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# *The Wide World of Chemical Engineering*





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# “The Wide World of Chemical Engineering”

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...WHAT SHOULD I DO  
IN THE FUTURE?



SORRY, I COULDN'T  
HELP BUT OVERHEAR!

WHAT DO YOU  
**WANT** TO DO?

I DON'T KNOW...

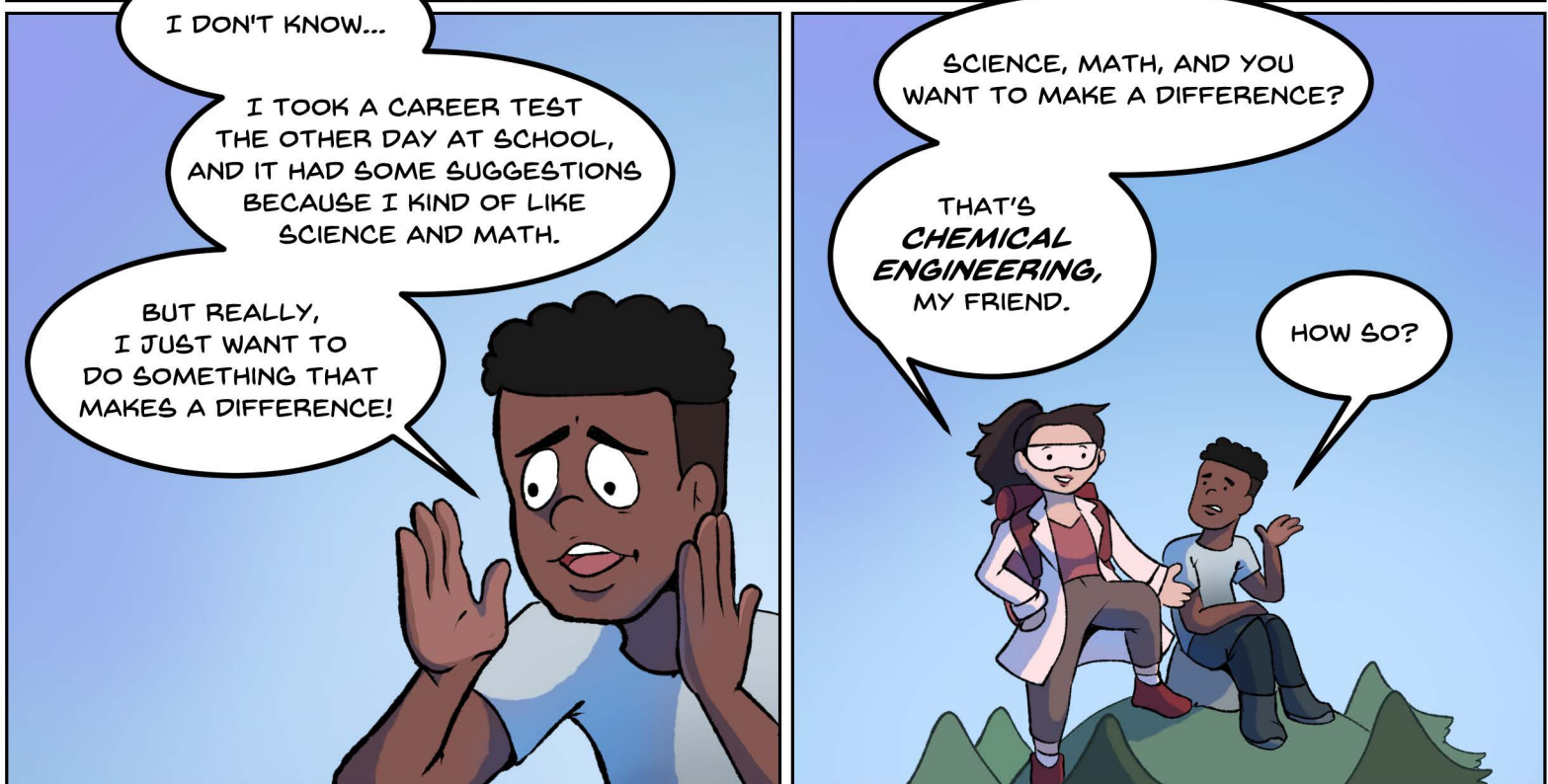
I TOOK A CAREER TEST  
THE OTHER DAY AT SCHOOL,  
AND IT HAD SOME SUGGESTIONS  
BECAUSE I KIND OF LIKE  
SCIENCE AND MATH.

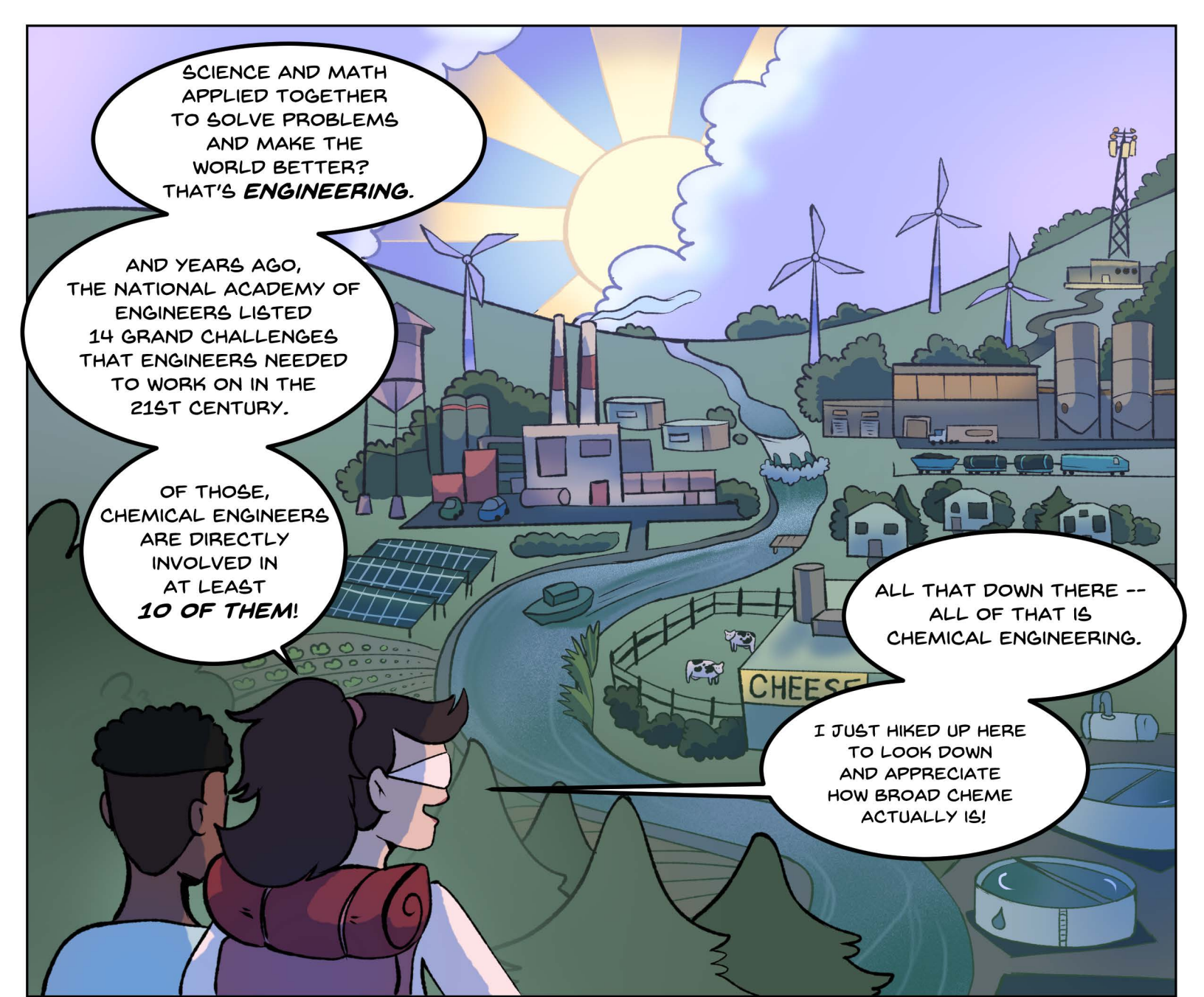
BUT REALLY,  
I JUST WANT TO  
DO SOMETHING THAT  
MAKES A DIFFERENCE!

SCIENCE, MATH, AND YOU  
WANT TO MAKE A DIFFERENCE?

THAT'S  
**CHEMICAL  
ENGINEERING,**  
MY FRIEND.

HOW SO?





SCIENCE AND MATH  
APPLIED TOGETHER  
TO SOLVE PROBLEMS  
AND MAKE THE  
WORLD BETTER?  
THAT'S **ENGINEERING**.

AND YEARS AGO,  
THE NATIONAL ACADEMY OF  
ENGINEERS LISTED  
14 GRAND CHALLENGES  
THAT ENGINEERS NEEDED  
TO WORK ON IN THE  
21ST CENTURY.

OF THOSE,  
CHEMICAL ENGINEERS  
ARE DIRECTLY  
INVOLVED IN  
AT LEAST  
**10 OF THEM!**

ALL THAT DOWN THERE --  
ALL OF THAT IS  
CHEMICAL ENGINEERING.

I JUST HIKE UP HERE  
TO LOOK DOWN  
AND APPRECIATE  
HOW BROAD CHEM  
ACTUALLY IS!

YEAH!!

DO YOU WANT ME  
TO SHOW YOU?

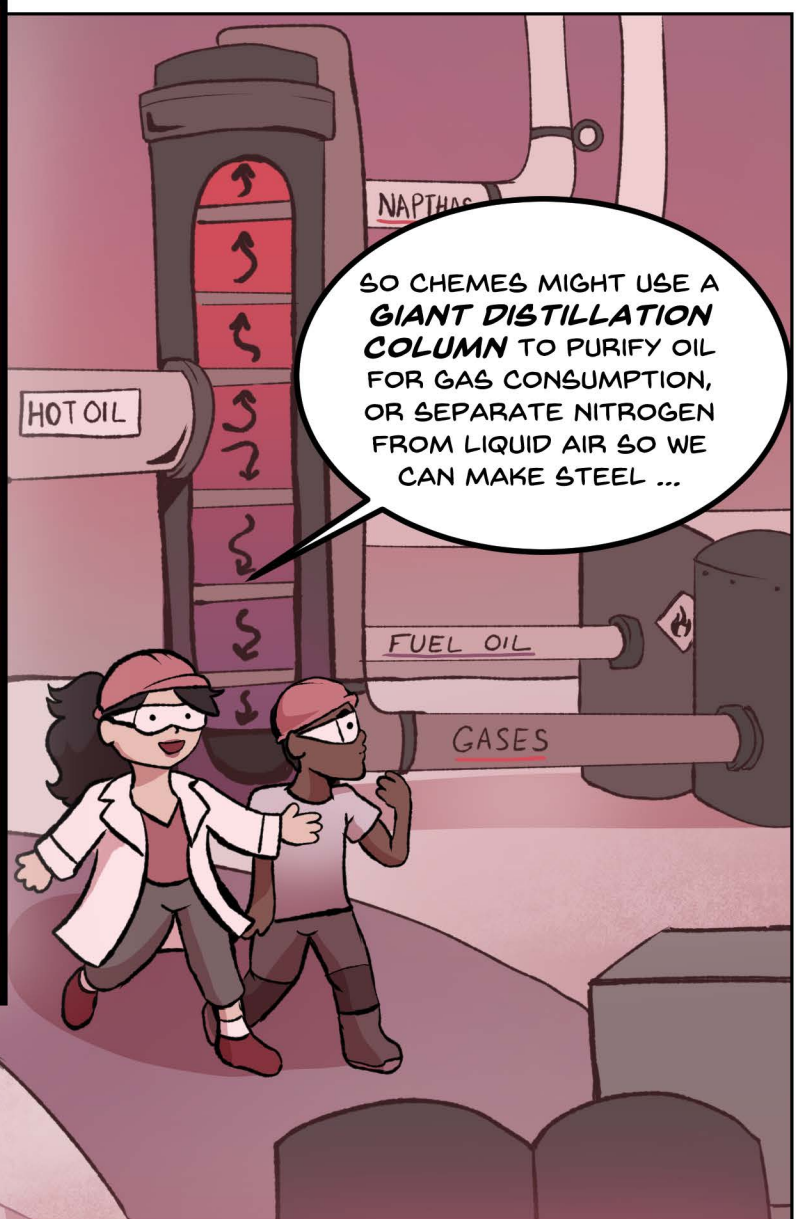
THEN LET'S GO IN  
AND TAKE A LOOK!

SO MOST PEOPLE ASSUME THAT CHEMICAL ENGINEERING IS THE PLACE TO BE IF YOU LIKE **MATH AND CHEMISTRY**. AND THAT'S PARTLY BECAUSE THEY DON'T REALIZE EVERYTHING THAT CHEMES ACTUALLY DO, BUT THERE'S SOME TRUTH TO IT, TOO.

FOR EXAMPLE, THERE ARE A LOT OF CHEMICALS WE NEED TO PRODUCE IN MASS QUANTITIES TO MEET PUBLIC DEMAND OR TO BE ABLE TO MAKE OTHER IMPORTANT PRODUCTS.



