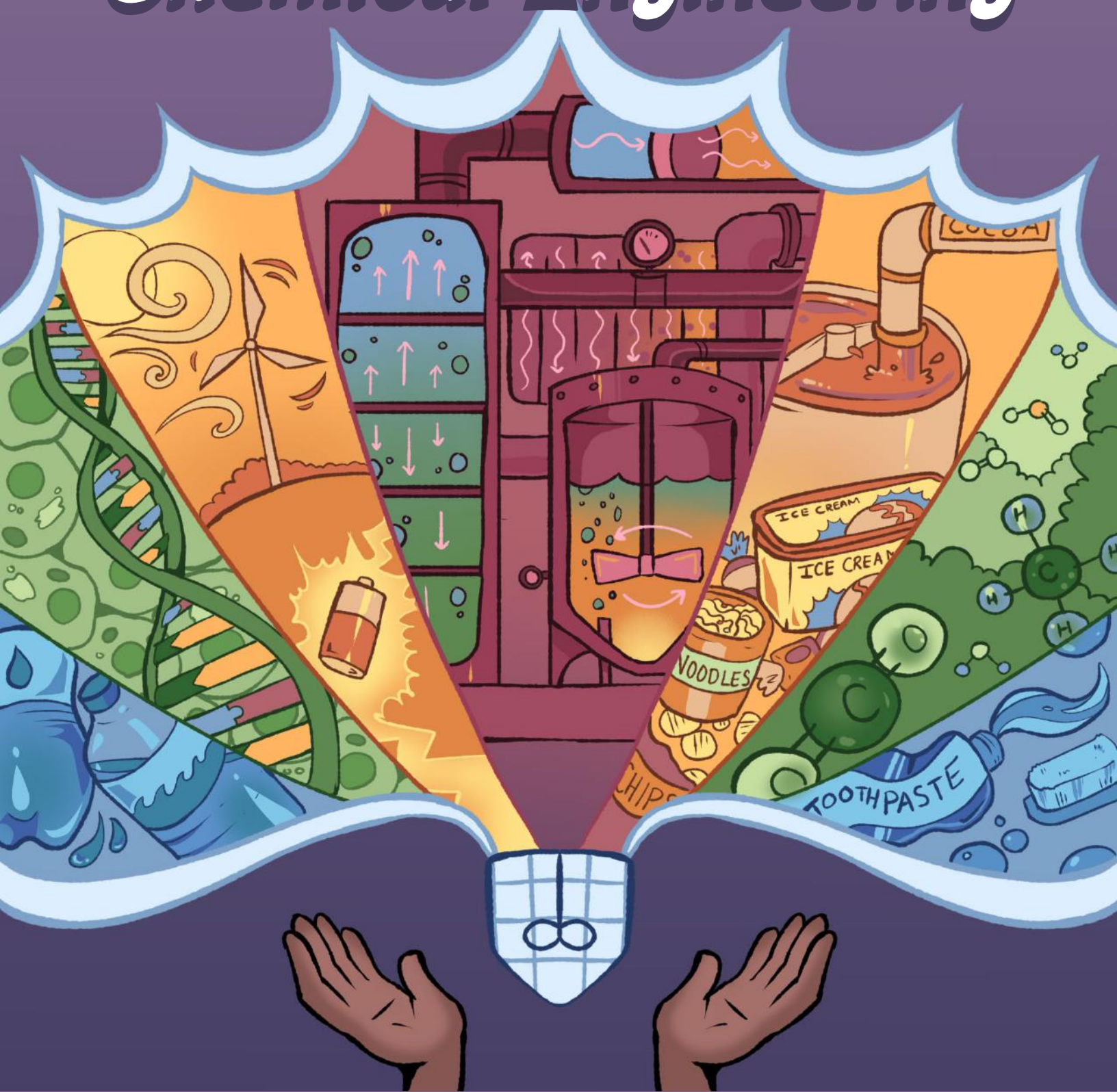




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The Wide World of Chemical Engineering

