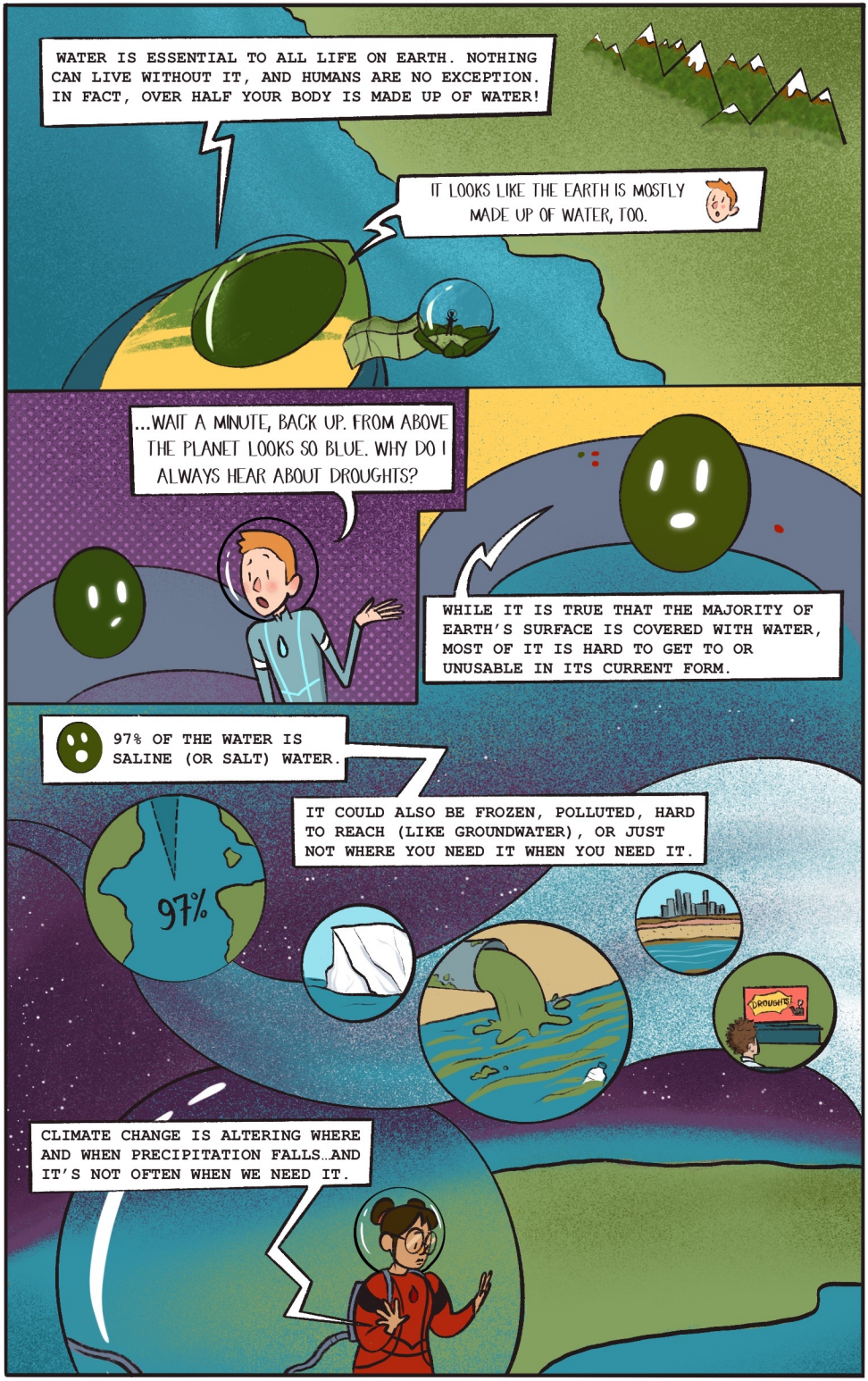
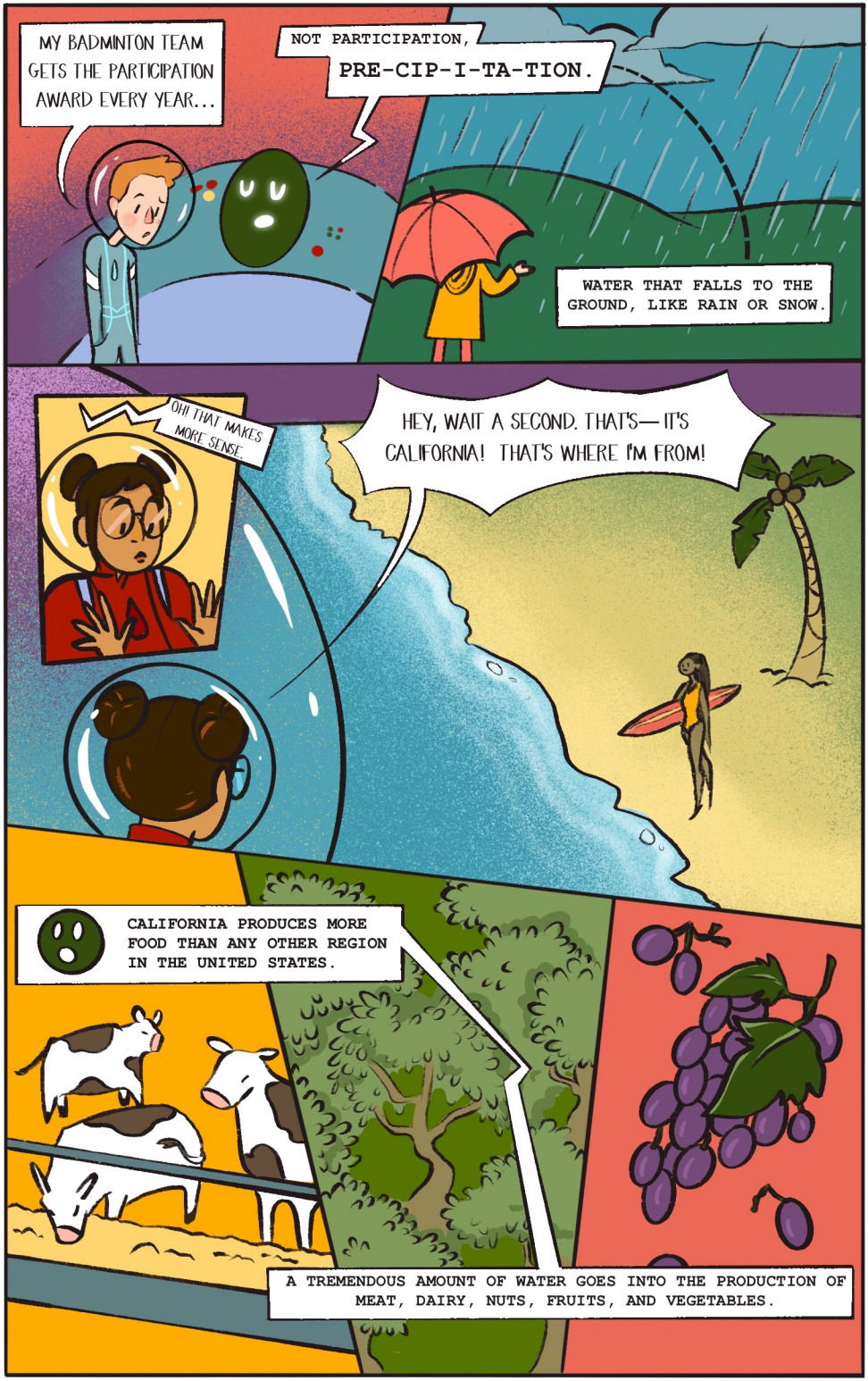