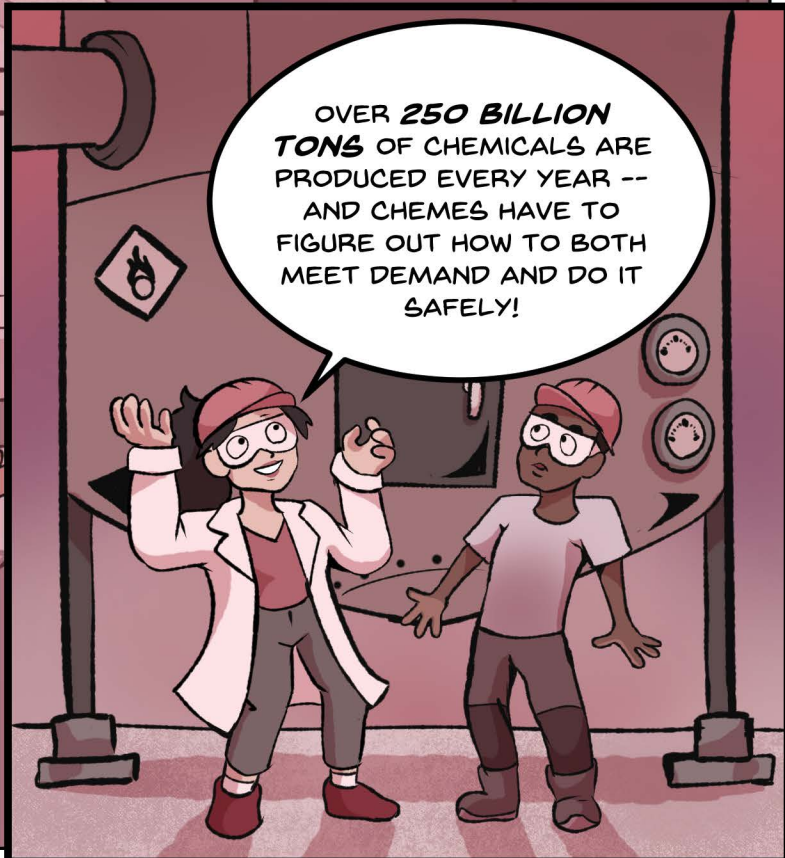
SO CHEMES MIGHT USE A **GIANT DISTILLATION COLUMN** TO PURIFY OIL FOR GAS CONSUMPTION, OR SEPARATE NITROGEN FROM LIQUID AIR SO WE CAN MAKE STEEL ...



OR MAYBE THEY'LL MAKE **SULFURIC ACID** THROUGH A FURNACE AND OTHER DEVICES, FOR USE IN FERTILIZERS OR TO MAKE OTHER CHEMICALS!



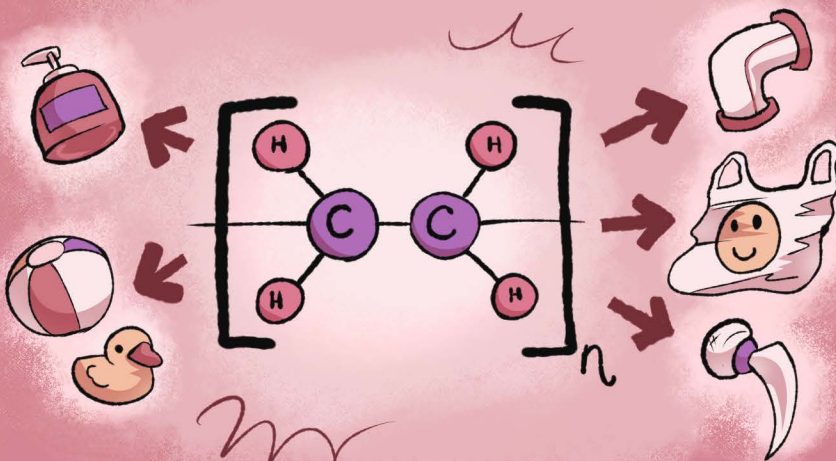
OVER **250 BILLION TONS** OF CHEMICALS ARE PRODUCED EVERY YEAR -- AND CHEMES HAVE TO FIGURE OUT HOW TO BOTH MEET DEMAND AND DO IT SAFELY!



...BILLION TONS?  
THAT'S A LOT OF  
CHEMISTRY.

DON'T JUST FOCUS  
ON THE CHEMISTRY,  
THOUGH. IT'S THE  
PROPERTIES OF THE  
MATERIALS  
THEMSELVES THAT  
MATTER JUST AS  
MUCH IF NOT MORE  
TO CHEMES.

LIKE PLASTICS! CONSIDER THE POLYMER CALLED  
**POLYETHYLENE**. DEPENDING ON HOW IT'S MADE, IT  
CAN BE USED IN PLASTIC BAGS, SOAP BOTTLES, TOYS,  
PIPES, OR EVEN HIP REPLACEMENTS! IT'S THE SAME  
BASIC CHEMICAL, BUT CHEMES CHANGE THE  
PROPERTIES SO IT HAS A WIDE RANGE OF USES!



MATERIAL SCIENCE, SUCH  
AS POLYMER SCIENCE, IS  
AN IMPORTANT FIELD  
THAT CHEMES PLAY A  
MASSIVE ROLE IN  
DEVELOPING, AND THE  
PRODUCT OF THEIR WORK  
IS ALL AROUND US!

IN OUR CLOTHES AND THE  
SYNTHETIC FIBERS THAT ARE WOVEN  
INTO THEM, THE METAL IN OUR  
APPLIANCES AND TECHNOLOGICAL  
DEVICES, EVEN THAT SLIME THAT  
SOME KIDS PLAY AROUND WITH WHEN  
THEY DON'T FEEL LIKE DOING  
HOMEWORK.

THAT'S A  
LOT MORE  
THAN JUST  
CHEMISTRY.

ANY MATERIAL YOU  
USE EVERY DAY WAS  
PROBABLY MADE OR  
TESTED BY A  
CHEMICAL ENGINEER.  
AND THIS GOES EVEN  
FOR THINGS THAT  
AREN'T PLASTIC OR  
MAN-MADE TOO!

WAIT, YOU SAID HIP  
REPLACEMENTS  
BEFORE. ISN'T  
THAT MEDICAL  
SCIENCE?

OH, CHEMES  
CAN DO A LOT  
OF GOOD  
MEDICALLY,  
AND BIOLOGICALLY,  
TOO. HERE, LET  
MY FRIEND  
SHOW YOU!

CHEMES ARE HEAVILY INVOLVED IN MEDICINE AND BIOLOGICAL FIELDS!

LIKE HIP REPLACEMENTS, OR OTHER MATERIALS THAT GO INSIDE SOMEONE'S BODY -- CHEMICAL ENGINEERS CAN FOCUS ON PRODUCING BIOMATERIALS THAT CAN INTERACT WITH THE HUMAN BODY AND WON'T BE CONTAMINATED OR REJECTED BY THE BODY.

AND ANY GOOD ENGINEER NEEDS GOOD TOOLS TO MEASURE WITH -- SO CHEMES ALSO WORK TO DEVELOP NEW SENSORS AND DEVICES THAT CAN DETECT EVEN SMALL TRACES OF DIFFERENT CHEMICALS FROM BLOOD OR OTHER SAMPLES.



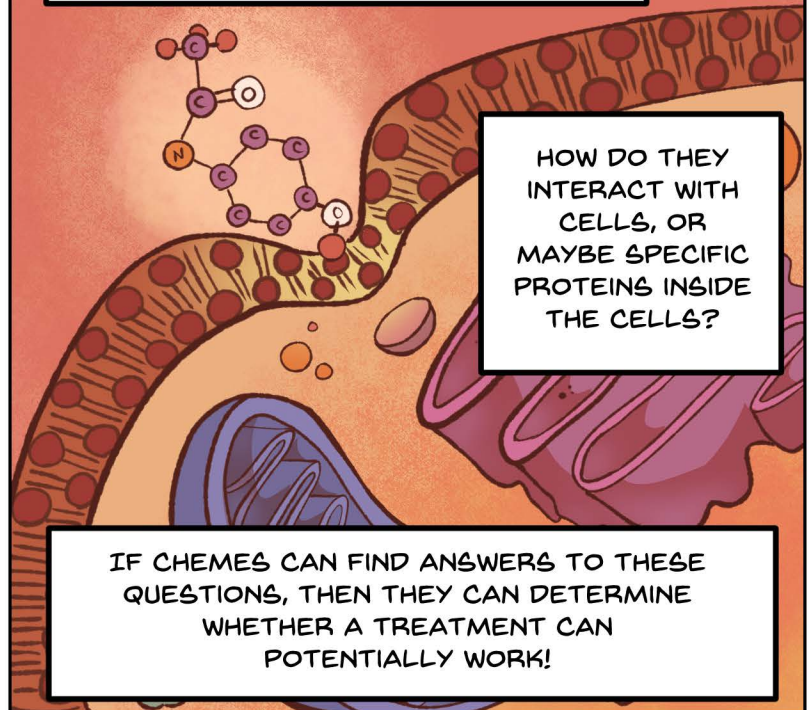
AND THAT LEADS TO A BIG PART OF CHEMICAL ENGINEERING WORK IN MEDICINES THEMSELVES! WE CALL IT '**DRUG DISCOVERY**' -- TRYING TO DETERMINE WHAT MEDICINES CAN PROVIDE TREATMENT, CURE DISEASES, FIGHT CANCER, AND MORE.


THE MOLECULES THAT ARE MADE COULD BE ALL THE WAY DOWN ON THE NANOSCALE -- HOW DO THEY MOVE INSIDE BLOOD? INSIDE **HUMAN TISSUE?**

HOW DO THEY INTERACT WITH CELLS, OR MAYBE SPECIFIC PROTEINS INSIDE THE CELLS?

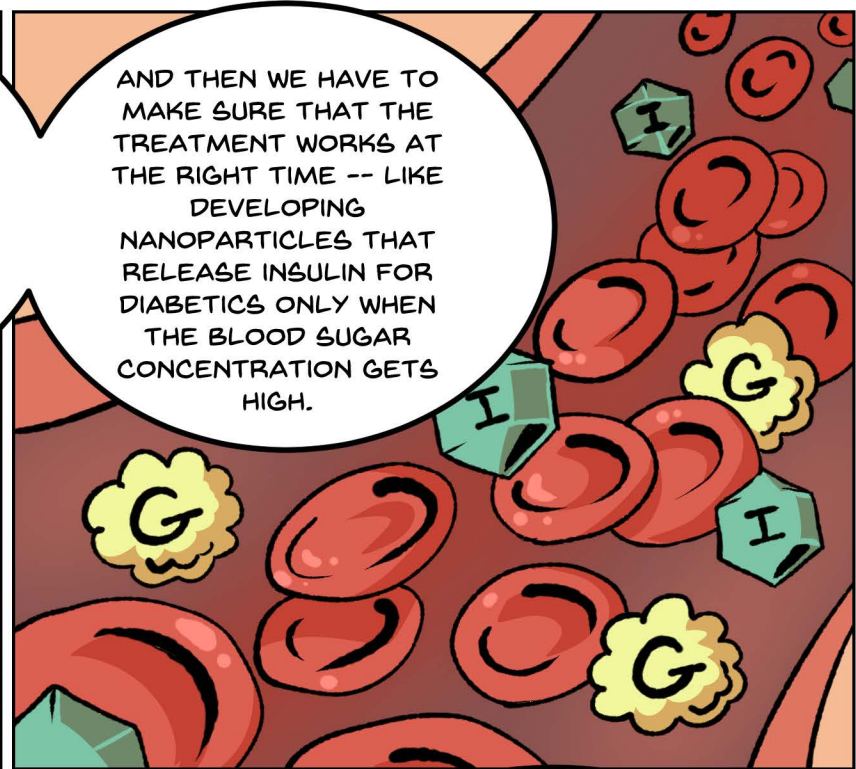


IF CHEMES CAN FIND ANSWERS TO THESE QUESTIONS, THEN THEY CAN DETERMINE WHETHER A TREATMENT CAN POTENTIALLY WORK!





ALL THAT LEADS TO THE NEXT STEP -- WHAT WE CALL **'DRUG DELIVERY'**. HOW DO WE TARGET CERTAIN SPECIFIC AREAS INSIDE THE BODY FOR TREATMENT? HOW DO THEY EVADE THE BODY'S NATURAL IMMUNE RESPONSE?

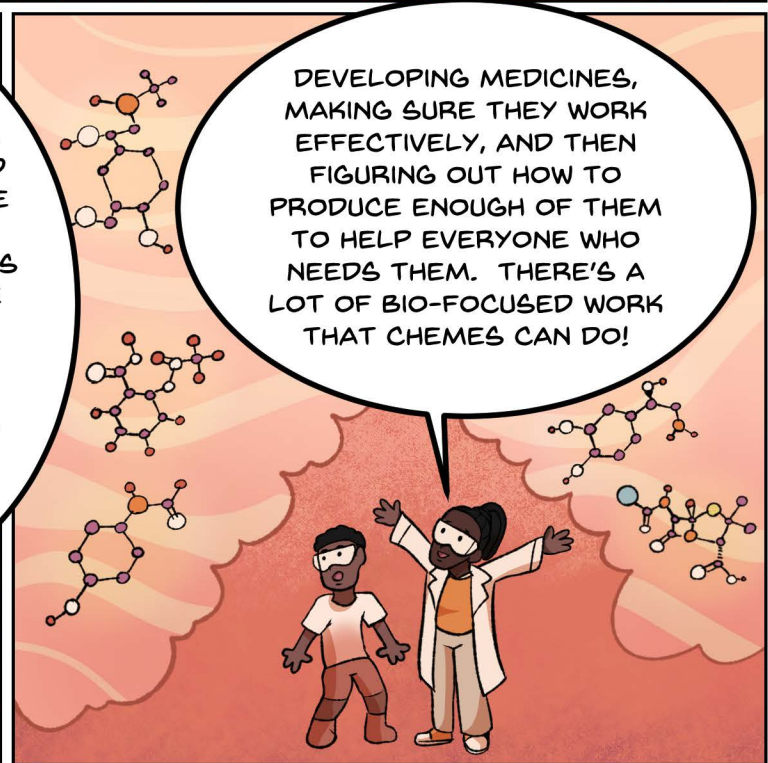


AND THEN WE HAVE TO MAKE SURE THAT THE TREATMENT WORKS AT THE RIGHT TIME -- LIKE DEVELOPING NANOPARTICLES THAT RELEASE INSULIN FOR DIABETICS ONLY WHEN THE BLOOD SUGAR CONCENTRATION GETS HIGH.



BUT AREN'T THERE ALSO BIOENGINEERS?

TRUE, AND BIOENGINEERS ARE HIGHLY SPECIALIZED TO FOCUS ON THESE PROBLEMS. BUT CHEMICAL ENGINEERS CAN TACKLE THESE SAME PROBLEMS, AND POTENTIALLY APPLY A BROADER SET OF SOLUTIONS TO ADDRESS THE CHALLENGES AT HAND!



DEVELOPING MEDICINES, MAKING SURE THEY WORK EFFECTIVELY, AND THEN FIGURING OUT HOW TO PRODUCE ENOUGH OF THEM TO HELP EVERYONE WHO NEEDS THEM. THERE'S A LOT OF BIO-FOCUSED WORK THAT CHEMES CAN DO!



AND WE'RE JUST GETTING STARTED ON THE MATERIALS THAT CHEMICAL ENGINEERING WORKS WITH!