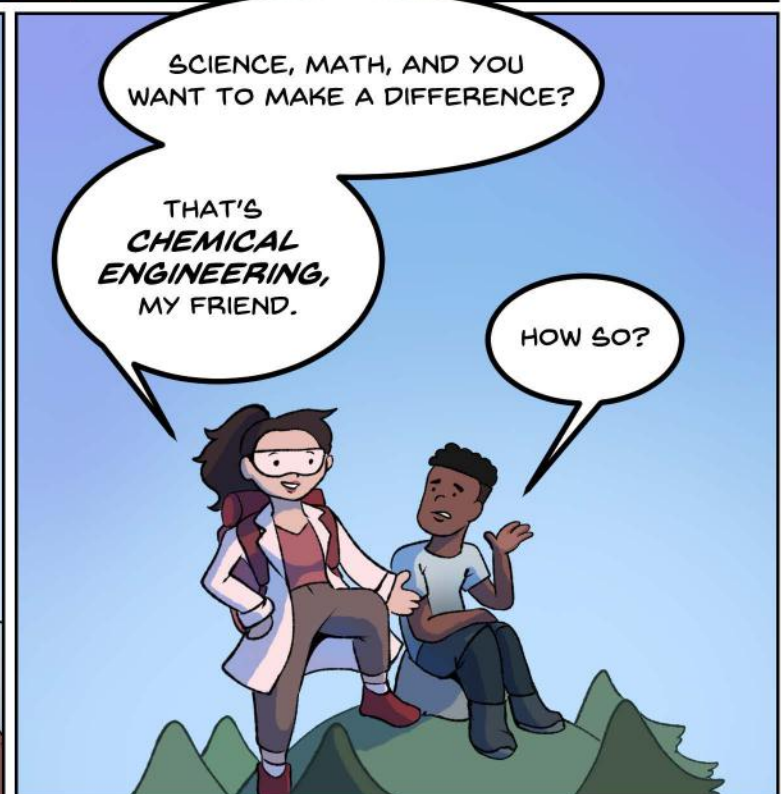


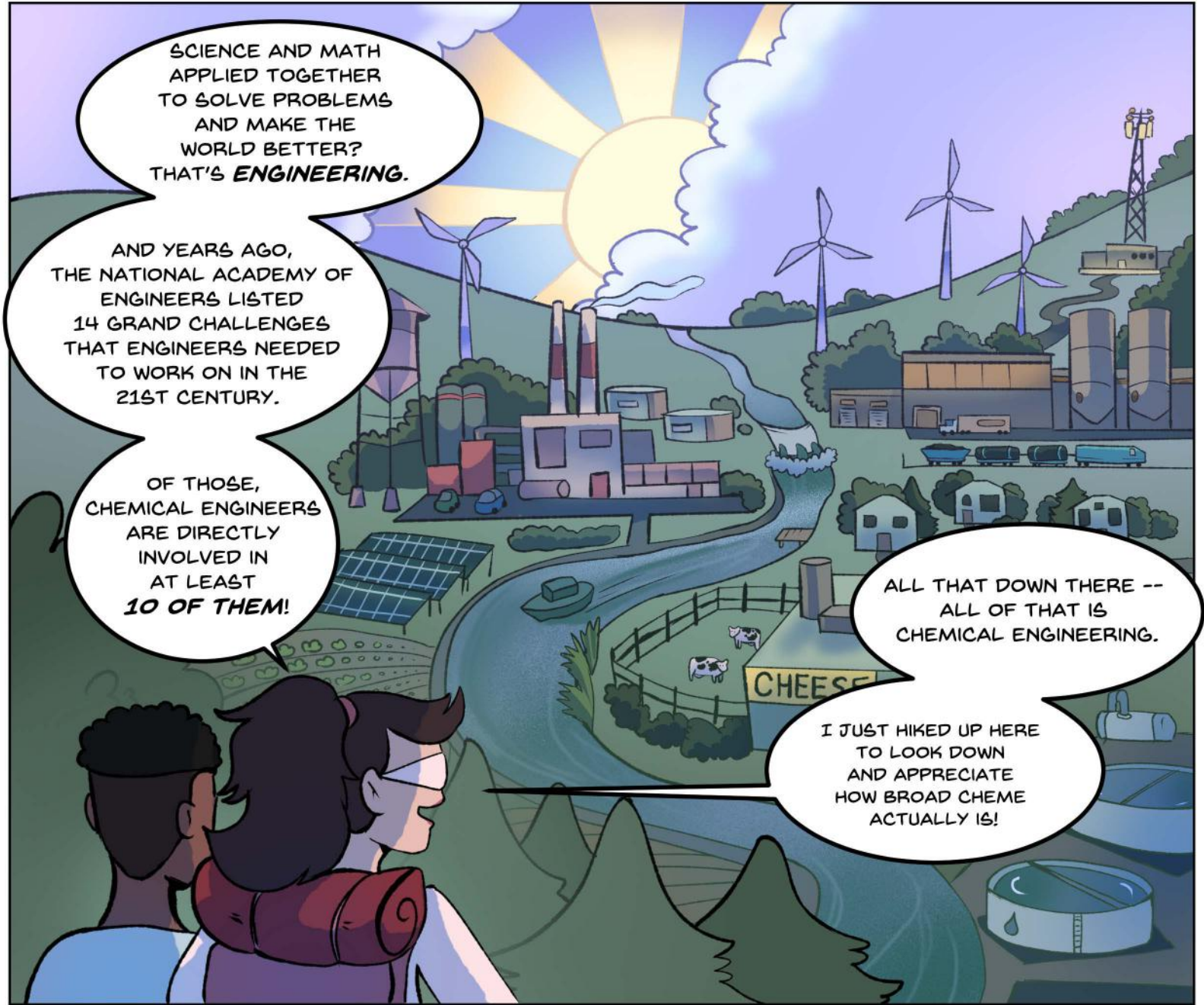
“The Wide World of Chemical Engineering”

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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 CHEME
ACTUALLY IS!



DO YOU WANT ME
TO SHOW YOU?

YEAH!!



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.



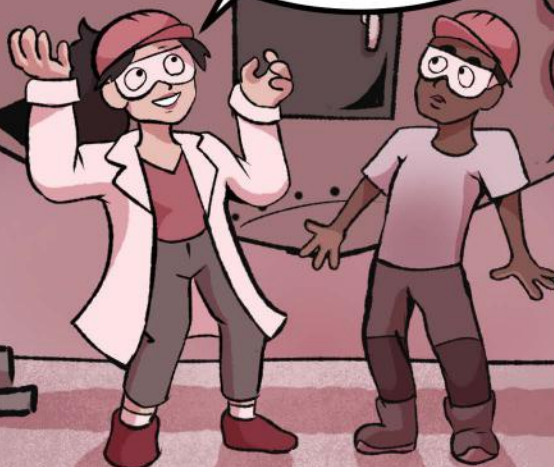
SO CHEMES MIGHT USE A
**GIANT DISTILLATION
COLUMN** TO PURIFY OIL
FOR GAS CONSUMPTION,
OR SEPARATE NITROGEN
FROM LIQUID AIR SO WE
CAN MAKE STEEL ...



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



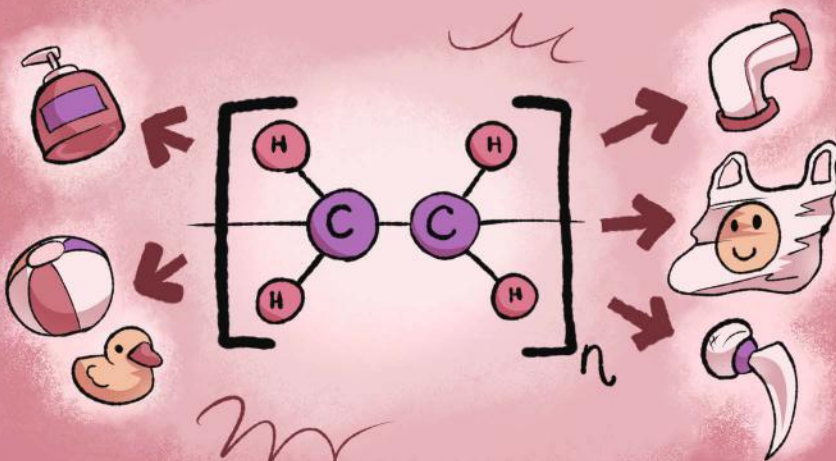
OVER **250 BILLION
TONS** OF CHEMICALS ARE
PRODUCED EVERY YEAR --
AND CHEMES HAVE TO
FIGURE OUT HOW TO BOTH
MEET DEMAND AND DO IT
SAFELY!