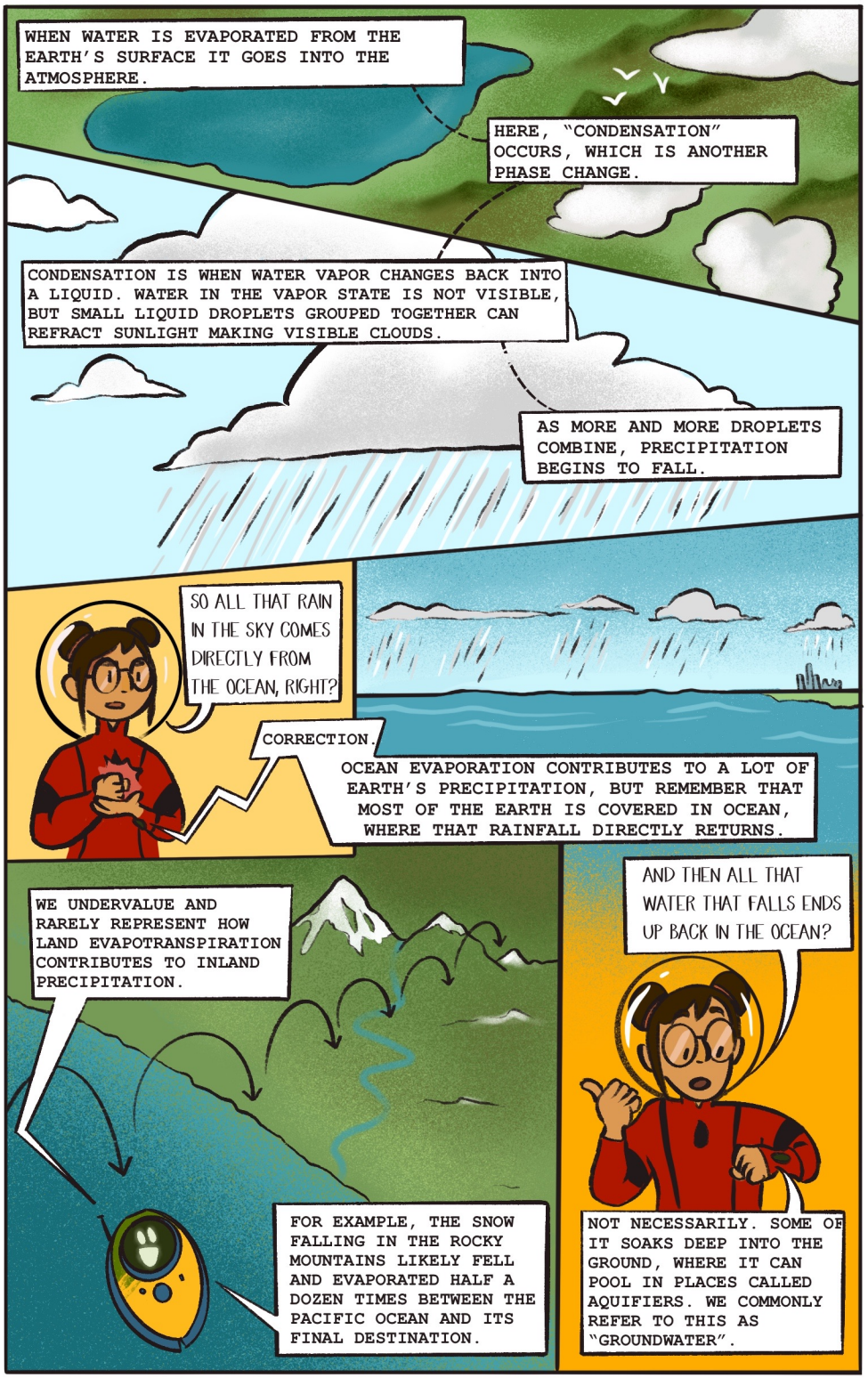
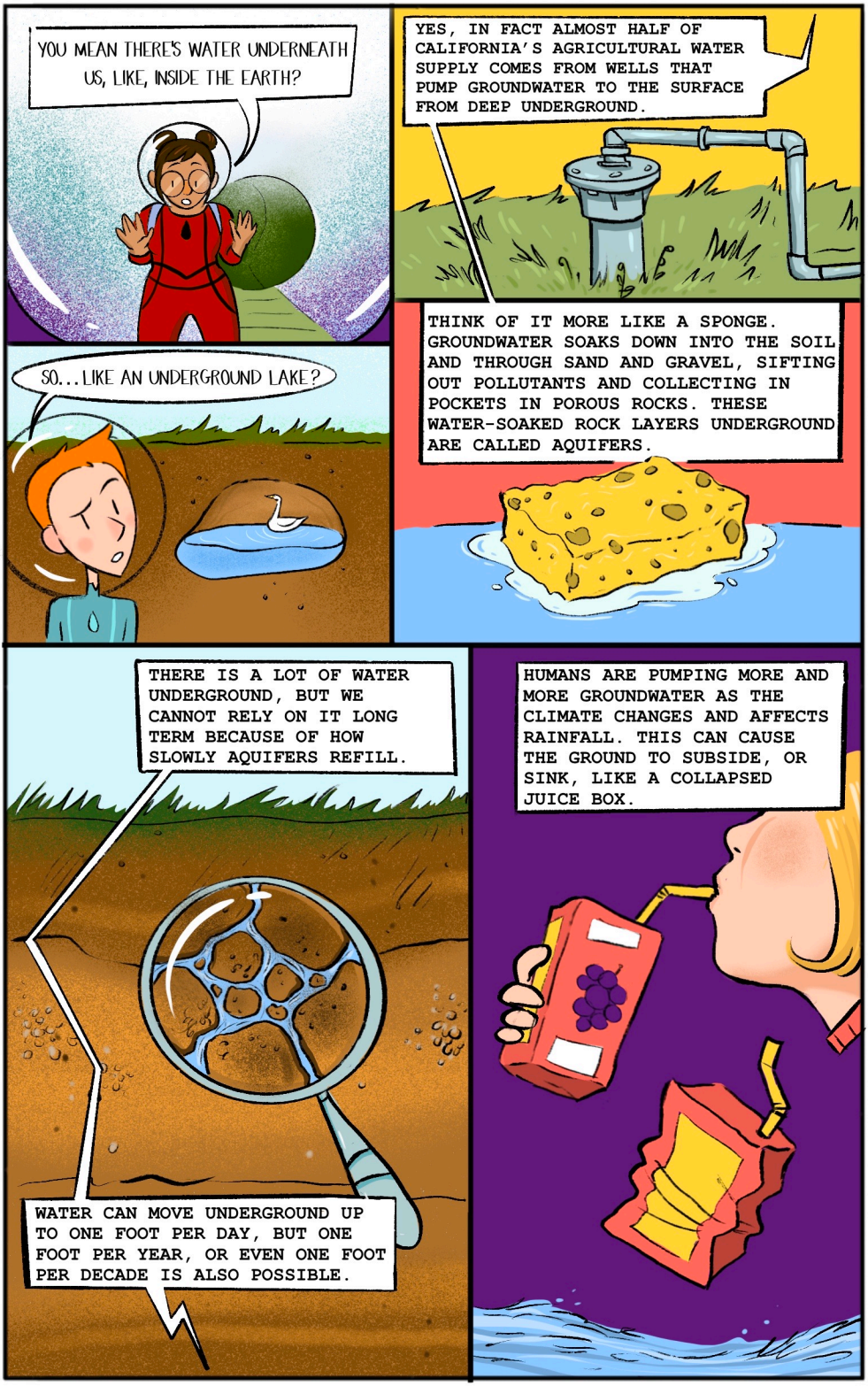
CHAPTER 4