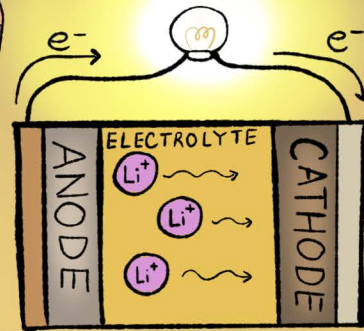


CHEMICAL MATERIALS, BIOMATERIALS... AND THEN THERE'S **ELECTROMATERIALS**. AND ENERGY! AND BATTERIES! A WHOLE OTHER FIELD WITHIN CHEMICAL ENGINEERING!



WAIT, BATTERIES? HOW IS THAT A CHEMICAL ENGINEERING CONCERN?

BATTERIES ARE BASICALLY JUST CHEMICAL PROCESSES -- AND INSIDE EACH BATTERY IS PRACTICALLY A MINIATURE FACTORY, WITH ALL THE PROCESSES GOING ON INSIDE!




AND THEY'RE A HUGE CONCERN TO MAKE SURE THAT WE CAN MEET THE DEMAND TO POWER ALL OUR EQUIPMENT AND DEVICES.


USUALLY, MOST BATTERIES ARE LITHIUM-ION OR LEAD-ACID BASED, BUT THOSE CAN BE EXPENSIVE OR HAVE TOXIC CHEMICALS. WE NEED SOLUTIONS THAT CAN PROVIDE MORE POWER AT A LOWER COST WITH SAFER CHEMICALS.

AND CHEMICALLY, THIS IS ALSO A STABILITY CONCERN. LITHIUM IS SO REACTIVE THAT IT CAN FORM **MICROFIBERS** WHICH CAN SHORT-CIRCUIT THE BATTERY -- SO ALTERNATIVES NEED TO BE ABLE TO HOLD UP TO LONG-TERM USE, TOO.

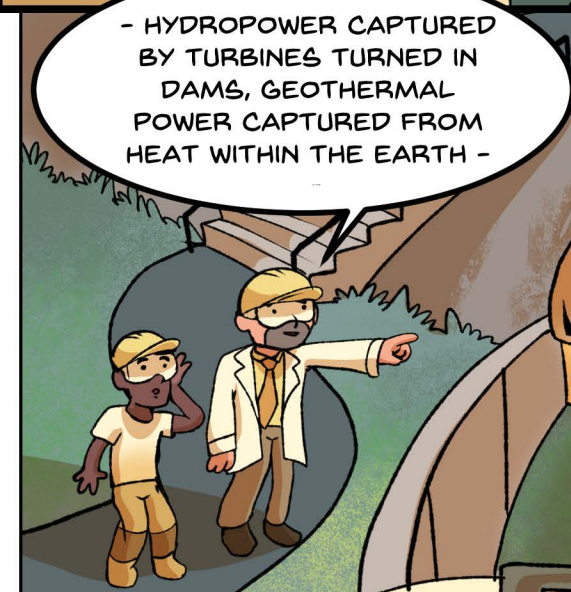
BUT CHEMICAL ENGINEERS ARE HARD AT WORK, RESEARCHING NEW MATERIAL COMBINATIONS AND TESTING THEM OUT!



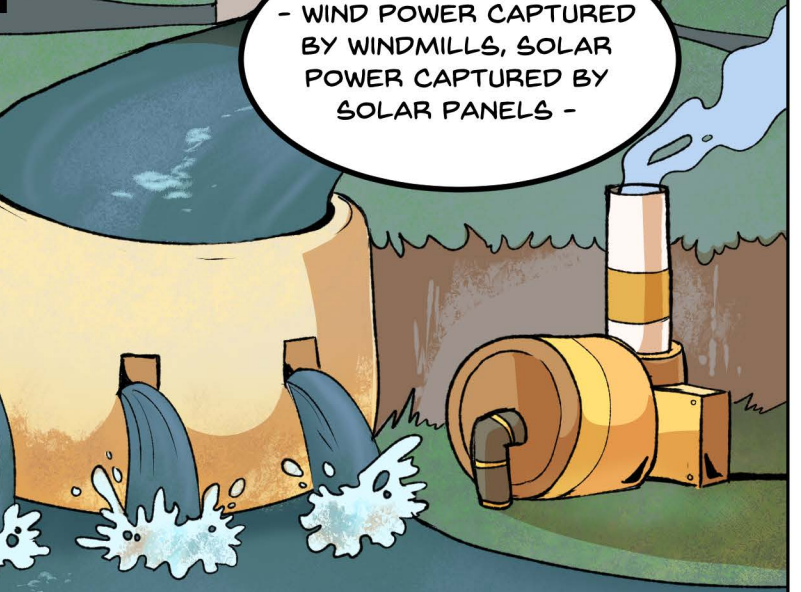
AND IT'S NOT JUST PROVIDING POWER THAT'S AN ENGINEERING CHALLENGE -- BUT ALSO HAVING A PLACE TO STORE IT!




THINK ABOUT THE RENEWABLE RESOURCES AVAILABLE TO US -



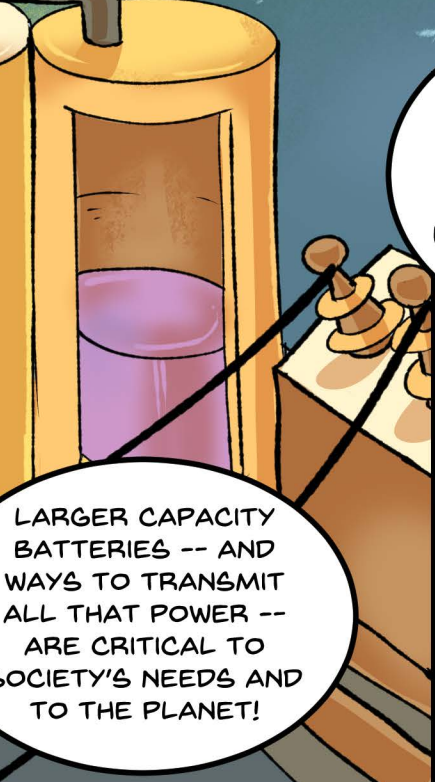
- HYDROPOWER CAPTURED BY TURBINES TURNED IN DAMS, GEOTHERMAL POWER CAPTURED FROM HEAT WITHIN THE EARTH -



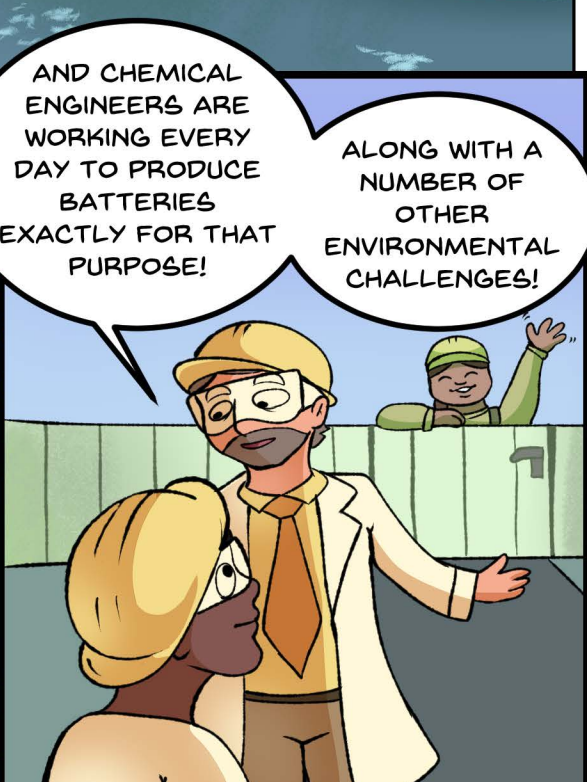
- WIND POWER CAPTURED BY WINDMILLS, SOLAR POWER CAPTURED BY SOLAR PANELS -



IT'S GREAT TO HAVE ALL THESE RESOURCES AVAILABLE SO WE CAN CUT DOWN ON OUR USE OF FOSSIL FUELS, BUT WE NEED A WAY TO STORE ALL THAT ENERGY TO MAKE THEM PRACTICAL SOLUTIONS.

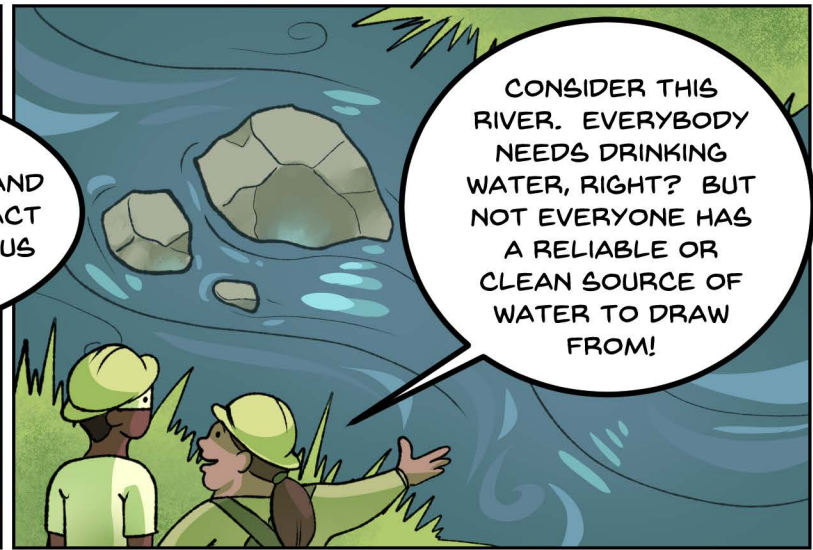
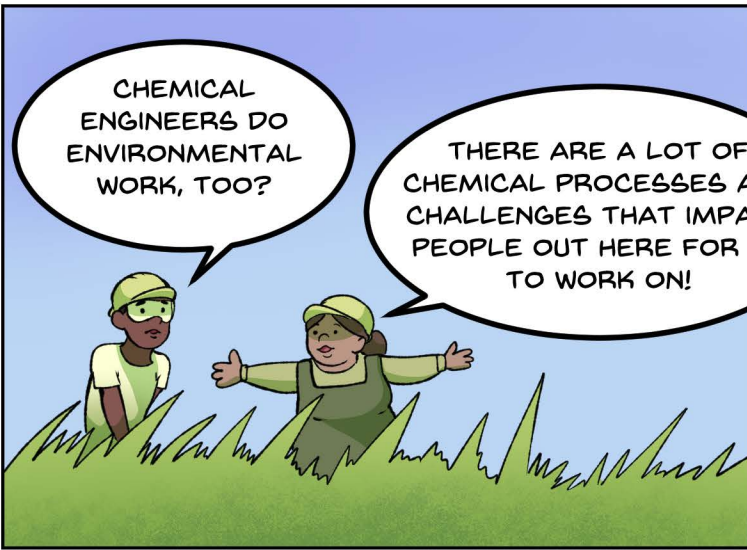


LARGER CAPACITY BATTERIES -- AND WAYS TO TRANSMIT ALL THAT POWER -- ARE CRITICAL TO SOCIETY'S NEEDS AND TO THE PLANET!

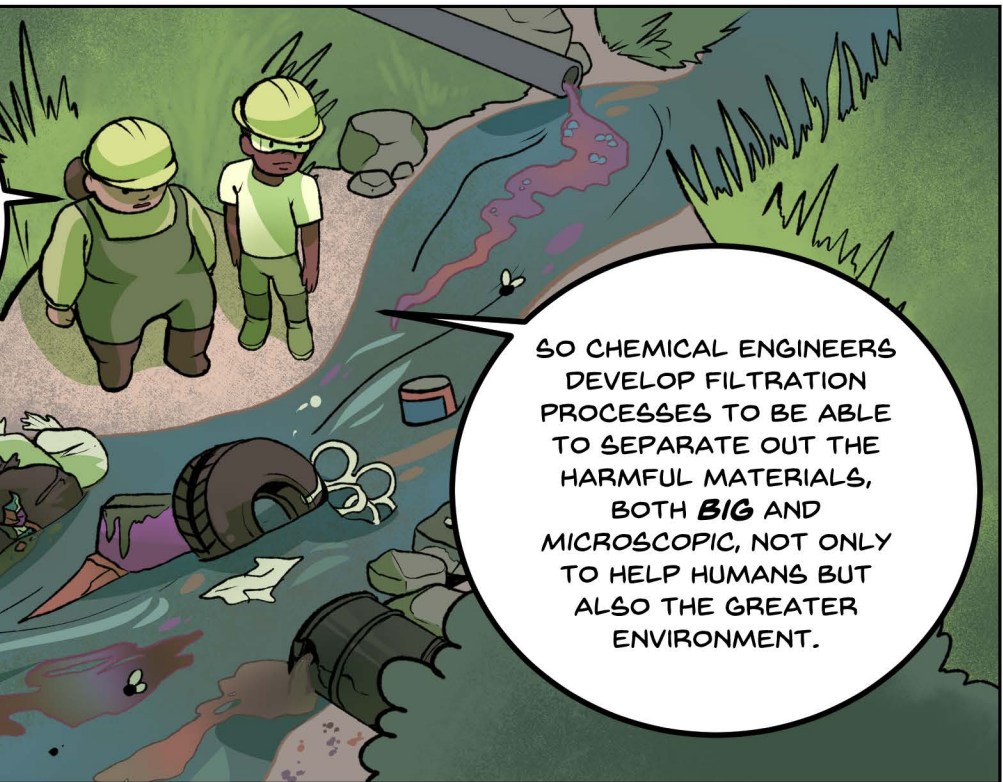
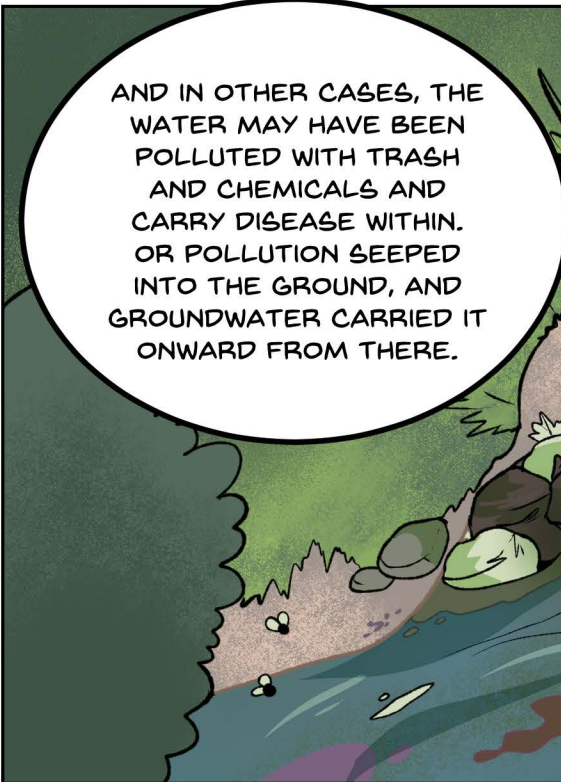


AND CHEMICAL ENGINEERS ARE WORKING EVERY DAY TO PRODUCE BATTERIES EXACTLY FOR THAT PURPOSE!