...**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.



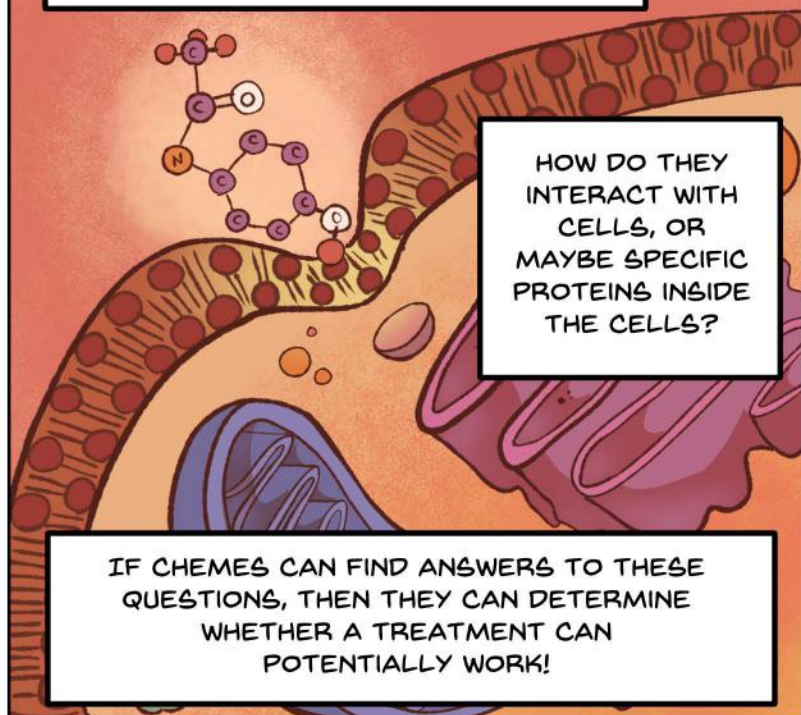
AND THAT LEADS TO A BIG PART OF CHEMICAL ENGINEERING WORK IN MEDICINES THEMSELVES! WE CALL IT '**DRUG DISCOVERY**' -- TRYING TO DETERMINE WHAT MEDICINES CAN PROVIDE TREATMENT, CURE DISEASES, FIGHT CANCER, AND MORE.




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

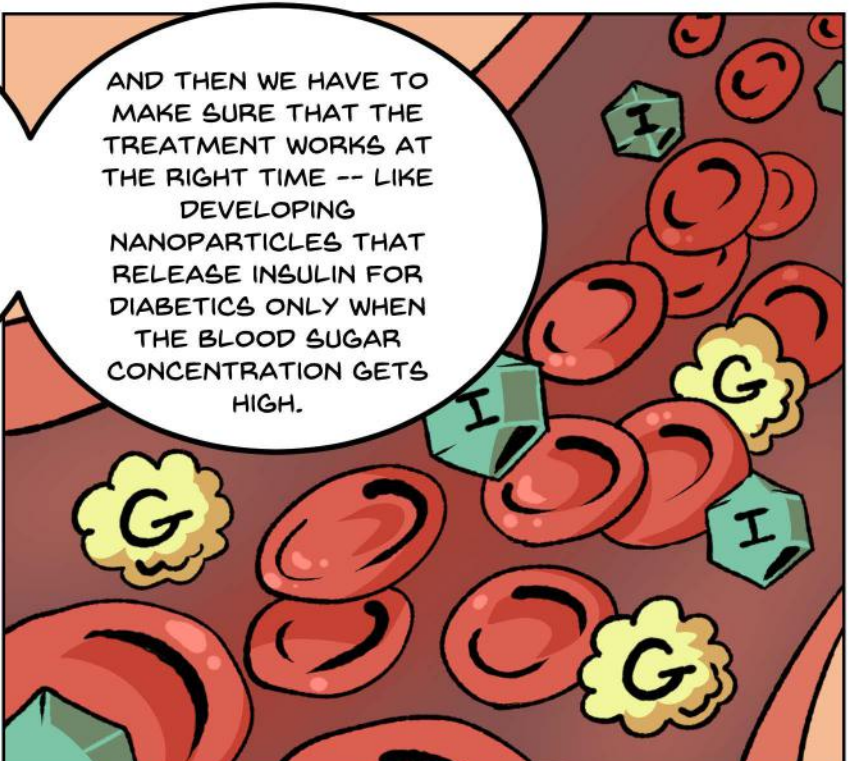
HOW DO THEY INTERACT WITH CELLS, OR MAYBE SPECIFIC PROTEINS INSIDE THE CELLS?

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?