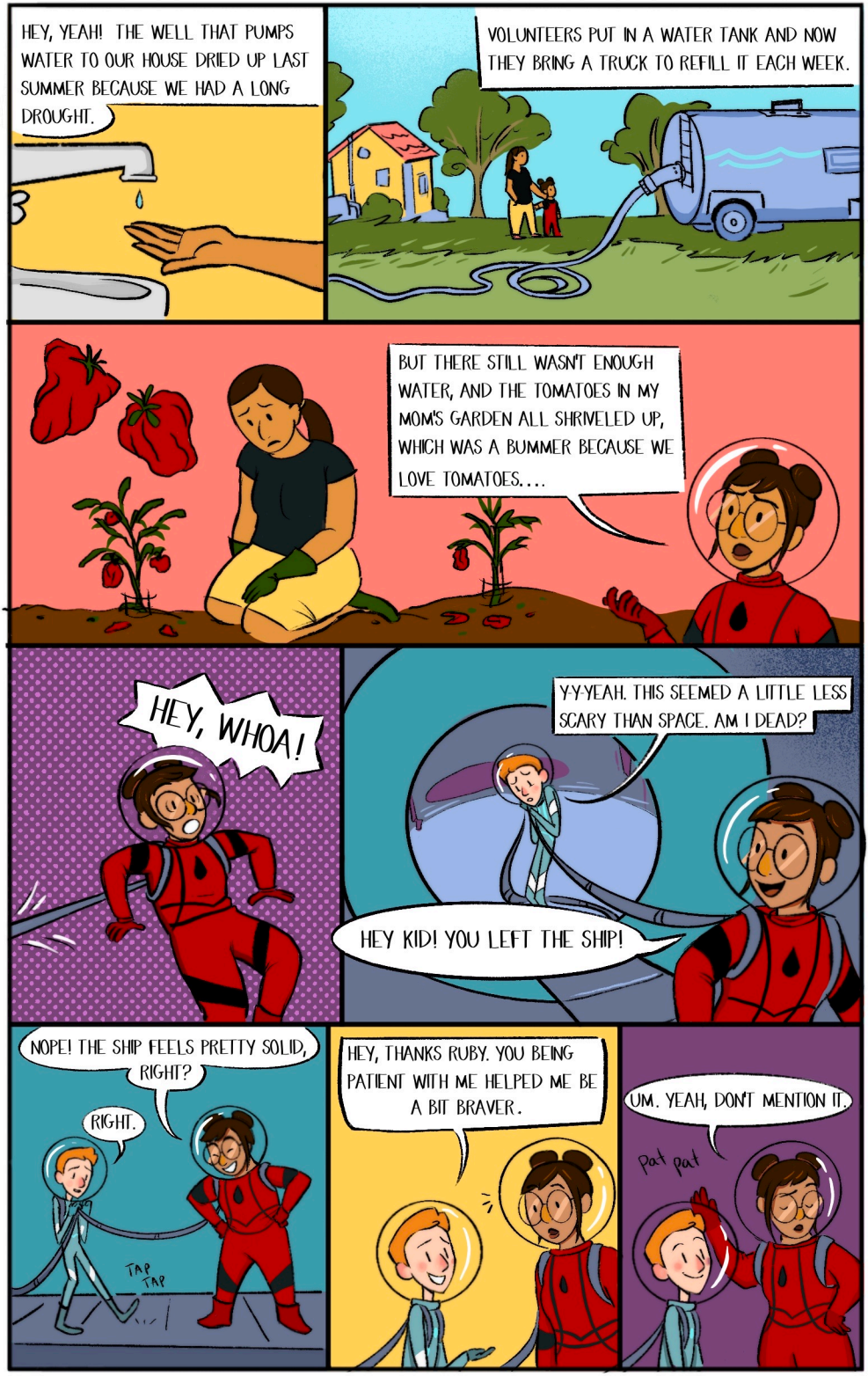
THE WATER CYCLE PT. 2

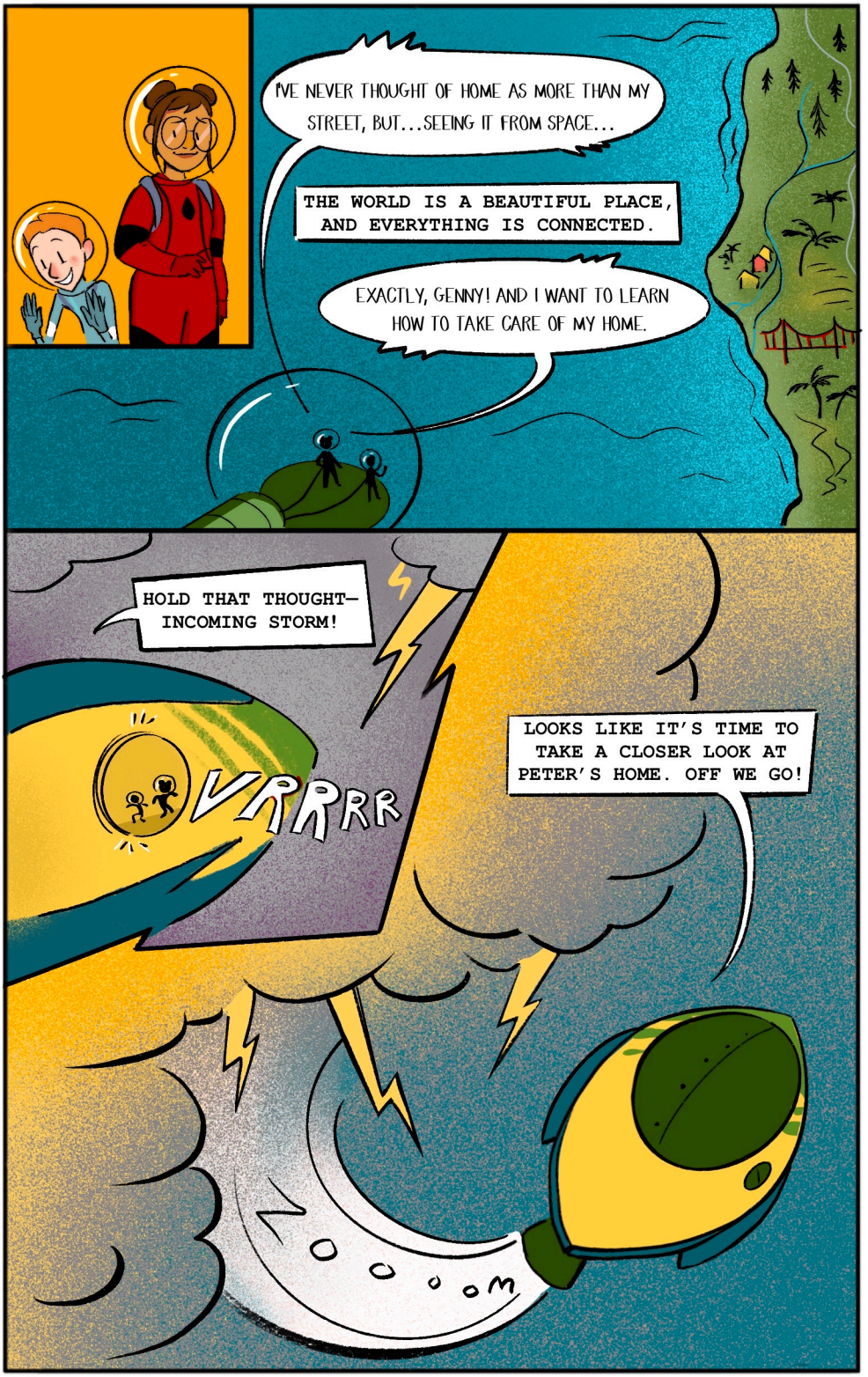

WATER IS ESSENTIAL TO ALL LIFE ON EARTH. NOTHING CAN LIVE WITHOUT IT, AND HUMANS ARE NO EXCEPTION. IN FACT, OVER HALF YOUR BODY IS MADE UP OF WATER!
IT LOOKS LIKE THE EARTH IS MOSTLY MADE UP OF WATER, TOO.
...WAIT A MINUTE, BACK UP. FROM ABOVE THE PLANET LOOKS SO BLUE. WHY DO I ALWAYS HEAR ABOUT DROUGHTS?
WHILE IT IS TRUE THAT THE MAJORITY OF EARTH'S SURFACE IS COVERED WITH WATER, MOST OF IT IS HARD TO GET TO OR UNUSABLE IN ITS CURRENT FORM.
97% OF THE WATER IS SALINE (OR SALT) WATER.
IT COULD ALSO BE FROZEN, POLLUTED, HARD TO REACH (LIKE GROUNDWATER), OR JUST NOT WHERE YOU NEED IT WHEN YOU NEED IT.
97%
DROUGHT!
CLIMATE CHANGE IS ALTERING WHERE AND WHEN PRECIPITATION FALLS...AND IT'S NOT OFTEN WHEN WE NEED IT.


MY BADMINTON TEAM GETS THE PARTICIPATION AWARD EVERY YEAR...
NOT PARTICIPATION,
PRE-CIP-I-TA-TION.
WATER THAT FALLS TO THE GROUND, LIKE RAIN OR SNOW.
OH! THAT MAKES MORE SENSE.
HEY, WAIT A SECOND. THAT'S— IT'S CALIFORNIA! THAT'S WHERE I'M FROM!
CALIFORNIA PRODUCES MORE FOOD THAN ANY OTHER REGION IN THE UNITED STATES.