ALONG WITH A NUMBER OF OTHER ENVIRONMENTAL CHALLENGES!



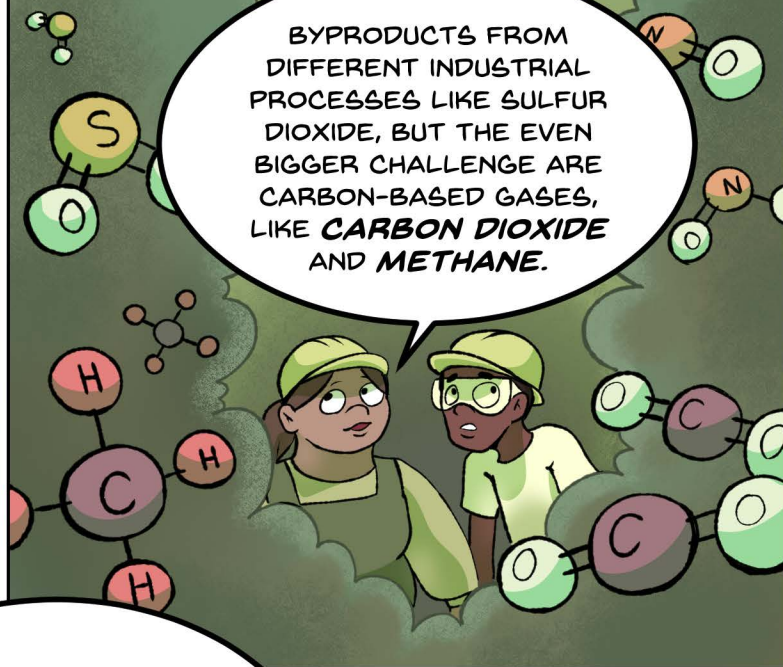
IN AREAS WHERE SALT WATER IS MOST PREVALENT, CHEMICAL ENGINEERS USE A PROCESS CALLED **REVERSE OSMOSIS** THAT ALLOWS THEM TO SEPARATE OUT SALT AND PROVIDE POTABLE WATER. IN SOME AREAS OF THE WORLD, THERE ARE GIANT FACILITIES THAT CAN PRODUCE MILLIONS OF GALLONS OF WATER PER DAY!



AND THEN THERE ARE CHEMICALS IN THE AIR THAT NEED SEPARATION, TOO. AND CHEMES CAN USE SYSTEMS LIKE **GAS ABSORBERS** OR FILTRATION TO REMOVE THOSE CONTAMINANTS.



BYPRODUCTS FROM DIFFERENT INDUSTRIAL PROCESSES LIKE SULFUR DIOXIDE, BUT THE EVEN BIGGER CHALLENGE ARE CARBON-BASED GASES, LIKE **CARBON DIOXIDE** AND **METHANE**.



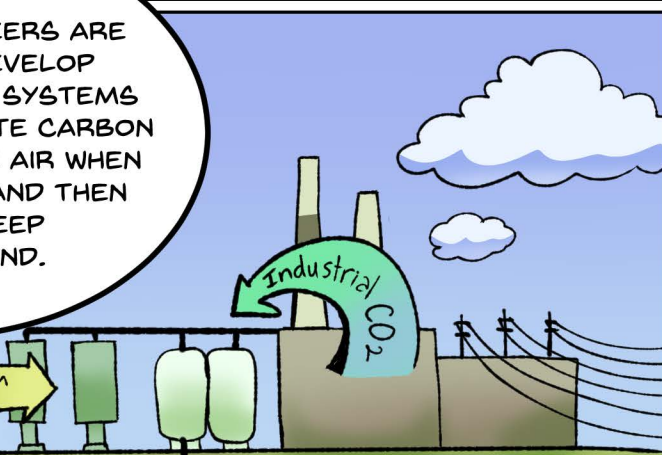
CARBON DIOXIDE IS A NATURAL PRODUCT OF COMBUSTION, WHICH HAS BEEN OUR MAJOR MEANS OF ENERGY PRODUCTION FOR DECADES -- BUT IT ALSO IS CHIEFLY RESPONSIBLE FOR HEATING THE PLANET AND INDUCING CLIMATE CHANGE.

CHEMICAL ENGINEERS ARE WORKING TO DEVELOP CARBON CAPTURE SYSTEMS THAT WILL SEPARATE CARBON DIOXIDE FROM THE AIR WHEN IT IS PRODUCED, AND THEN STORE IT DEEP UNDERGROUND.



CO<sub>2</sub> from AIR

Industrial CO<sub>2</sub>



Coal mine

Depleted Gas Reservoir

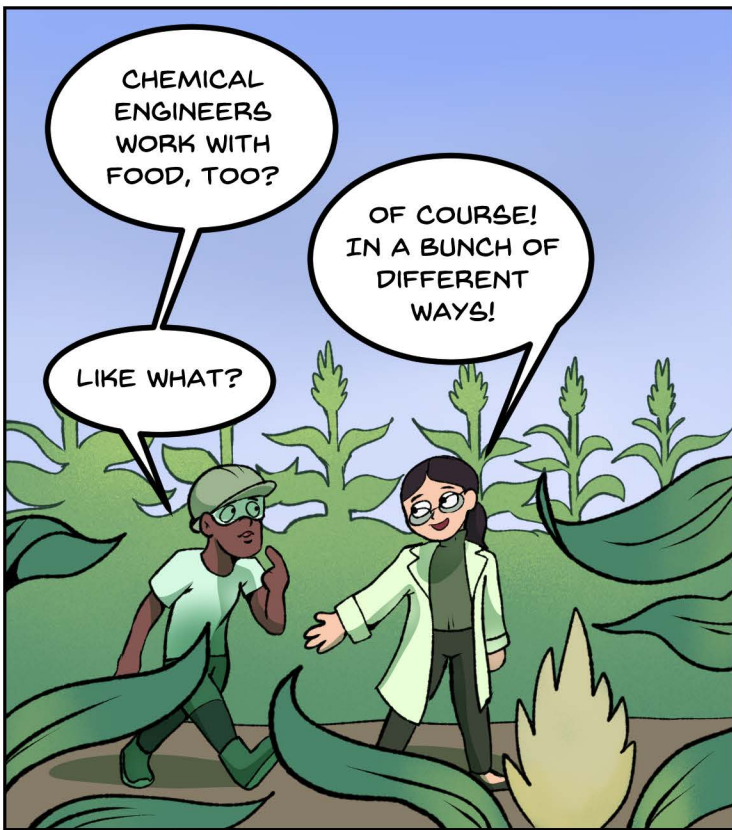
Deep Aquifer

THIS IS A TREMENDOUS CHALLENGE, BUT CHEMICAL ENGINEERS ARE UP FOR THE TASK!

SO CHEMICAL ENGINEERS ARE HEAVILY INVOLVED IN TAKING CARE OF THE ENVIRONMENT-

AS WELL AS ALL THE FOOD WE DRAW FROM IT!

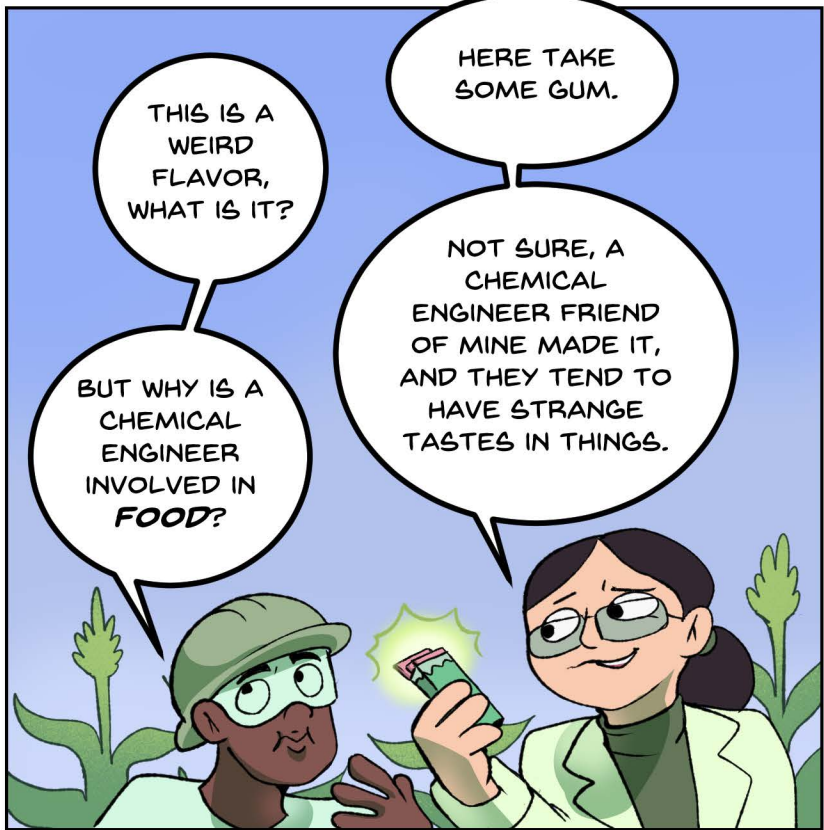




CHEMICAL ENGINEERS WORK WITH FOOD, TOO?

OF COURSE! IN A BUNCH OF DIFFERENT WAYS!

LIKE WHAT?

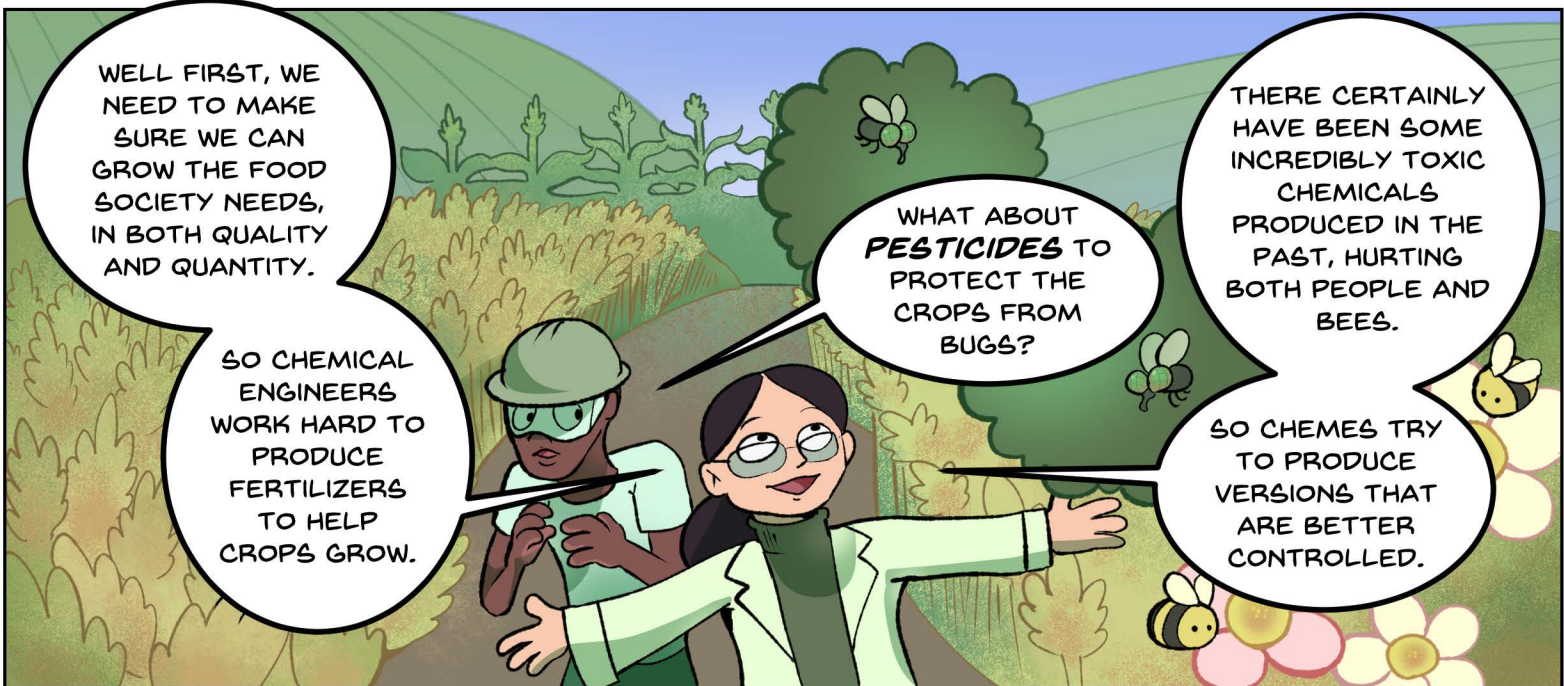


HERE TAKE SOME GUM.

THIS IS A WEIRD FLAVOR, WHAT IS IT?

BUT WHY IS A CHEMICAL ENGINEER INVOLVED IN **FOOD**?

NOT SURE, A CHEMICAL ENGINEER FRIEND OF MINE MADE IT, AND THEY TEND TO HAVE STRANGE TASTES IN THINGS.