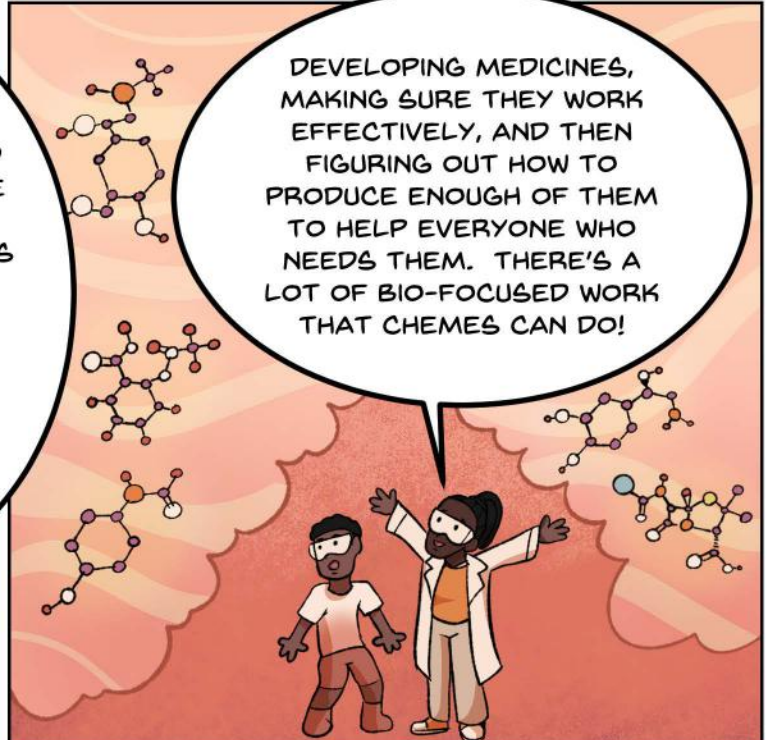


AND THEN WE HAVE TO MAKE SURE THAT THE TREATMENT WORKS AT THE RIGHT TIME -- LIKE DEVELOPING NANOPARTICLES THAT RELEASE INSULIN FOR DIABETICS ONLY WHEN THE BLOOD SUGAR CONCENTRATION GETS HIGH.



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!



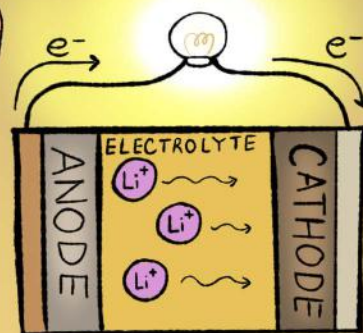
AND WE'RE JUST GETTING STARTED ON THE MATERIALS THAT CHEMICAL ENGINEERING WORKS WITH!

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!

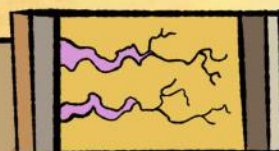


AND THEY'RE A HUGE CONCERN
TO MAKE SURE THAT WE CAN
MEET THE DEMAND TO POWER
ALL OUR EQUIPMENT AND
DEVICES.

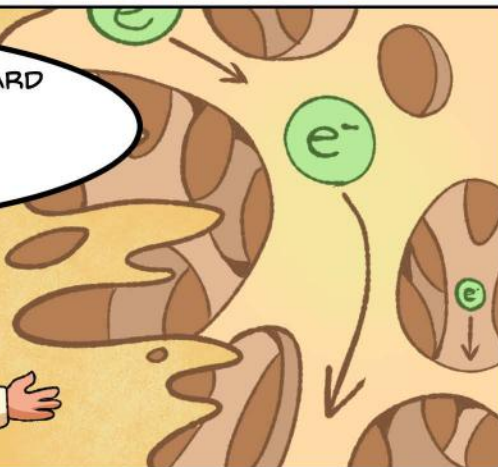
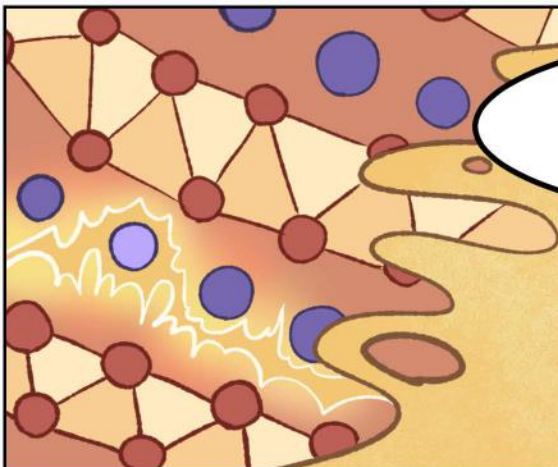
USUALLY, MOST
BATTERIES ARE
LITHIUM-ION OR LEAD-
ACID BASED, BUT
THOSE CAN BE
EXPENSIVE OR HAVE
TOXIC CHEMICALS. WE
NEED SOLUTIONS THAT
CAN PROVIDE MORE
POWER AT A LOWER
COST WITH SAFER
CHEMICALS.



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 -

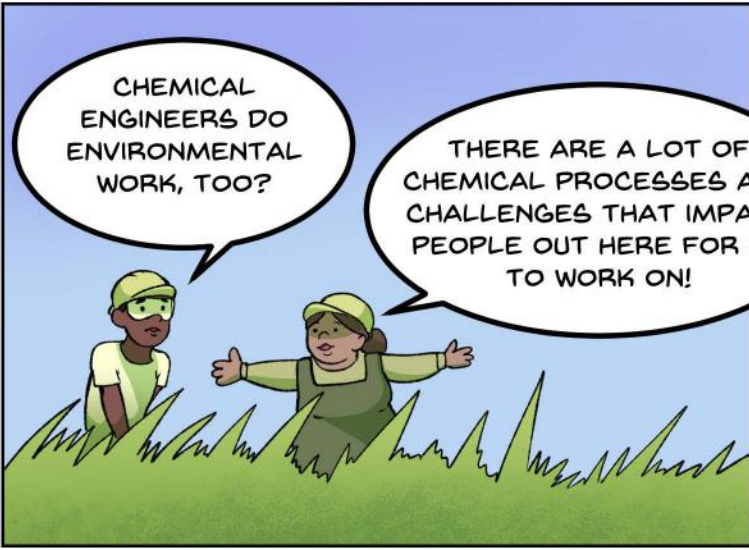
- WIND POWER CAPTURED BY WINDMILLS, SOLAR POWER CAPTURED BY SOLAR PANELS -

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!