A TREMENDOUS AMOUNT OF WATER GOES INTO THE PRODUCTION OF MEAT, DAIRY, NUTS, FRUITS, AND VEGETABLES.


WHEN WATER IS EVAPORATED FROM THE EARTH'S SURFACE IT GOES INTO THE ATMOSPHERE.
HERE, "CONDENSATION" OCCURS, WHICH IS ANOTHER PHASE CHANGE.
CONDENSATION IS WHEN WATER VAPOR CHANGES BACK INTO A LIQUID. WATER IN THE VAPOR STATE IS NOT VISIBLE, BUT SMALL LIQUID DROPLETS GROUPED TOGETHER CAN REFRACT SUNLIGHT MAKING VISIBLE CLOUDS.
AS MORE AND MORE DROPLETS COMBINE, PRECIPITATION BEGINS TO FALL.
SO ALL THAT RAIN IN THE SKY COMES DIRECTLY FROM THE OCEAN, RIGHT?
CORRECTION.
OCEAN EVAPORATION CONTRIBUTES TO A LOT OF EARTH'S PRECIPITATION, BUT REMEMBER THAT MOST OF THE EARTH IS COVERED IN OCEAN, WHERE THAT RAINFALL DIRECTLY RETURNS.
WE UNDERVALUE AND RARELY REPRESENT HOW LAND EVAPOTRANSPIRATION CONTRIBUTES TO INLAND PRECIPITATION.
FOR EXAMPLE, THE SNOW FALLING IN THE ROCKY MOUNTAINS LIKELY FELL AND EVAPORATED HALF A DOZEN TIMES BETWEEN THE PACIFIC OCEAN AND ITS FINAL DESTINATION.
AND THEN ALL THAT WATER THAT FALLS ENDS UP BACK IN THE OCEAN?
NOT NECESSARILY. SOME OF IT SOAKS DEEP INTO THE GROUND, WHERE IT CAN POOL IN PLACES CALLED AQUIFIERS. WE COMMONLY REFER TO THIS AS "GROUNDWATER".

