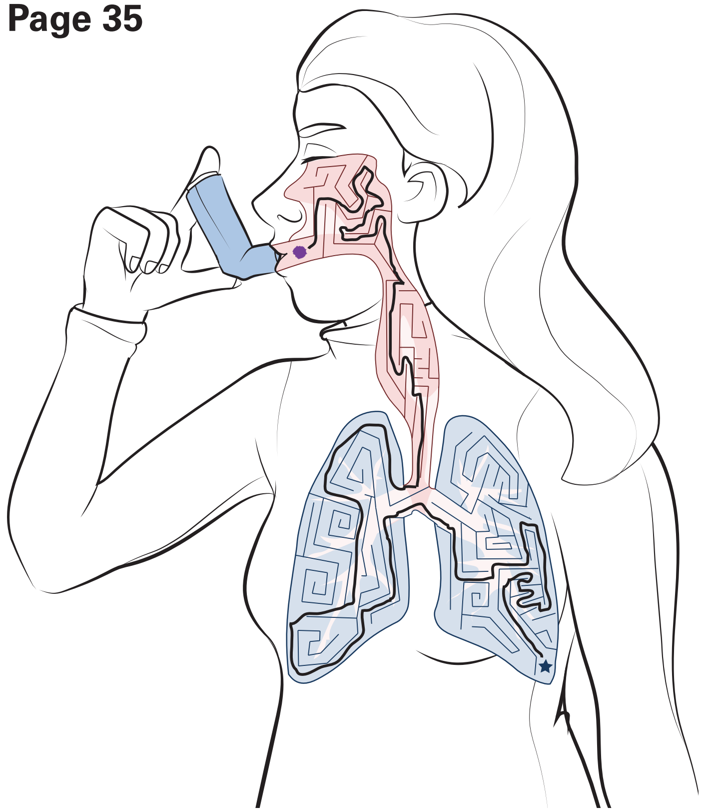

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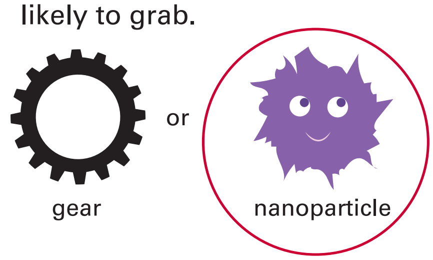
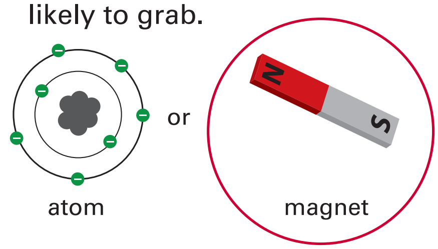
Circle the object you are **more** likely to grab.



Circle the object you are **less** likely to grab.



About VCU College of Engineering

The VCU College of Engineering, an innovation front-runner in academics and research, brings real-world education to Central Virginia. Our collaborative and multidisciplinary partnerships prepare undergraduate, master's and doctoral students for leadership. Part of a premier research university, the VCU College of Engineering enhances regional and global prosperity through cutting-edge developments in tissue engineering, drug delivery, bioinformatics, cybersecurity, mechanical systems and particle science. We make it real by turning great ideas into breakthrough technologies. Our facilities are hubs of discovery, powered by an expanding student body and faculty committed to excellence. We encourage partnering with industry and the community, bringing new collaborators into our projects. Our key research areas include: sustainability and energy engineering; micro and nano electronic systems; pharmaceutical engineering; mechanobiology and regenerative medicine; big data mining; and device design and development.

About VCU and VCU Health

*Virginia Commonwealth University is a major, urban public research university with national and international rankings in sponsored research. Located in downtown Richmond, VCU enrolls more than 31,000 students in 217 degree and certificate programs in the arts, sciences and humanities. Thirty-eight of the programs are unique in Virginia, many of them crossing the disciplines of VCU's 11 schools and three colleges. The VCU Health brand represents the VCU health sciences academic programs, the VCU Massey Cancer Center and the VCU Health System, which comprises VCU Medical Center (the only academic medical center and Level I trauma center in the region), Community Memorial Hospital, Children's Hospital of Richmond at VCU, MCV Physicians and Virginia Premier Health Plan. For more, please visit **www.vcu.edu** and **vcuhealth.org**.*

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