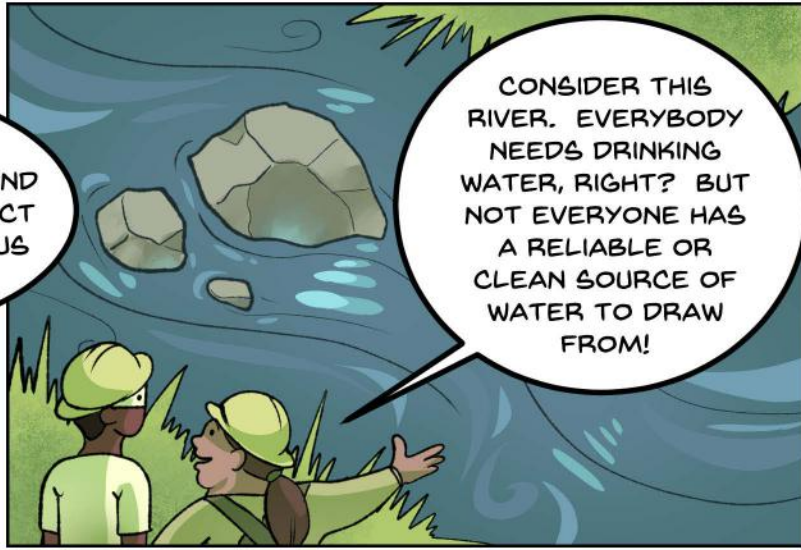
AND CHEMICAL ENGINEERS ARE WORKING EVERY DAY TO PRODUCE BATTERIES EXACTLY FOR THAT PURPOSE!

ALONG WITH A NUMBER OF OTHER ENVIRONMENTAL CHALLENGES!



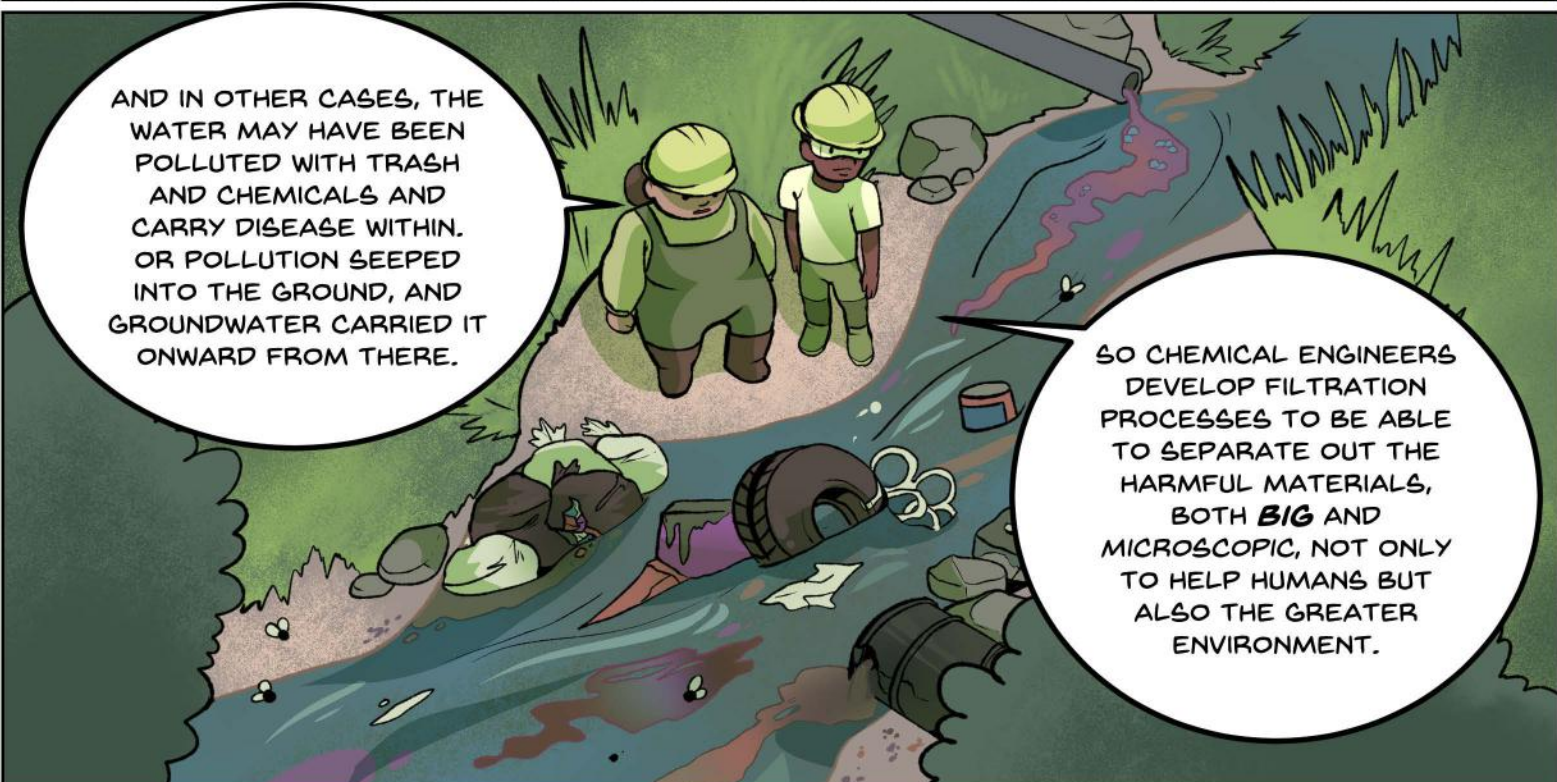
CHEMICAL ENGINEERS DO ENVIRONMENTAL WORK, TOO?

THERE ARE A LOT OF CHEMICAL PROCESSES AND CHALLENGES THAT IMPACT PEOPLE OUT HERE FOR US TO WORK ON!



CONSIDER THIS RIVER. EVERYBODY NEEDS DRINKING WATER, RIGHT? BUT NOT EVERYONE HAS A RELIABLE OR CLEAN SOURCE OF WATER TO DRAW FROM!

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!