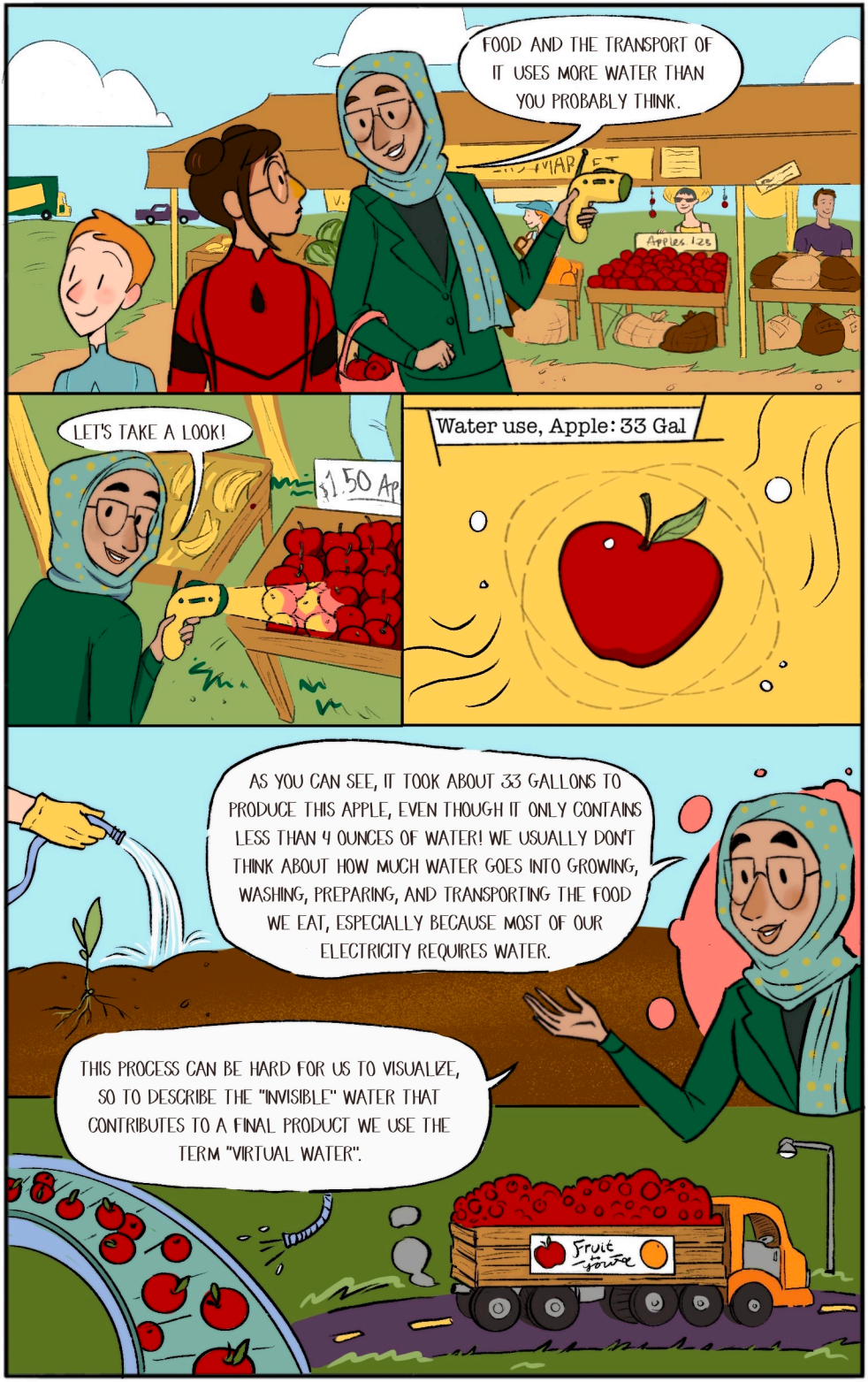

YOU MEAN THERE'S WATER UNDERNEATH US, LIKE, INSIDE THE EARTH?
YES, IN FACT ALMOST HALF OF CALIFORNIA'S AGRICULTURAL WATER SUPPLY COMES FROM WELLS THAT PUMP GROUNDWATER TO THE SURFACE FROM DEEP UNDERGROUND.
SO...LIKE AN UNDERGROUND LAKE?
THINK OF IT MORE LIKE A SPONGE. GROUNDWATER SOAKS DOWN INTO THE SOIL AND THROUGH SAND AND GRAVEL, SIFTING OUT POLLUTANTS AND COLLECTING IN POCKETS IN POROUS ROCKS. THESE WATER-SOAKED ROCK LAYERS UNDERGROUND ARE CALLED AQUIFERS.
THERE IS A LOT OF WATER UNDERGROUND, BUT WE CANNOT RELY ON IT LONG TERM BECAUSE OF HOW SLOWLY AQUIFERS REFILL.
WATER CAN MOVE UNDERGROUND UP TO ONE FOOT PER DAY, BUT ONE FOOT PER YEAR, OR EVEN ONE FOOT PER DECADE IS ALSO POSSIBLE.
HUMANS ARE PUMPING MORE AND MORE GROUNDWATER AS THE CLIMATE CHANGES AND AFFECTS RAINFALL. THIS CAN CAUSE THE GROUND TO SUBSIDE, OR SINK, LIKE A COLLAPSED JUICE BOX.

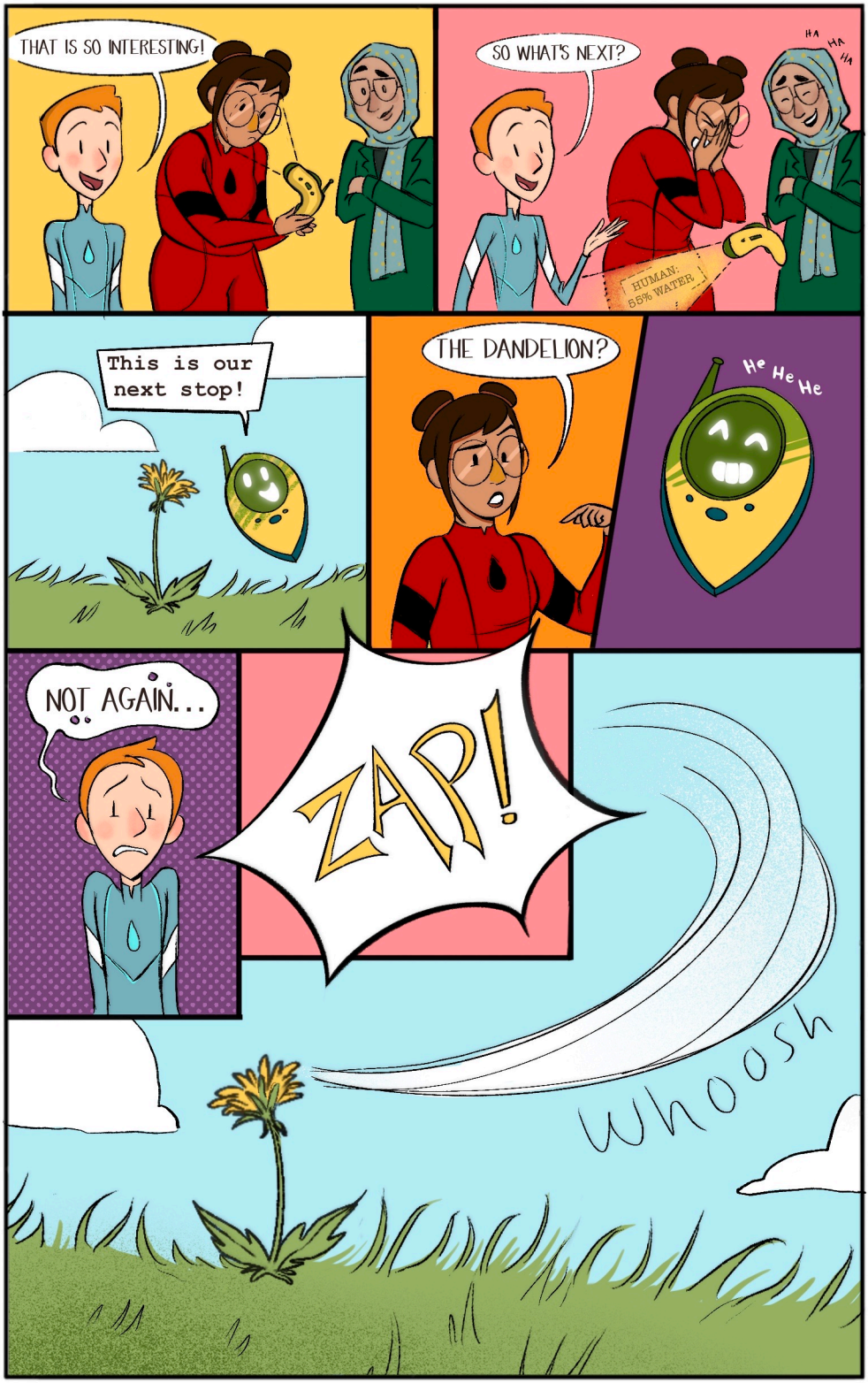

HEY, YEAH! THE WELL THAT PUMPS WATER TO OUR HOUSE DRIED UP LAST SUMMER BECAUSE WE HAD A LONG DROUGHT.
VOLUNTEERS PUT IN A WATER TANK AND NOW THEY BRING A TRUCK TO REFILL IT EACH WEEK.
BUT THERE STILL WASN'T ENOUGH WATER, AND THE TOMATOES IN MY MOM'S GARDEN ALL SHRIVELED UP, WHICH WAS A BUMMER BECAUSE WE LOVE TOMATOES....
HEY, WHOA!
Y-Y-YEAH. THIS SEEMED A LITTLE LESS SCARY THAN SPACE. AM I DEAD?
HEY KID! YOU LEFT THE SHIP!
NOPE! THE SHIP FEELS PRETTY SOLID, RIGHT?
RIGHT.
TAP TAP
HEY, THANKS RUBY. YOU BEING PATIENT WITH ME HELPED ME BE A BIT BRAVER.
UM. YEAH, DON'T MENTION IT.
Pat pat