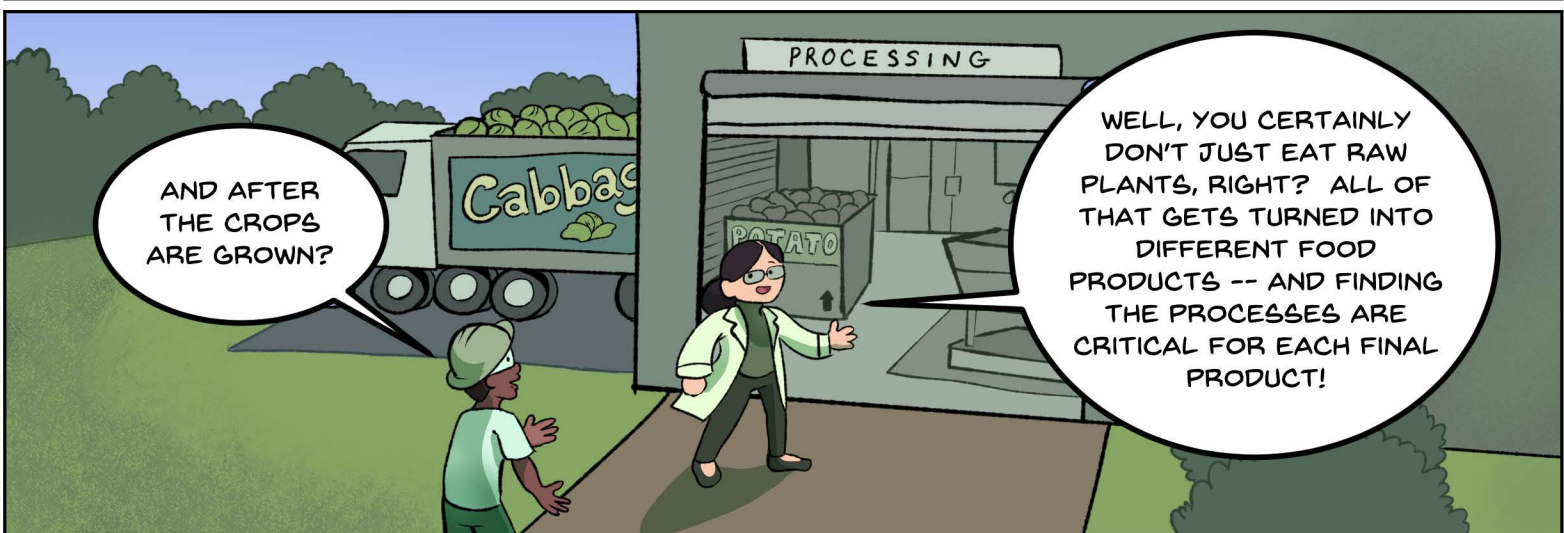
WELL FIRST, WE NEED TO MAKE SURE WE CAN GROW THE FOOD SOCIETY NEEDS, IN BOTH QUALITY AND QUANTITY.

SO CHEMICAL ENGINEERS WORK HARD TO PRODUCE FERTILIZERS TO HELP CROPS GROW.

WHAT ABOUT **PESTICIDES** TO PROTECT THE CROPS FROM BUGS?

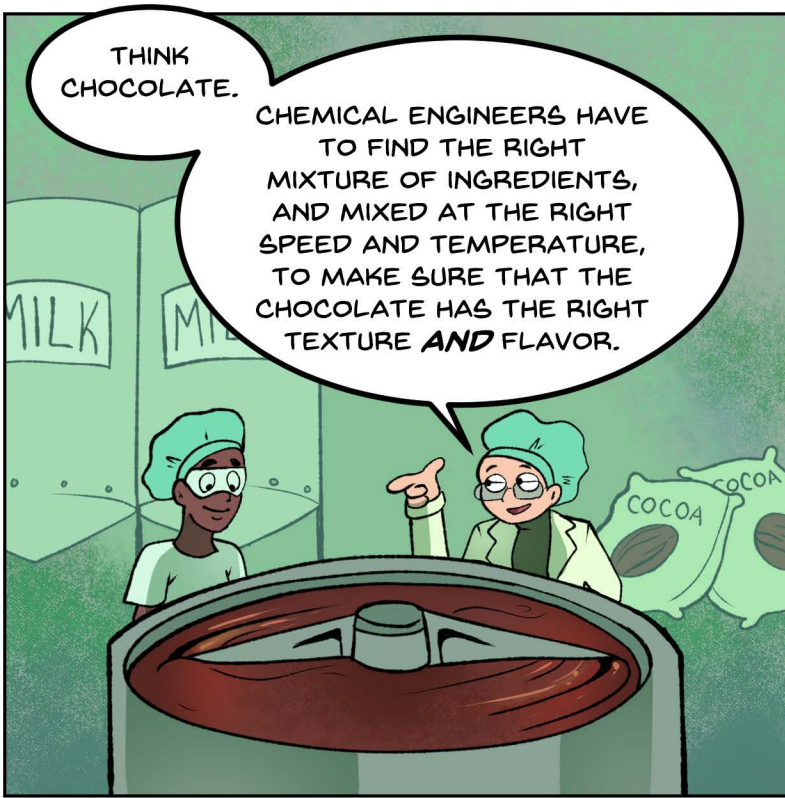
THERE CERTAINLY HAVE BEEN SOME INCREDIBLY TOXIC CHEMICALS PRODUCED IN THE PAST, HURTING BOTH PEOPLE AND BEES.

SO CHEMES TRY TO PRODUCE VERSIONS THAT ARE BETTER CONTROLLED.



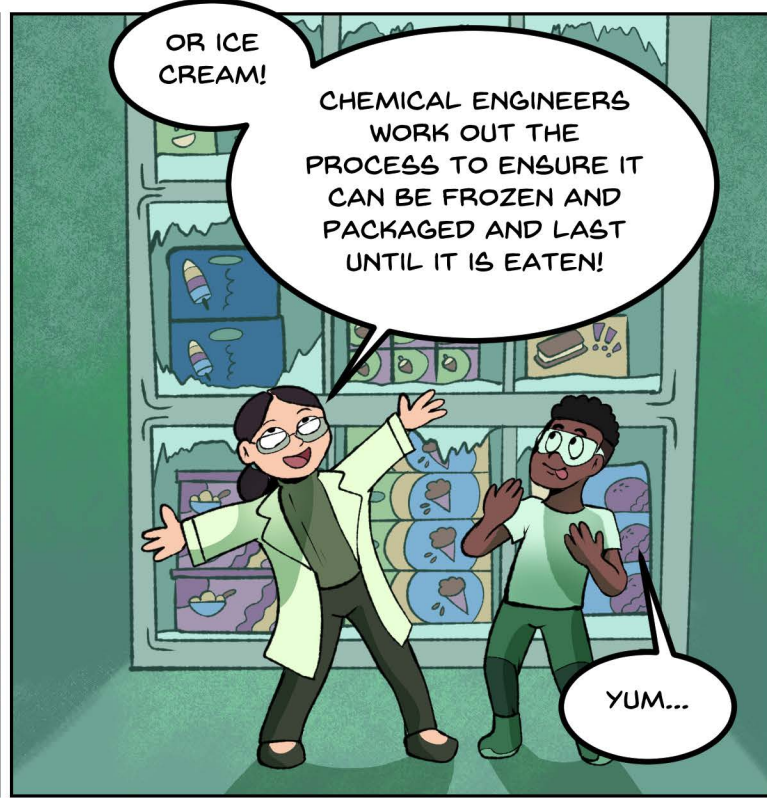
AND AFTER THE CROPS ARE GROWN?

WELL, YOU CERTAINLY DON'T JUST EAT RAW PLANTS, RIGHT? ALL OF THAT GETS TURNED INTO DIFFERENT FOOD PRODUCTS -- AND FINDING THE PROCESSES ARE CRITICAL FOR EACH FINAL PRODUCT!



THINK CHOCOLATE.

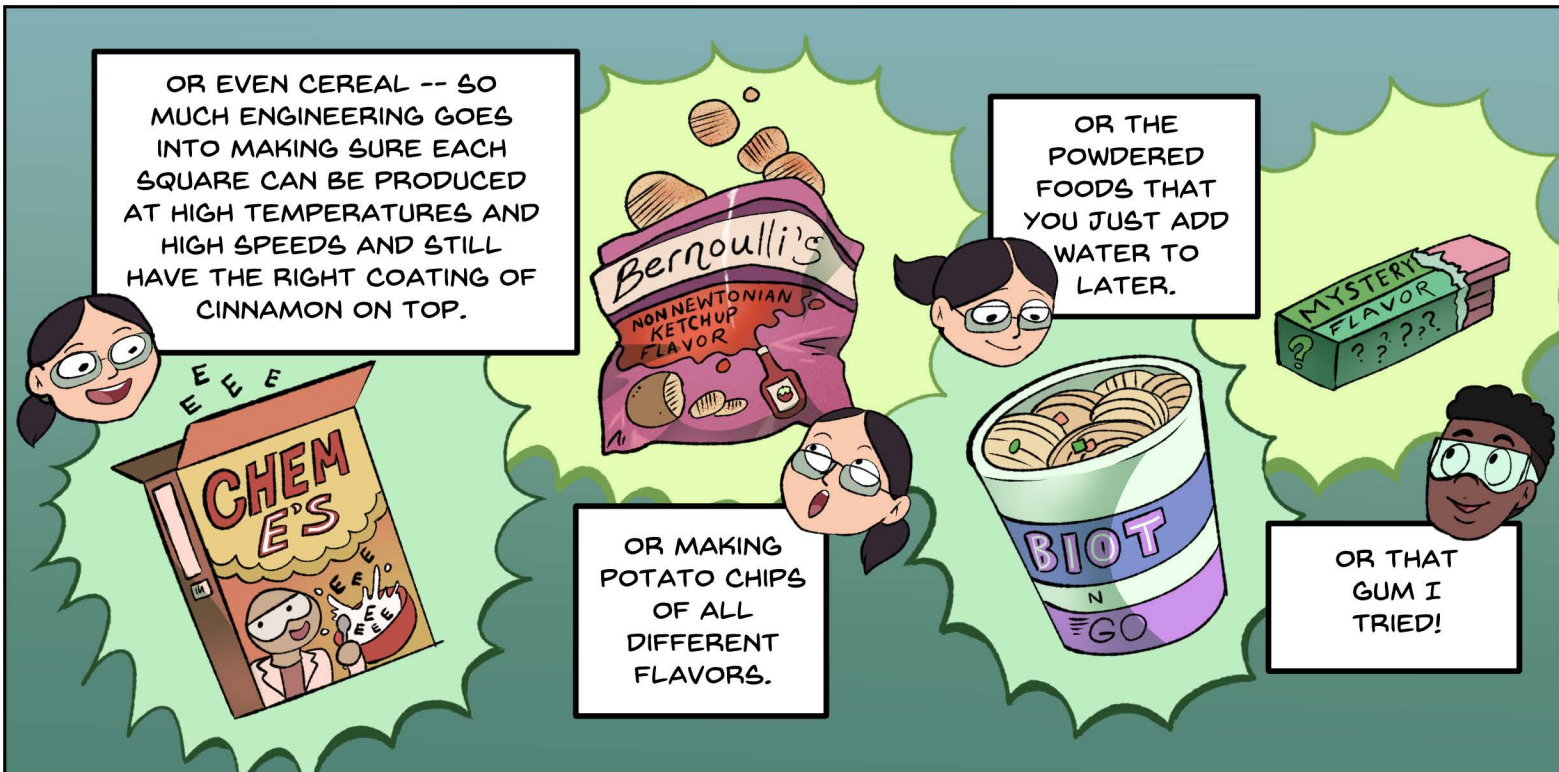
CHEMICAL ENGINEERS HAVE TO FIND THE RIGHT MIXTURE OF INGREDIENTS, AND MIXED AT THE RIGHT SPEED AND TEMPERATURE, TO MAKE SURE THAT THE CHOCOLATE HAS THE RIGHT TEXTURE **AND** FLAVOR.



OR ICE CREAM!

CHEMICAL ENGINEERS WORK OUT THE PROCESS TO ENSURE IT CAN BE FROZEN AND PACKAGED AND LAST UNTIL IT IS EATEN!

YUM...



OR EVEN CEREAL -- SO MUCH ENGINEERING GOES INTO MAKING SURE EACH SQUARE CAN BE PRODUCED AT HIGH TEMPERATURES AND HIGH SPEEDS AND STILL HAVE THE RIGHT COATING OF CINNAMON ON TOP.

OR THE POWDERED FOODS THAT YOU JUST ADD WATER TO LATER.

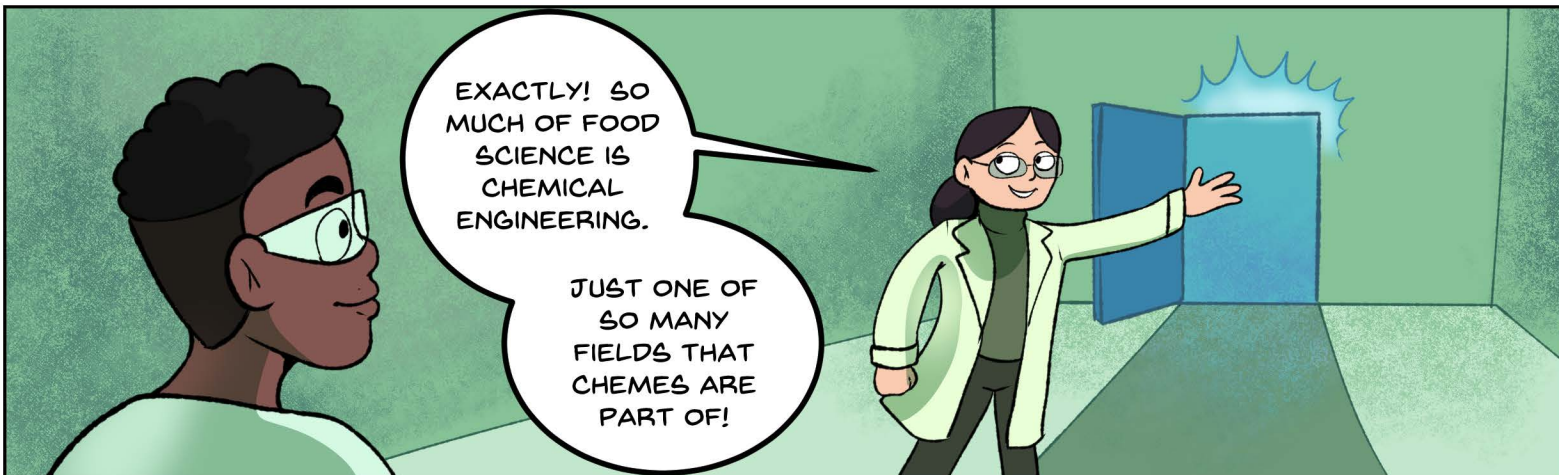
Bernoulli's  
NON-NEWTONIAN KETCHUP FLAVOR

OR MAKING POTATO CHIPS OF ALL DIFFERENT FLAVORS.