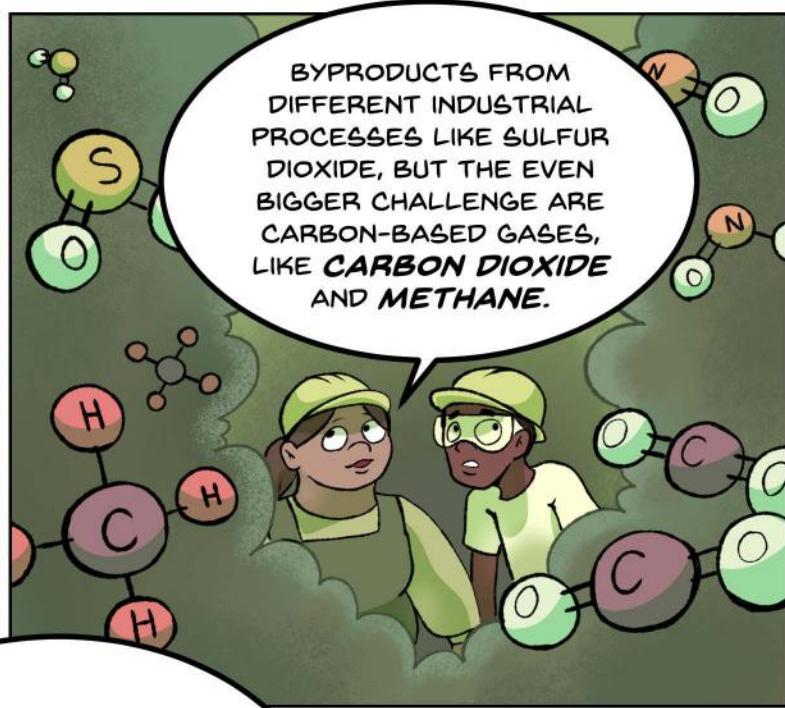
AND IN OTHER CASES, THE WATER MAY HAVE BEEN POLLUTED WITH TRASH AND CHEMICALS AND CARRY DISEASE WITHIN. OR POLLUTION SEEPED INTO THE GROUND, AND GROUNDWATER CARRIED IT ONWARD FROM THERE.

SO CHEMICAL ENGINEERS DEVELOP FILTRATION PROCESSES TO BE ABLE TO SEPARATE OUT THE HARMFUL MATERIALS, BOTH **BIG** AND MICROSCOPIC, NOT ONLY TO HELP HUMANS BUT ALSO THE GREATER ENVIRONMENT.

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.

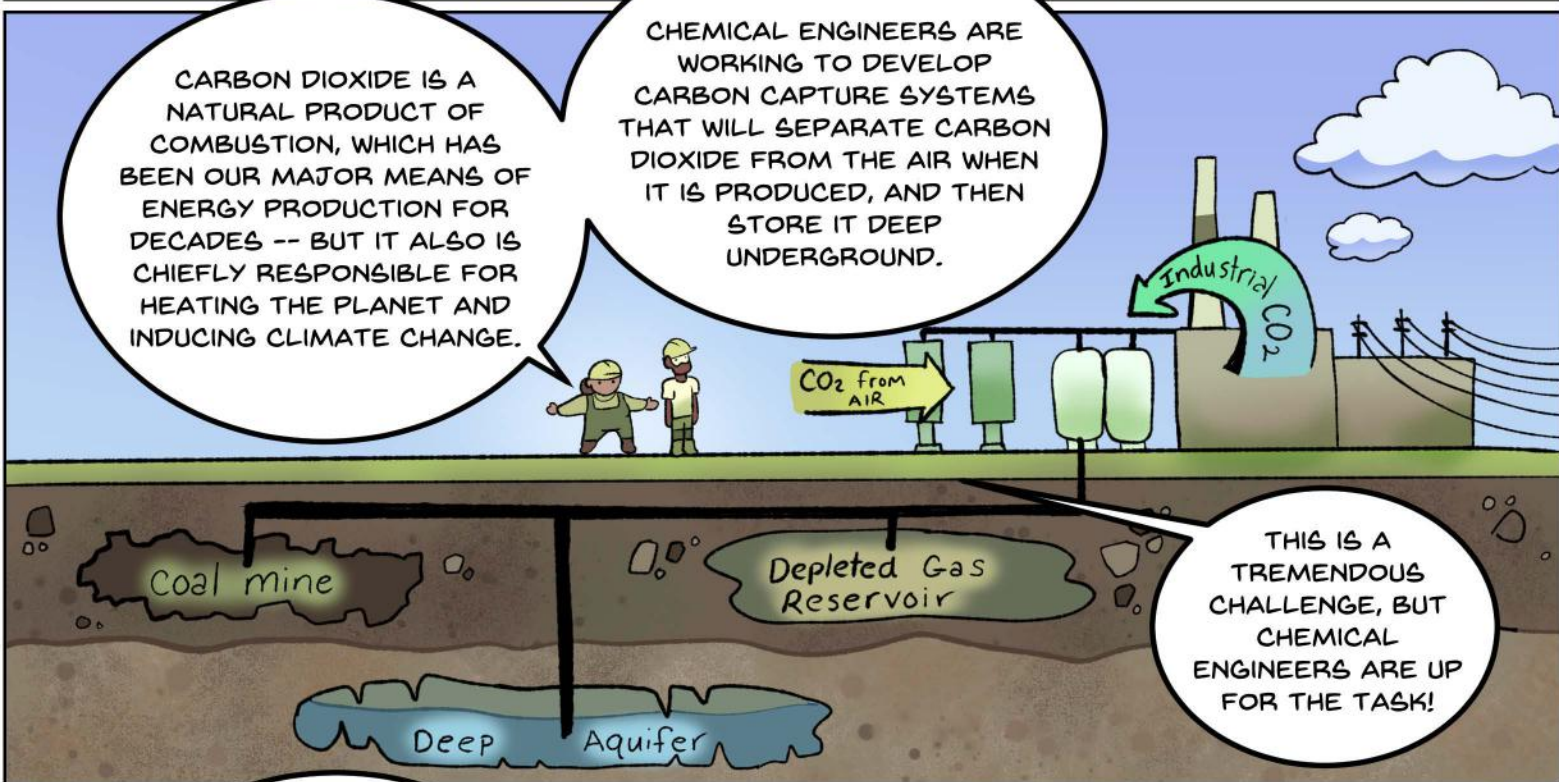


BYPRODUCTS FROM DIFFERENT INDUSTRIAL PROCESSES LIKE SULFUR DIOXIDE, BUT THE EVEN BIGGER CHALLENGE ARE CARBON-BASED GASES, LIKE **CARBON DIOXIDE** AND **METHANE**.