I'VE NEVER THOUGHT OF HOME AS MORE THAN MY STREET, BUT...SEEING IT FROM SPACE...
THE WORLD IS A BEAUTIFUL PLACE, AND EVERYTHING IS CONNECTED.
EXACTLY, GENNY! AND I WANT TO LEARN HOW TO TAKE CARE OF MY HOME.
HOLD THAT THOUGHT— INCOMING STORM!
VRRRR
LOOKS LIKE IT'S TIME TO TAKE A CLOSER LOOK AT PETER'S HOME. OFF WE GO!
ZOOOOM


WE HAVE LANDED, WELCOME TO IDAHO.
Veggies
Fruit
OH, WE'RE AT A FARMER'S MARKET! WE SHOULD BUY SOME PLANTS!
RUBY AND PETER! HELLO!
HI HUDA! WHAT SCIENCE-Y STUFF AWAITS US HERE?
I'M GLAD YOU ASKED! HERE, TAKE THIS SCANNER. WHEN YOU POINT IT AT SOMETHING, IT WILL TELL YOU THE "WATER PRINT" OF AN ITEM, ITS JOURNEY THROUGH WATER.
HMMM...
WATER IS NEEDED TO GROW PLANTS LIKE COTTON THAT ARE USED TO MAKE CLOTHES. IN FACT, 3% OF THE WATER IN GLOBAL CROP PRODUCTION IS USED IN GROWING COTTON.
540G
2000G
WAIT, THERE ARE PLANTS IN MY CLOTHES?


A SINGLE COTTON SHIRT NEEDS 540 GALLONS OF WATER AND A PAIR OF JEANS REQUIRES OVER 2000 GALLONS OF WATER.
WITH THE OVERPRODUCTION OF NEW CLOTHES AND CONSUMERS PURCHASING THEM, THAT ADDS UP TO A LOT OF WATER USE! WE CAN HELP REDUCE THAT WATER FOOTPRINT BY BEING MINDFUL OF HOW OFTEN WE WASH OUR CLOTHES AND TRY TO SHOP FOR THEM SECONDHAND.
MANY ITEMS OF CLOTHING ARE WORN LESS THAN TEN TIMES BEFORE BEING DISCARDED. SHOPPING FOR LIGHTLY USED CLOTHING IS A MORE SUSTAINABLE AND WATER FRIENDLY OPTION, PLUS IT'S USUALLY CHEAPER!
HEY, I LOVE THRIFTING! SEEMS LIKE I'M SAVING WATER (AND MONEY) ONE PAIR OF CUTE SECOND-HAND PANTS AT A TIME. BEING A FASHIONABLE AND ENVIRONMENTALLY CONSCIOUS HERO FOR EARTH SEEMS LIKE MY KIND OF GIG.


FOOD AND THE TRANSPORT OF IT USES MORE WATER THAN YOU PROBABLY THINK.
Apples 1.25
LET'S TAKE A LOOK!
$1.50 Ap
Water use, Apple: 33 Gal
AS YOU CAN SEE, IT TOOK ABOUT 33 GALLONS TO PRODUCE THIS APPLE, EVEN THOUGH IT ONLY CONTAINS LESS THAN 4 OUNCES OF WATER! WE USUALLY DON'T THINK ABOUT HOW MUCH WATER GOES INTO GROWING, WASHING, PREPARING, AND TRANSPORTING THE FOOD WE EAT, ESPECIALLY BECAUSE MOST OF OUR ELECTRICITY REQUIRES WATER.
THIS PROCESS CAN BE HARD FOR US TO VISUALIZE, SO TO DESCRIBE THE "INVISIBLE" WATER THAT CONTRIBUTES TO A FINAL PRODUCT WE USE THE TERM "VIRTUAL WATER".
Fruit to your


THAT IS SO INTERESTING!
SO WHAT'S NEXT?
HA HA HA
HUMAN: 65% WATER
This is our next stop!
THE DANDELION?
He He He
NOT AGAIN...
ZAP!
Whoosh

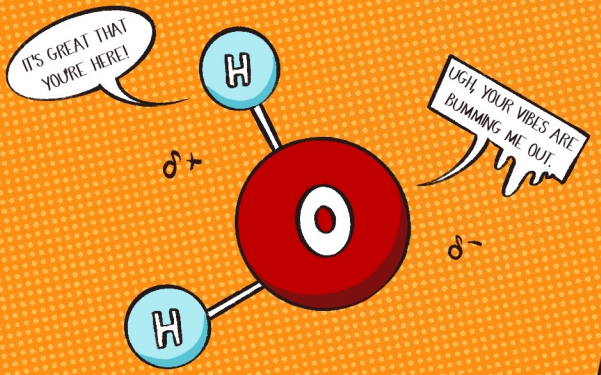

WELL, THIS IS ALL VERY—GREEN. WHERE ARE WE NOW?
WE'RE INSIDE THE STEM OF A PLANT.
IN ORDER TO MAKE THIS PALATABLE TO YOUR HUMAN MINDS, WATER HAS BEEN TRANSFORMED INTO A HUMAN-LIKE FORM YOU CAN GRASP.
LIKE A FILTER ON A PHONE, BUT... FOR MY BRAIN? HOW CAN SOMETHING BE SO TERRIFYING AND COOL AT THE SAME TIME?
AH, HERE COMES SOME WATER NOW.
WATER


WHAT IS HE DOING?
WATER, FRANKLY, IS A WEIRD, UNIQUE MOLECULE, WHICH ALLOWS IT TO MOVE IN INTERESTING WAYS.
WHY DO I GET THE FEELING HE AND JIJI WOULD GET ALONG REALLY WELL...?
'SUP MY LIL' GNARLY DUDES?
WHY ARE YOU WEARING SHADES? WE'RE INSIDE.
I'M A FIGMENT OF YOUR IMAGINATION. WHY'D YOU PUT ME IN SHADES?
...
TOUCHÉ.

THAT WAS A LITTLE FEISTY.

WHY IS EVERYONE SO SASSY IN THE WORLD OF SCIENCE?

APOLOGIES—WATER IS A POLAR MOLECULE, MEANING IT'S POSITIVE ON ONE END AND NEGATIVE ON THE OTHER.



BUT IT ALSO MEANS HE WON'T BOIL OVER EASILY...

HIS SCIENTIFIC PROPERTY OF HAVING A HIGH BOILING POINT TRANSLATES TO HIS PERSONALITY—IN THIS CASE IT MEANS HE TAKES A LONG TIME TO WARM UP TO PEOPLE.

WHICH IS WHY I ASSUME HE'S BEEN PERSONIFIED AS A 1990s SURFER BUFFOON.


WHOA
SWOOOP!
Xylem-vator

YOU'LL NEVER LEAVE, RIGHT MAN?

NEVER!

HE SEEMS A LITTLE...CLINGY.

ANOTHER RESULT OF BEING A POLAR MOLECULE.

THE POSITIVE AND NEGATIVE ENDS ATTRACT, ALLOWING WATER MOLECULES TO STICK TOGETHER LIKE A MAGNET.

THAT GIVES WATER THE ABILITY TO CLING AND TRAVEL UPWARDS THROUGH STRUCTURES LIKE THIS LEAF STEM.

THIS IS CALLED THE CAPILLARY EFFECT, AND IT ALLOWS WATER FLOW THROUGH PLANTS.

IT ALSO LETS IT TRAVEL THROUGH BLOOD VESSELS IN ANIMALS AND HUMANS.