BIOT  
N  
GO

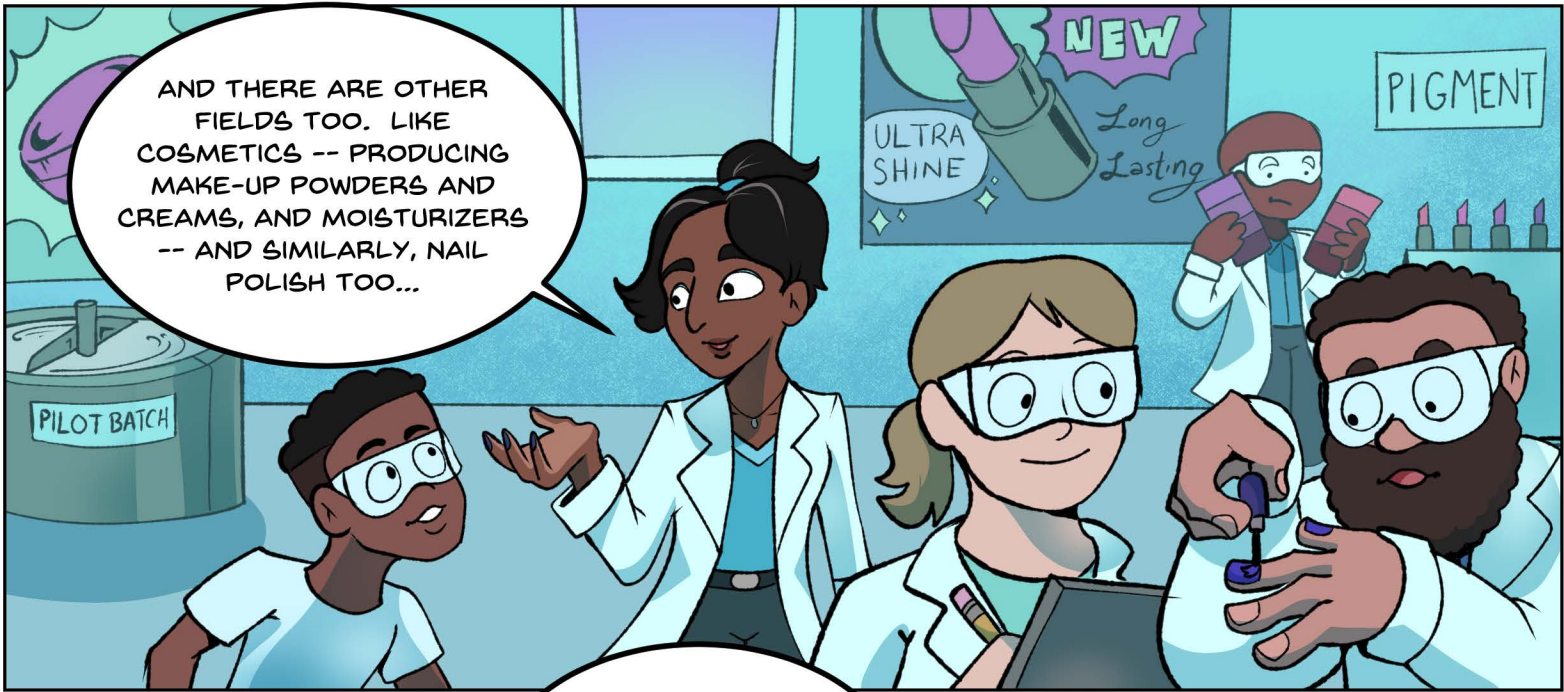
MYSTERY FLAVOR  
?????

OR THAT GUM I TRIED!

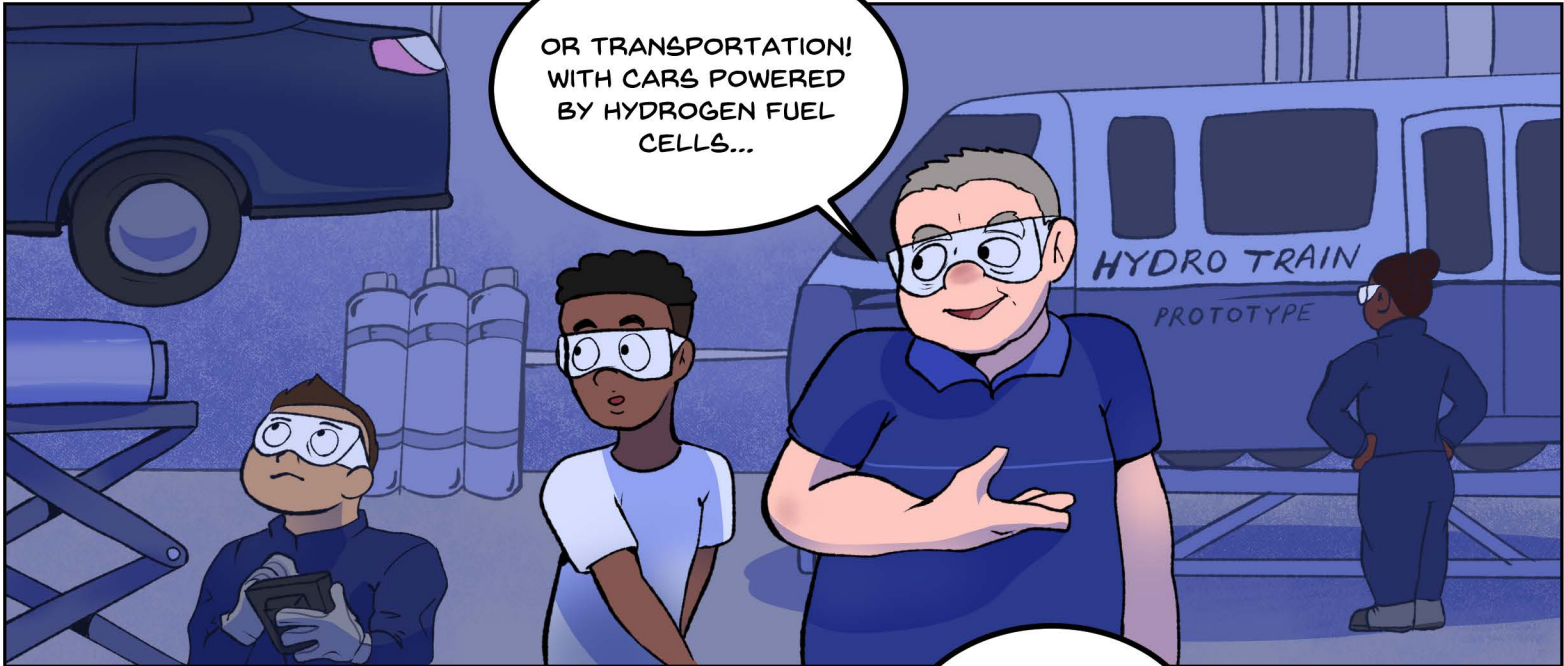


EXACTLY! SO MUCH OF FOOD SCIENCE IS CHEMICAL ENGINEERING.

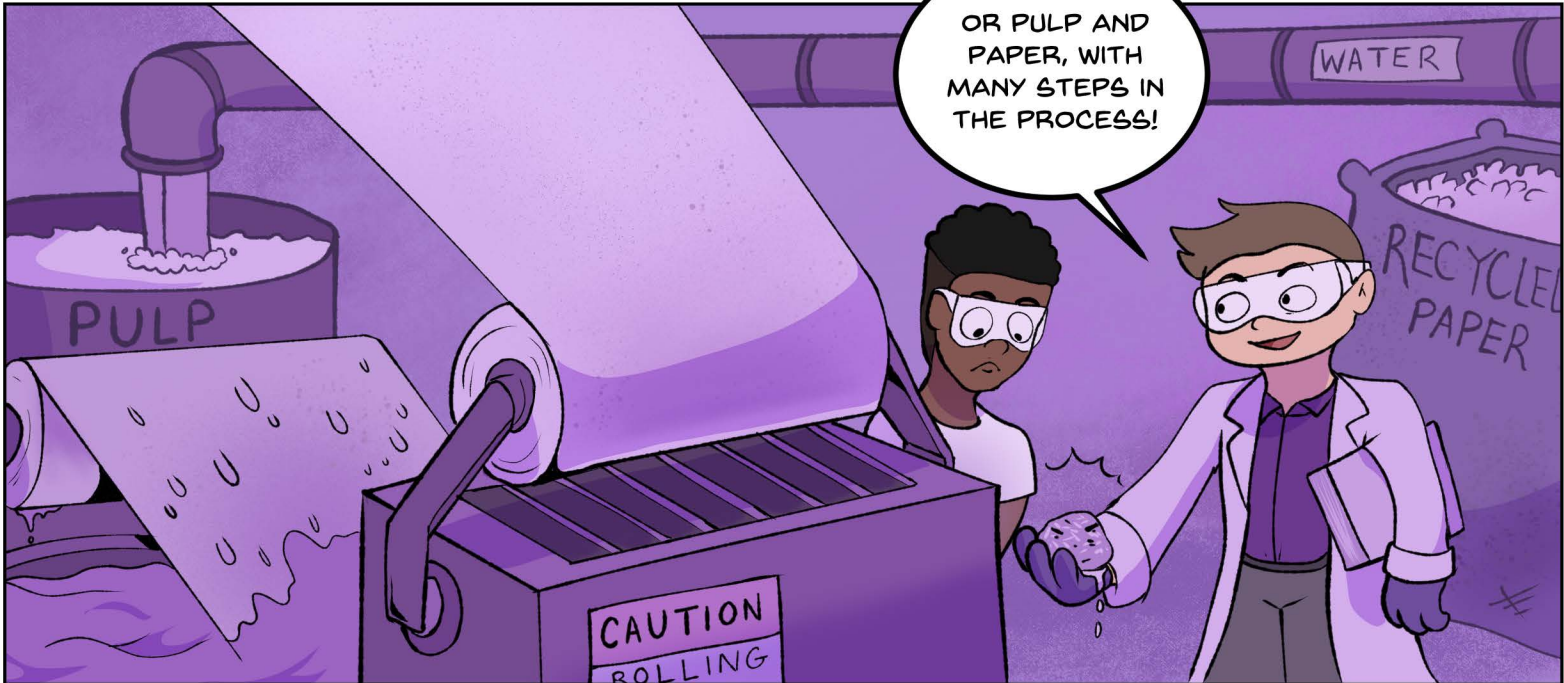
JUST ONE OF SO MANY FIELDS THAT CHEMES ARE PART OF!



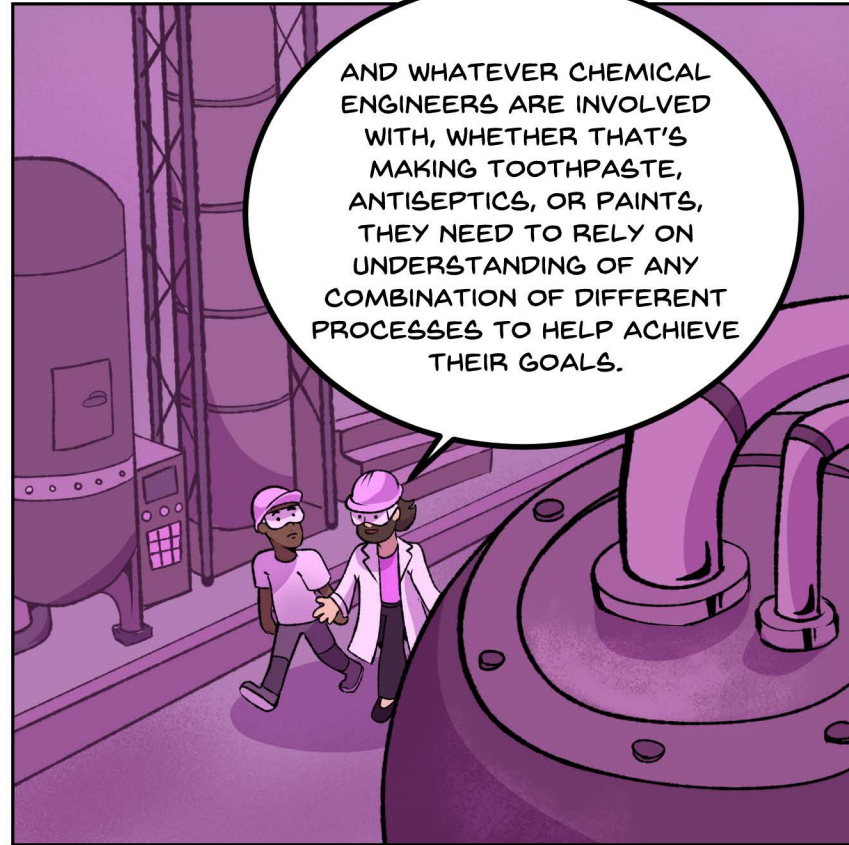
AND THERE ARE OTHER FIELDS TOO. LIKE COSMETICS -- PRODUCING MAKE-UP POWDERS AND CREAMS, AND MOISTURIZERS -- AND SIMILARLY, NAIL POLISH TOO...



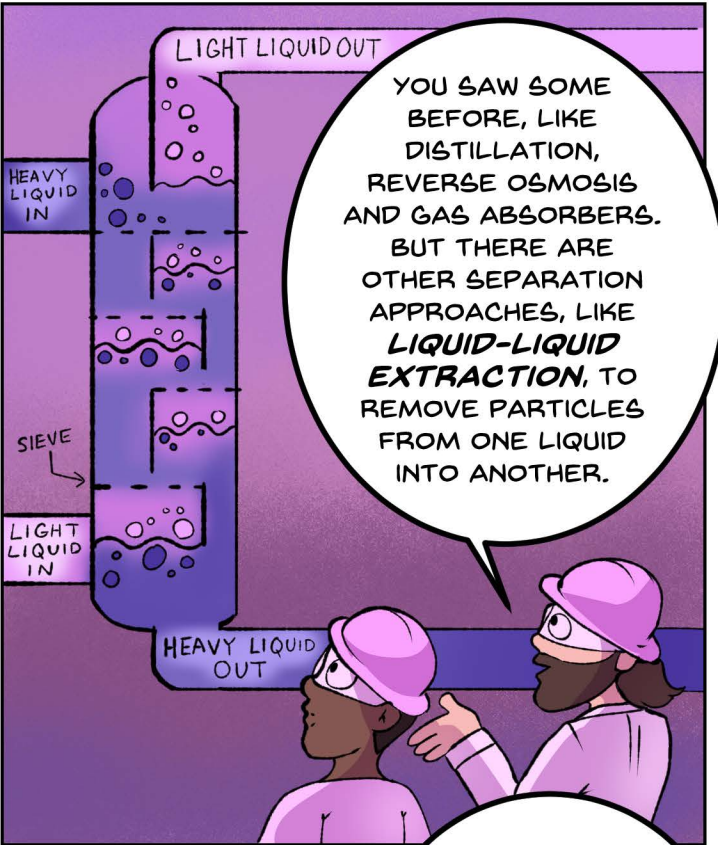
OR TRANSPORTATION! WITH CARS POWERED BY HYDROGEN FUEL CELLS...