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.

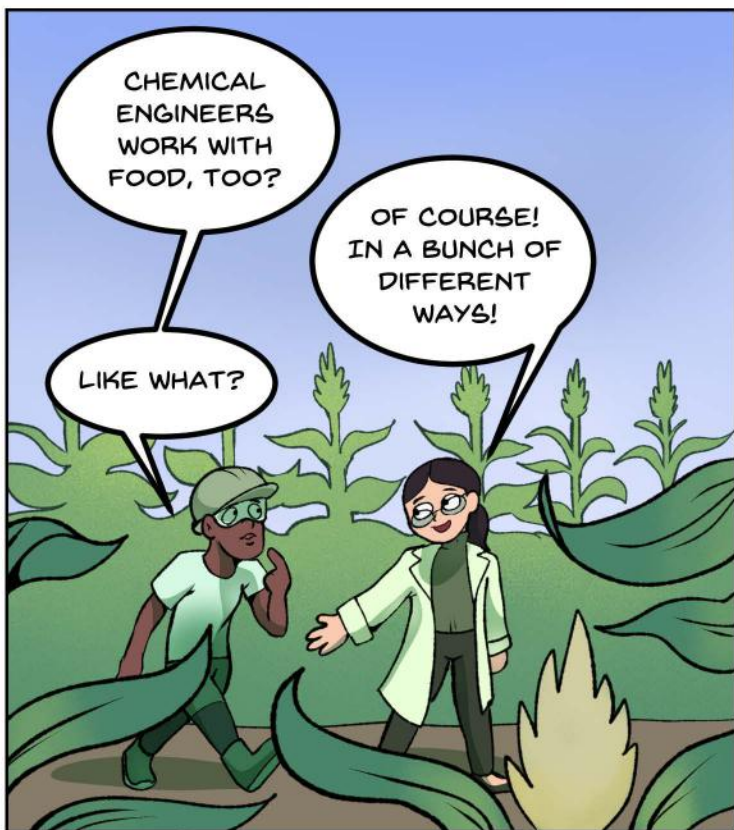


THIS IS A TREMENDOUS CHALLENGE, BUT CHEMICAL ENGINEERS ARE UP FOR THE TASK!

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?

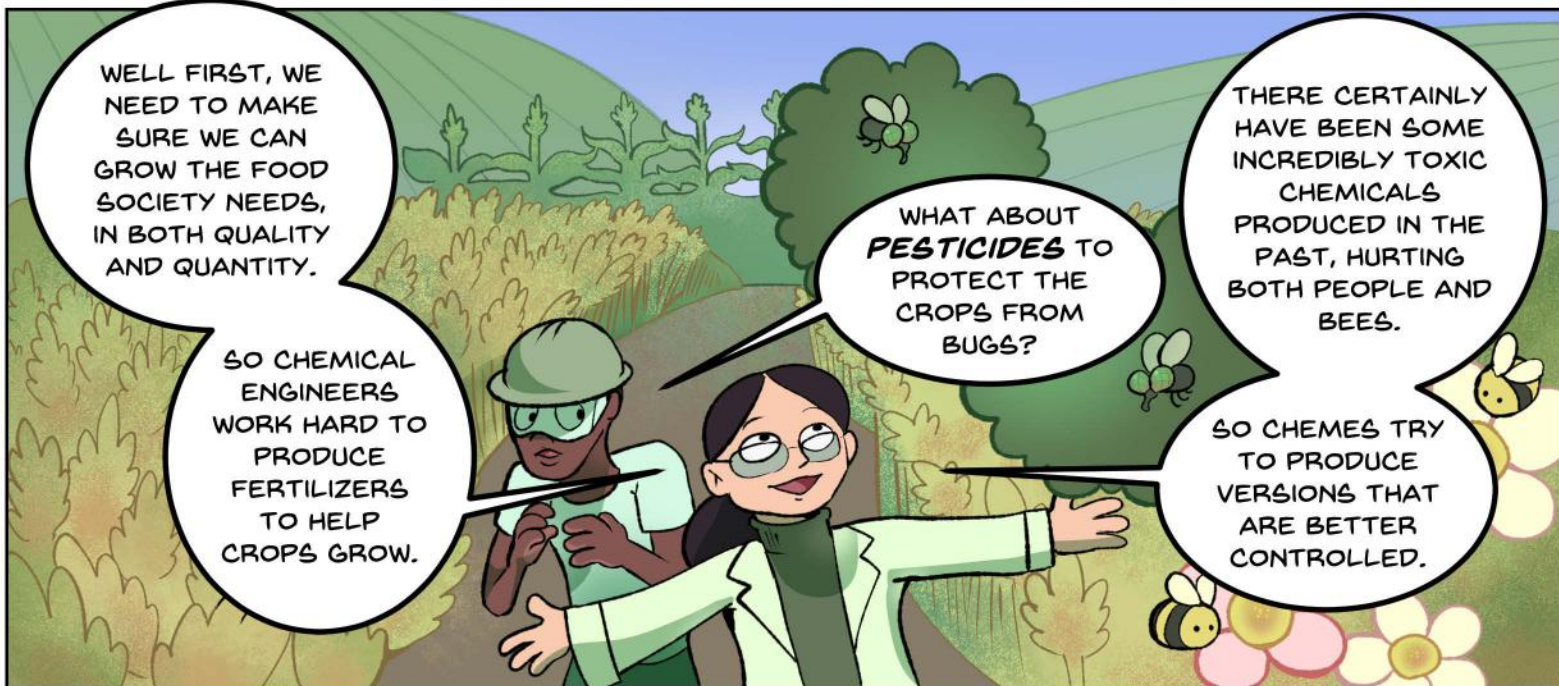


THIS IS A WEIRD FLAVOR, WHAT IS IT?