BECAUSE WATER IS POLAR, IT'S GOOD AT DISSOLVING THINGS-THIS HELPS IT CARRY SALT AND NUTRIENTS THROUGHOUT PLANTS OR BODIES TO NOURISH THEM.


BUT SOMETIMES I'M TOO GOOD AT DISSOLVING THINGS. I DISSOLVE A LOT OF CHEMICALS EASILY AND I'M OFTEN USED TO RINSE AND WASH OFF TOXINS FROM THINGS. IT'S A REAL BUMMER.
UGH, I SAW SOME OF THAT EARLIER—IT MAKES ME SO MAD! I CAN'T BELIEVE PEOPLE WOULD DO THAT TO YOU!
Leaf #2
WELL, WHEN YOU'RE EVERYWHERE IT'S EASY TO BE TAKEN FOR GRANTED.
I WON'T. NOT ANYMORE.
SO WATER CAN MOVE THROUGHOUT LIVING THINGS, AND IT'S REALLY IMPORTANT. DIDN'T YOU SAY HE MOVES ACROSS THE EARTH, TOO?
RIGHT YOU ARE!
TEMPERATURES ON EARTH ARE PERFECT FOR WATER TO CHANGE PHASES.
IT IS COLD ENOUGH TO FREEZE WATER, AND HOT ENOUGH TO EVAPORATE IT. IN FACT, WE HAVE LARGE AMOUNTS OF ALL THREE PHASES: ICE, FLOWING WATER, AND WATER VAPOR ALL AROUND US.

AND IT MEANS ICE, WATER AND WATER VAPOR CAN MOVE IN UNIQUE AND SEPARATE PATHWAYS.

WHAT DO YOU MEAN BY THAT?

WELL, ICE--WATER'S SOLID FORM-- MOVES VERY SLOWLY. USUALLY IT FLOWS DOWNHILL WITH GRAVITY OR DRIFTS WITH OCEAN CURRENTS LIKE ICEBERGS.

YET ANOTHER ONE OF WATER'S UNIQUE AND IMPORTANT PROPERTIES.

NOW THAT I THINK ABOUT IT, IT'S TOTALLY WEIRD THAT SOLID ICE FLOATS ON LIQUID WATER.

WHEN WATER FREEZES, ITS POLARITY LOCKS IT INTO A CRYSTAL SHAPE THAT CAUSES IT TO EXPAND.

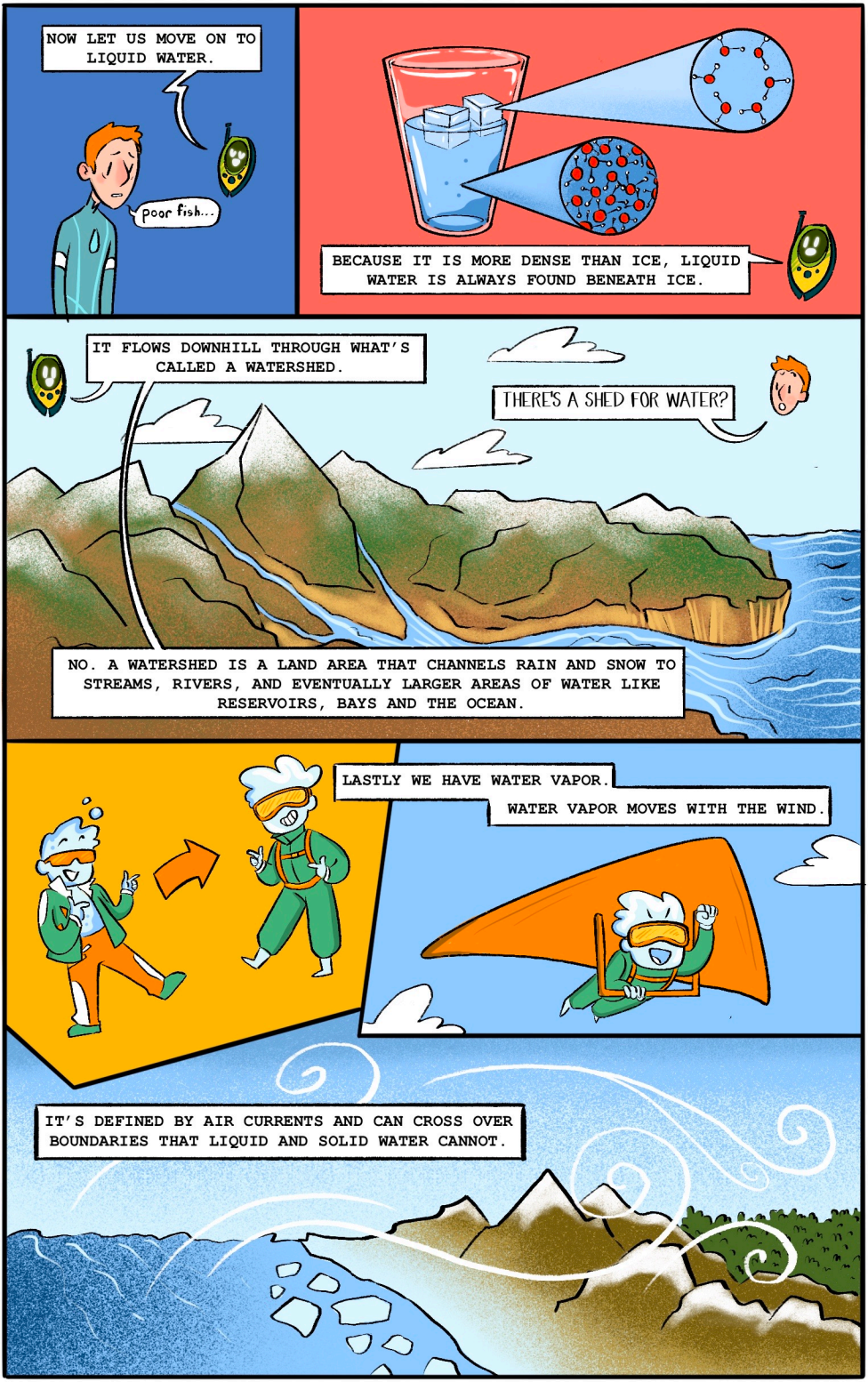
IS THAT LIKE THE CAN OF GINGER ALE I LEFT IN MY CAR LAST WINTER? IT EXPLODED.