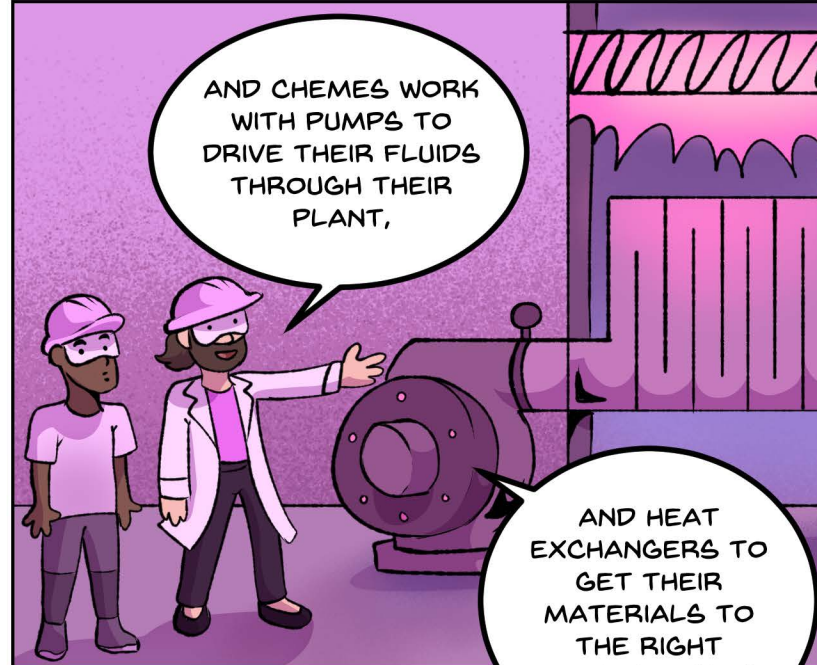
OR PULP AND PAPER, WITH MANY STEPS IN THE PROCESS!



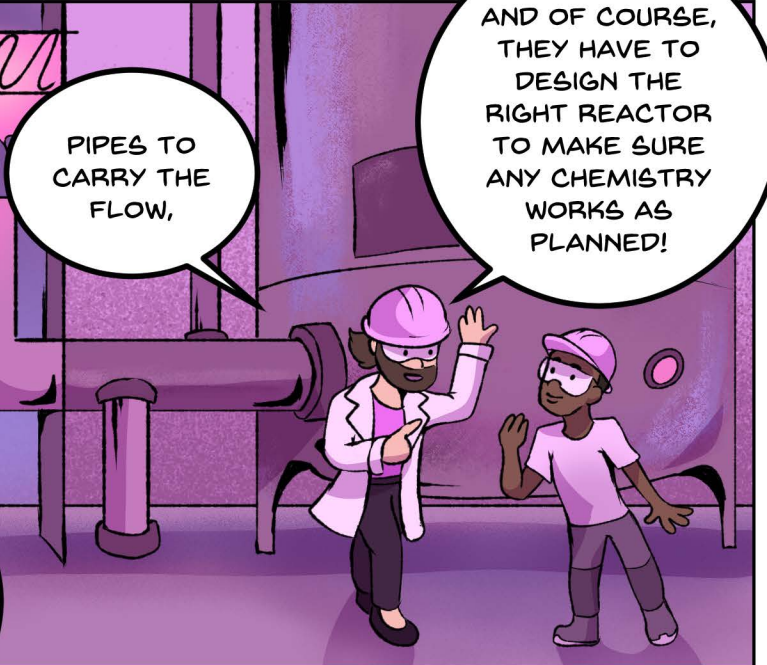
AND WHATEVER CHEMICAL ENGINEERS ARE INVOLVED WITH, WHETHER THAT'S MAKING TOOTHPASTE, ANTISEPTICS, OR PAINTS, THEY NEED TO RELY ON UNDERSTANDING OF ANY COMBINATION OF DIFFERENT PROCESSES TO HELP ACHIEVE THEIR GOALS.



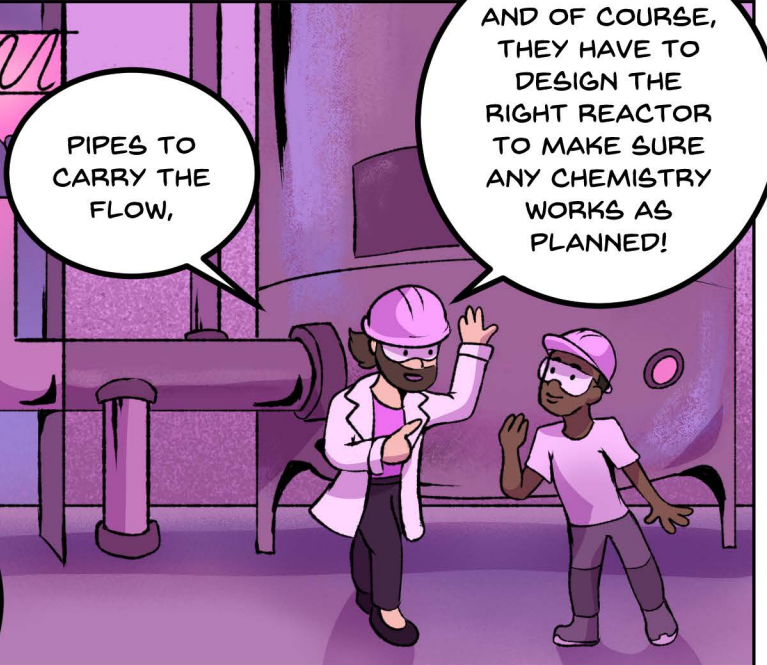
YOU SAW SOME BEFORE, LIKE DISTILLATION, REVERSE OSMOSIS AND GAS ABSORBERS. BUT THERE ARE OTHER SEPARATION APPROACHES, LIKE **LIQUID-LIQUID EXTRACTION**, TO REMOVE PARTICLES FROM ONE LIQUID INTO ANOTHER.



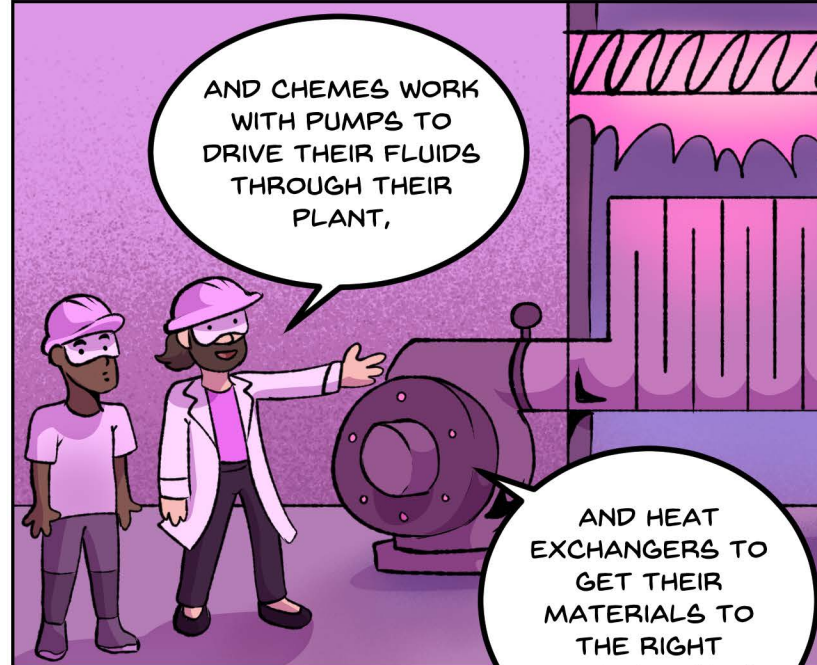
AND CHEMES WORK WITH PUMPS TO DRIVE THEIR FLUIDS THROUGH THEIR PLANT,



PIPES TO CARRY THE FLOW,



AND OF COURSE, THEY HAVE TO DESIGN THE RIGHT REACTOR TO MAKE SURE ANY CHEMISTRY WORKS AS PLANNED!



AND HEAT EXCHANGERS TO GET THEIR MATERIALS TO THE RIGHT TEMPERATURES.

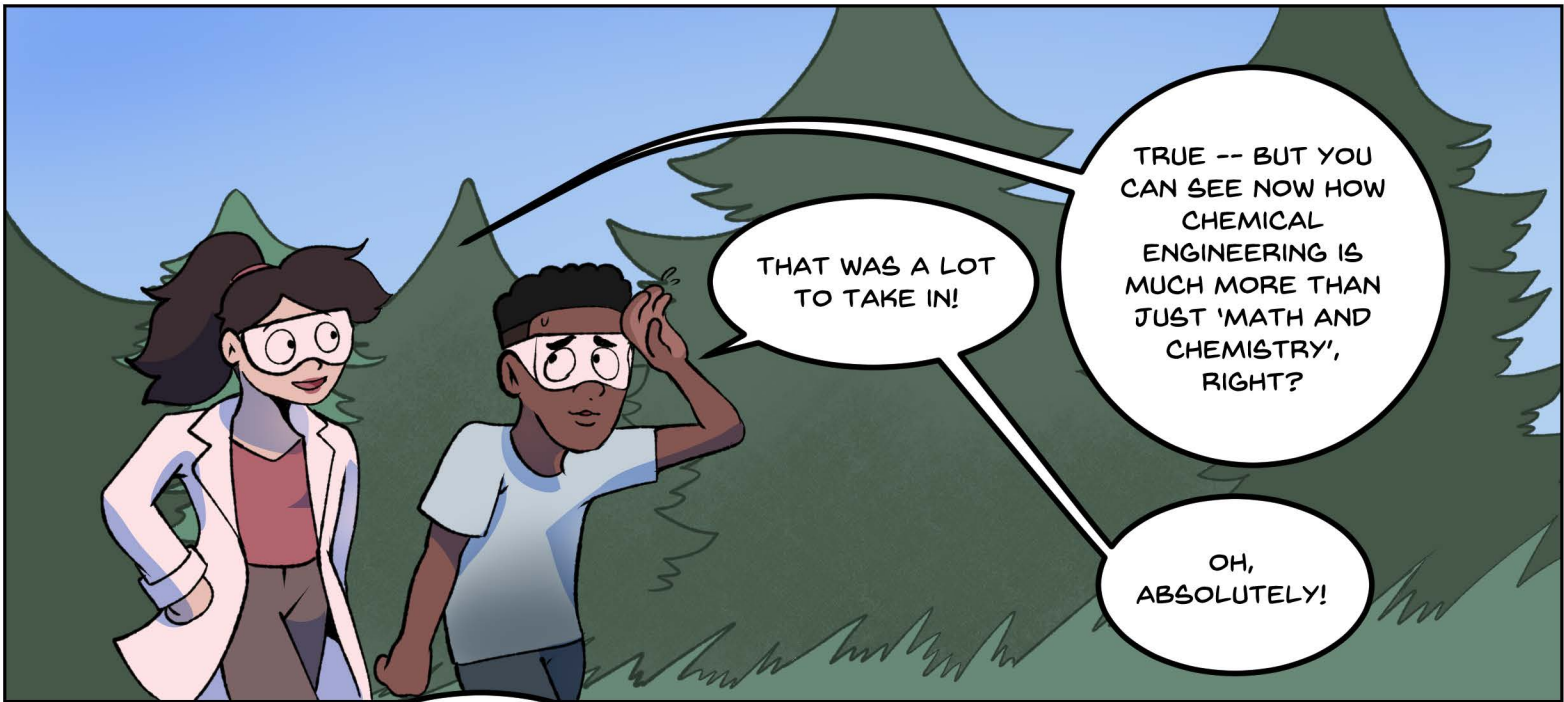


DO YOU THINK YOU GET THE PICTURE NOW?



YEAH!

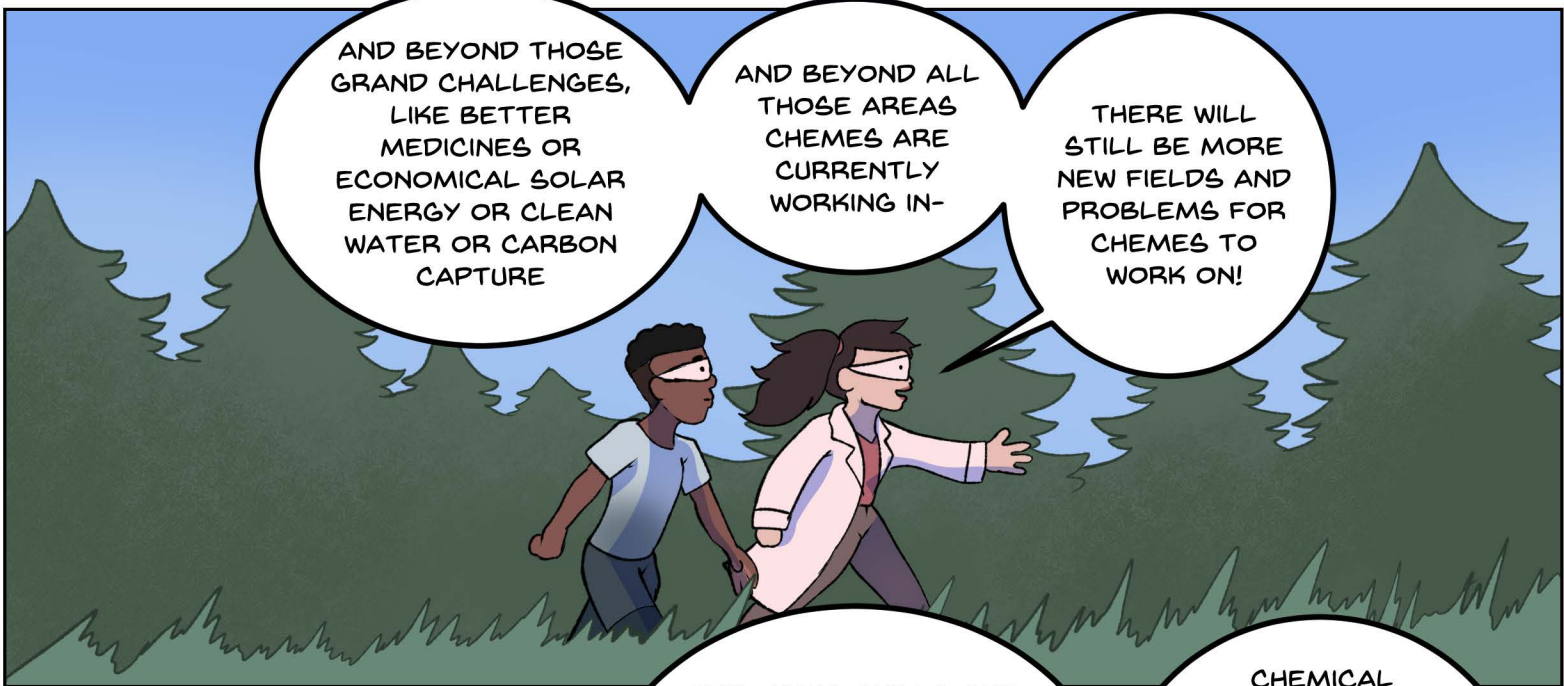




THAT WAS A LOT TO TAKE IN!