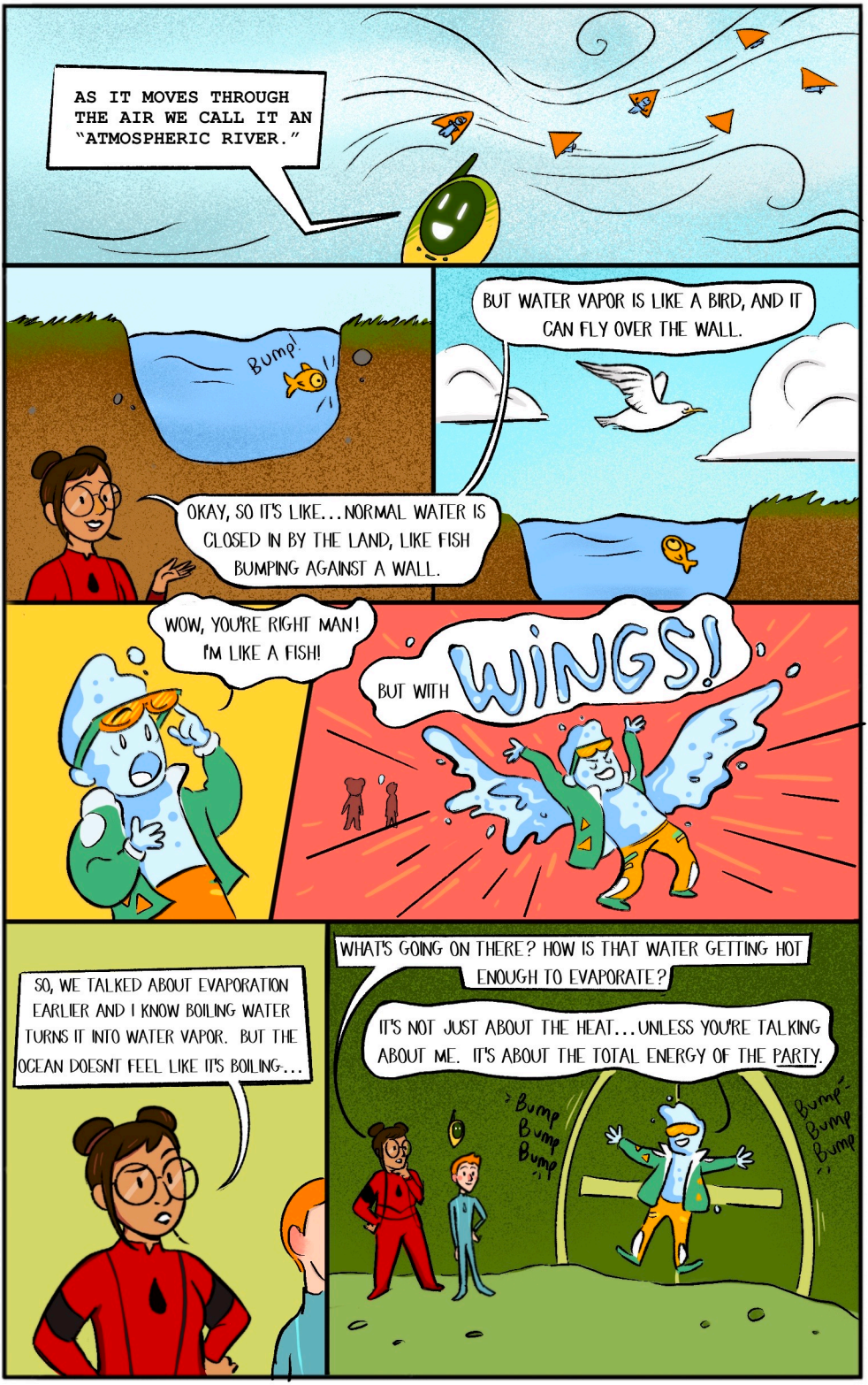
YES—AS THE LIQUID TURNED TO ICE, IT BECAME BIGGER THAN THE CONTAINER IT WAS IN.

OUT IN THE WILD, IF WATER DIDN'T EXPAND WHEN IT FROZE, IT WOULD SINK TO THE BOTTOM OF EVERY LAKE, RIVER AND OCEAN.

THIS WOULD CRUSH OR SUFFOCATE ALL AQUATIC LIFE LIVING BENEATH IT WITH DEVASTATING EFFICIENCY.

THUD!


NOW LET US MOVE ON TO LIQUID WATER.
poor fish...
BECAUSE IT IS MORE DENSE THAN ICE, LIQUID WATER IS ALWAYS FOUND BENEATH ICE.
IT FLOWS DOWNHILL THROUGH WHAT'S CALLED A WATERSHED.
THERE'S A SHED FOR WATER?
NO. A WATERSHED IS A LAND AREA THAT CHANNELS RAIN AND SNOW TO STREAMS, RIVERS, AND EVENTUALLY LARGER AREAS OF WATER LIKE RESERVOIRS, BAYS AND THE OCEAN.
LASTLY WE HAVE WATER VAPOR.
WATER VAPOR MOVES WITH THE WIND.
IT'S DEFINED BY AIR CURRENTS AND CAN CROSS OVER BOUNDARIES THAT LIQUID AND SOLID WATER CANNOT.


AS IT MOVES THROUGH THE AIR WE CALL IT AN "ATMOSPHERIC RIVER."
Bump!
OKAY, SO IT'S LIKE...NORMAL WATER IS CLOSED IN BY THE LAND, LIKE FISH BUMPING AGAINST A WALL.
BUT WATER VAPOR IS LIKE A BIRD, AND IT CAN FLY OVER THE WALL.
WOW, YOU'RE RIGHT MAN! I'M LIKE A FISH!
BUT WITH WINGS!
SO, WE TALKED ABOUT EVAPORATION EARLIER AND I KNOW BOILING WATER TURNS IT INTO WATER VAPOR. BUT THE OCEAN DOESNT FEEL LIKE IT'S BOILING...
WHAT'S GOING ON THERE? HOW IS THAT WATER GETTING HOT ENOUGH TO EVAPORATE?
IT'S NOT JUST ABOUT THE HEAT...UNLESS YOU'RE TALKING ABOUT ME. IT'S ABOUT THE TOTAL ENERGY OF THE PARTY.
Bump Bump Bump
Bump Bump Bump


I LIKE TO THINK OF IT AS...
A MOSHPIT!!
THE SUN GIVES US THE ENERGY WE NEED TO PARTY!
AND THE MORE SUN, THE WILDER THE PARTY GETS!
Do it!
Do it!
Do it!
SOME MOLECULES GET SO WOUND UP WITH GOOD VIBES THEY GO SAILING OUT OF THE CIRCLE AND INTO THE AIR.
WOOOO
...


WELL, THIS HAS BEEN REFRESHING TO SAY THE LEAST. WE'D BETTER GET GOING, SAY GOODBYE KIDS!
THANK YOU, BYE!
STAY FRESH, KIDDOS!
ZAP!
SO, WHAT HAVE BE LEARNED ABOUT OUR FRIEND WATER?
HE HAS A LOT OF TENSION ON THE SURFACE BUT DEEP DOWN HE'S PRETTY CHILL.
YEAH?
HEY, I'VE NOTICED YOU CAN BE A LITTLE LIKE WATER.
YUP, IT TAKES A WHILE FOR YOU TO WARM UP TO PEOPLE. SO...
SO WHAT? ARE YOU TRYING TO MAKE ME INTO SOME KIND OF CHEESY METAPHOR?
YES. BECAUSE I THINK WE'RE FRIENDS NOW!
AND I WANT YOU TO KNOW YOU CAN TRUST ME.
OH. UM... THANKS.
I DON'T REALLY KNOW WHY I PUSH PEOPLE AWAY. I GUESS I'VE HAD SOME WEIRD EXPERIENCES IN THE PAST WHERE OTHERS WANTED TO BE MY FRIEND BECAUSE THEY THOUGHT I'D MAKE THEM LOOK COOL, BUT THEY DIDN'T ACTUALLY KNOW ME.


WELL, I DON'T THINK YOU'RE COOL AT ALL!
THANKS?
YOU'RE WELCOME. YOU'RE A SCIENCE WEIRDO! WHY ELSE WOULD YOU BE HERE WITH ME?
YOU KNOW WHAT, WEIRDO? MAYBE I LIKE THAT.
Tussle Tussle
HUMANS.
THIS IS CERTAINLY HEARTWARMING, BUT ENOUGH BANTER!
ONWARDS AND UPWARDS!