TRUE -- BUT YOU CAN SEE NOW HOW CHEMICAL ENGINEERING IS MUCH MORE THAN JUST 'MATH AND CHEMISTRY', RIGHT?

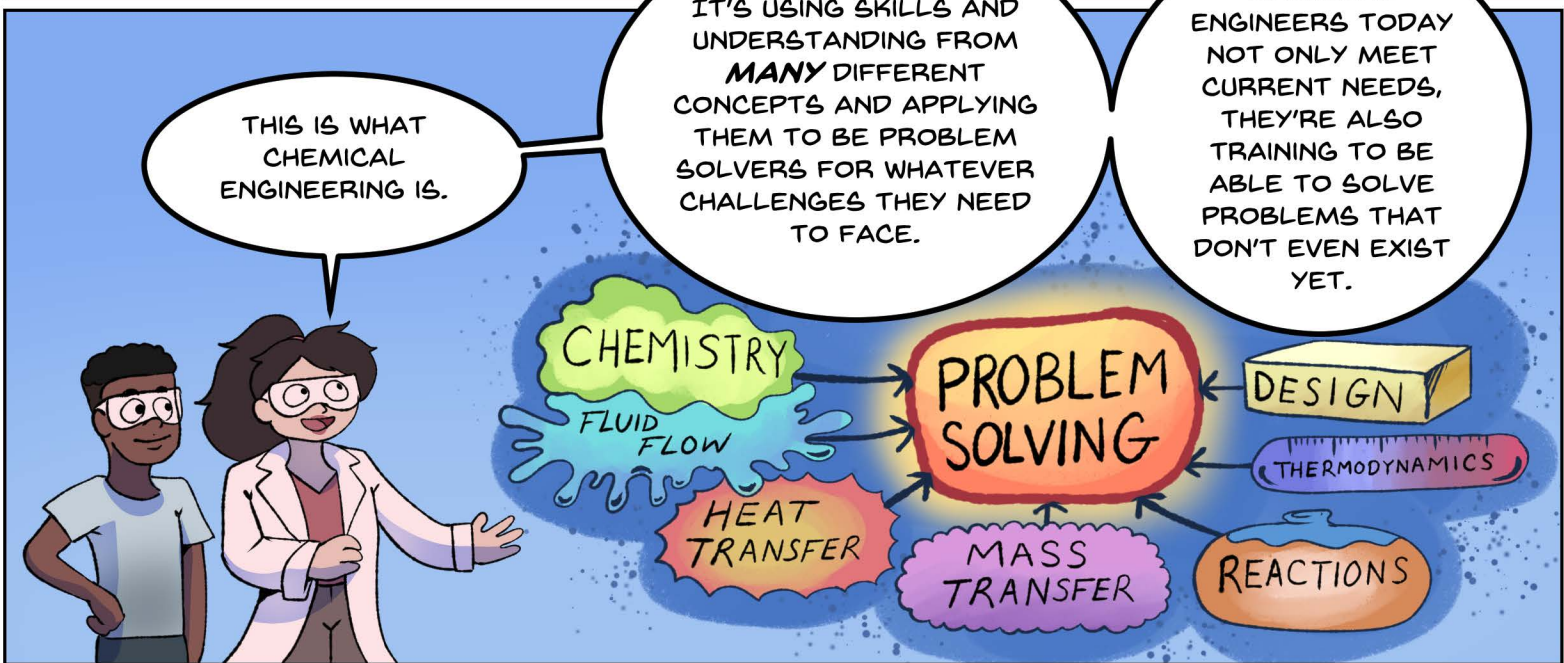
OH, ABSOLUTELY!



AND BEYOND THOSE GRAND CHALLENGES, LIKE BETTER MEDICINES OR ECONOMICAL SOLAR ENERGY OR CLEAN WATER OR CARBON CAPTURE

AND BEYOND ALL THOSE AREAS CHEMES ARE CURRENTLY WORKING IN-

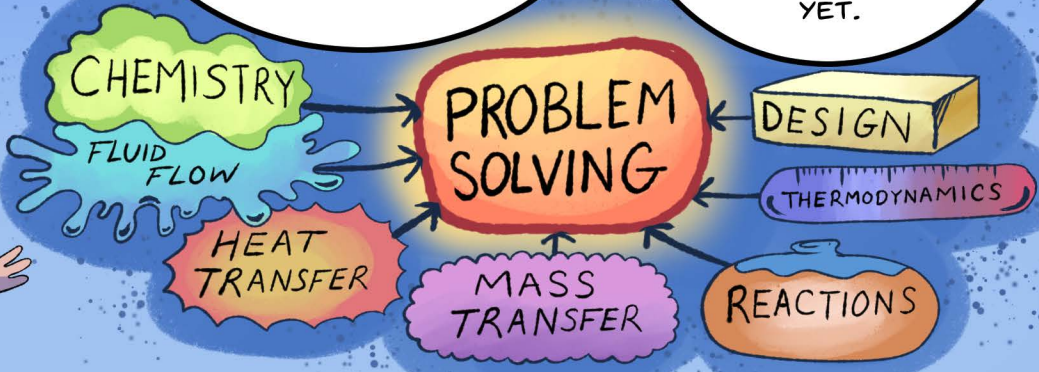
THERE WILL STILL BE MORE NEW FIELDS AND PROBLEMS FOR CHEMES TO WORK ON!

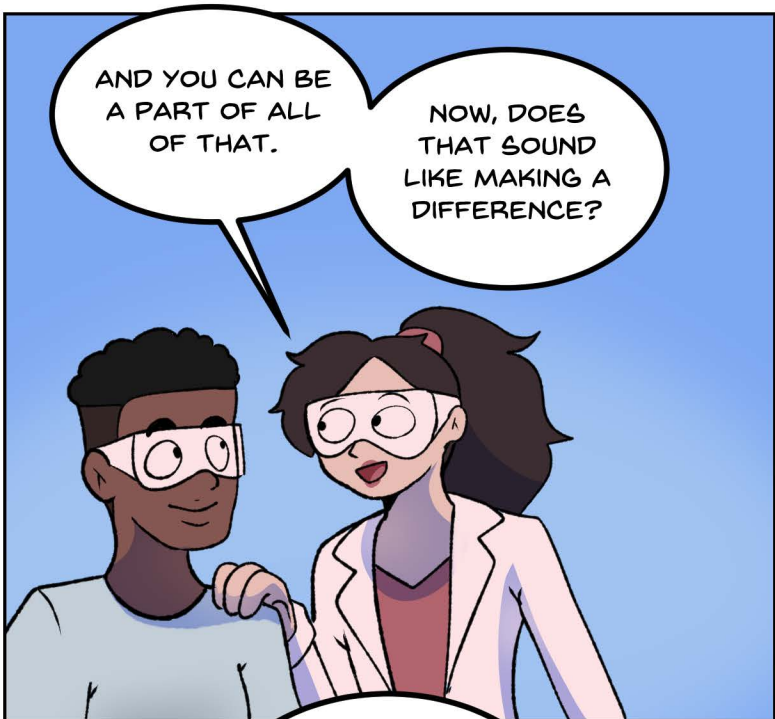


THIS IS WHAT CHEMICAL ENGINEERING IS.

IT'S USING SKILLS AND UNDERSTANDING FROM **MANY** DIFFERENT CONCEPTS AND APPLYING THEM TO BE PROBLEM SOLVERS FOR WHATEVER CHALLENGES THEY NEED TO FACE.

CHEMICAL ENGINEERS TODAY NOT ONLY MEET CURRENT NEEDS, THEY'RE ALSO TRAINING TO BE ABLE TO SOLVE PROBLEMS THAT DON'T EVEN EXIST YET.





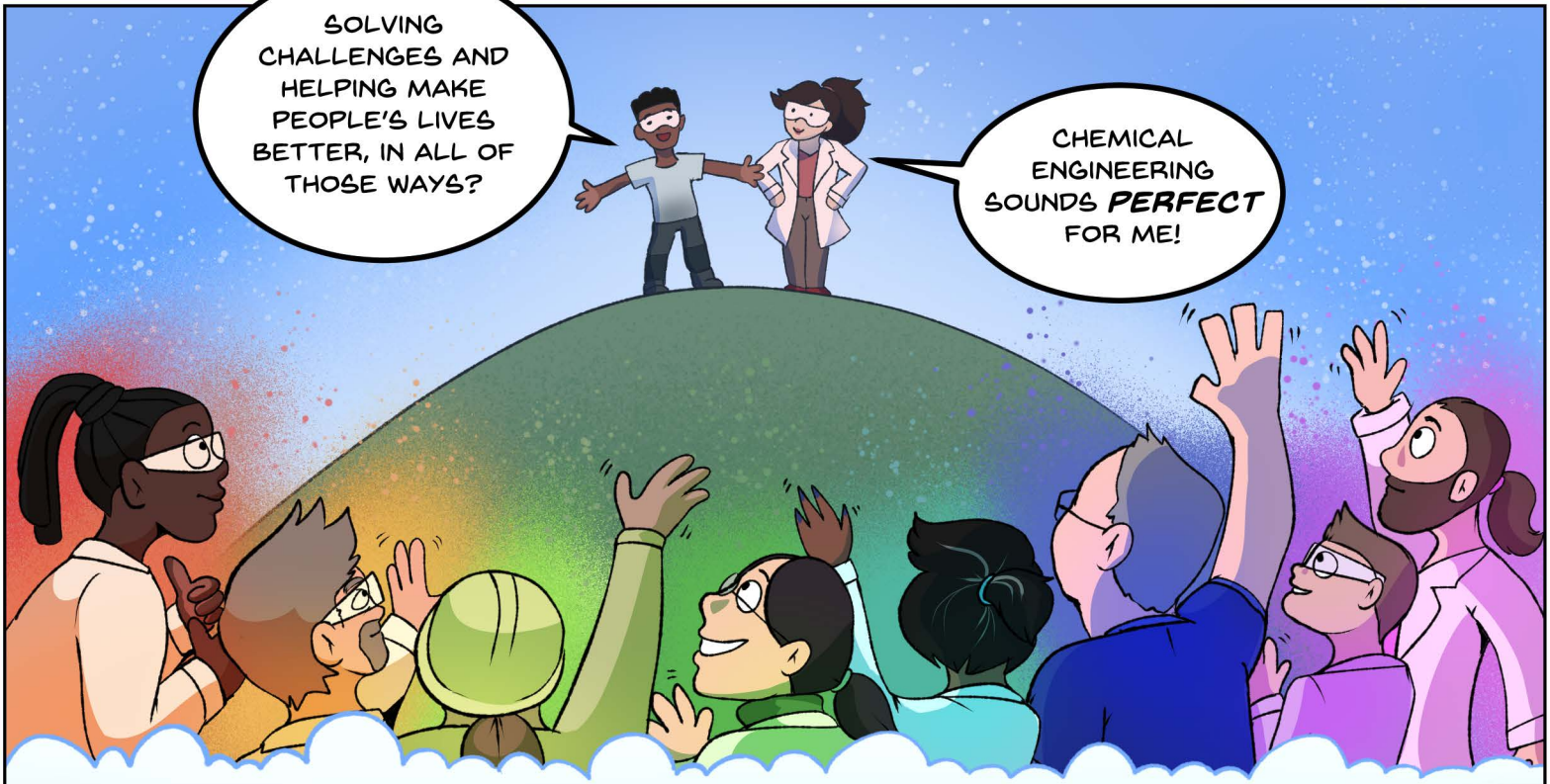
AND YOU CAN BE A PART OF ALL OF THAT.

NOW, DOES THAT SOUND LIKE MAKING A DIFFERENCE?



YEAH. YES, IT DOES.

I DON'T KNOW WHICH OF THOSE FIELDS I EXACTLY WANT TO BE A PART OF JUST YET...BUT I'VE GOT TIME TO FIGURE IT OUT.



SOLVING CHALLENGES AND HELPING MAKE PEOPLE'S LIVES BETTER, IN ALL OF THOSE WAYS?

CHEMICAL ENGINEERING SOUNDS *PERFECT* FOR ME!

# THE WIDE WORLD OF CHEMICAL ENGINEERING

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## AICHE K-12

This comic was produced through the support of the American Institute of Chemical Engineers (AIChE) Foundation and their Doing A World Of Good initiative.

The creative team was an undergraduate student, a teaching professor, and an alum, all from the Northeastern University Chemical Engineering Department.

More educational engineering comics can be found at [sciencetheworld.com](http://sciencetheworld.com).

The mission of the Department of Chemical Engineering at Northeastern University is to educate and train students in chemical engineering practice through integrating an inclusive classroom environment with hands-on and co-op experiences while solving research problems that impact our world.

Our vision: We lead in discovery and innovation to educate diverse chemical engineers who will solve tomorrow's *global* grand challenges.

Cooperative education enables students to integrate practical workplace knowledge with classroom learning so the educational experiences are synergistic and deepen the learning process. The chemical engineering community encourages professional development through active participation and leadership in student organizations, professional societies, and departmental activities. As a result, the chemical engineering program prepares students for industrial careers, graduate programs, or professional medical, law, and business schools.