HERE TAKE SOME GUM.

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

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



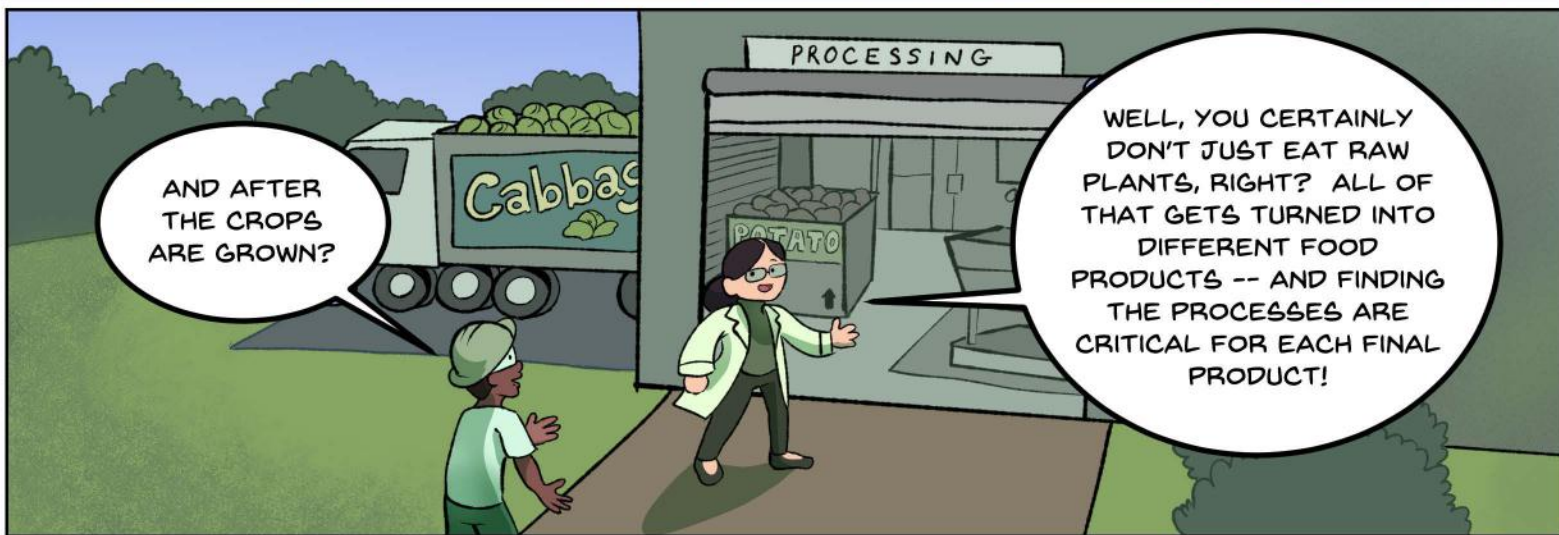
WELL FIRST, WE NEED TO MAKE SURE WE CAN GROW THE FOOD SOCIETY NEEDS, IN BOTH QUALITY AND QUANTITY.

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

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

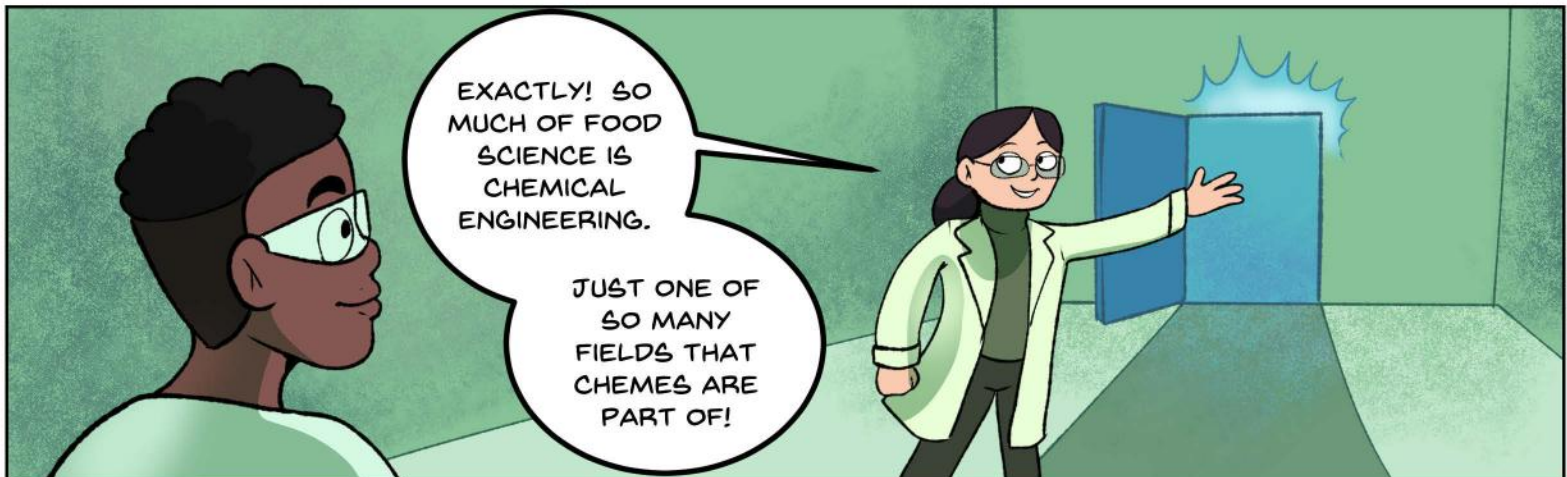
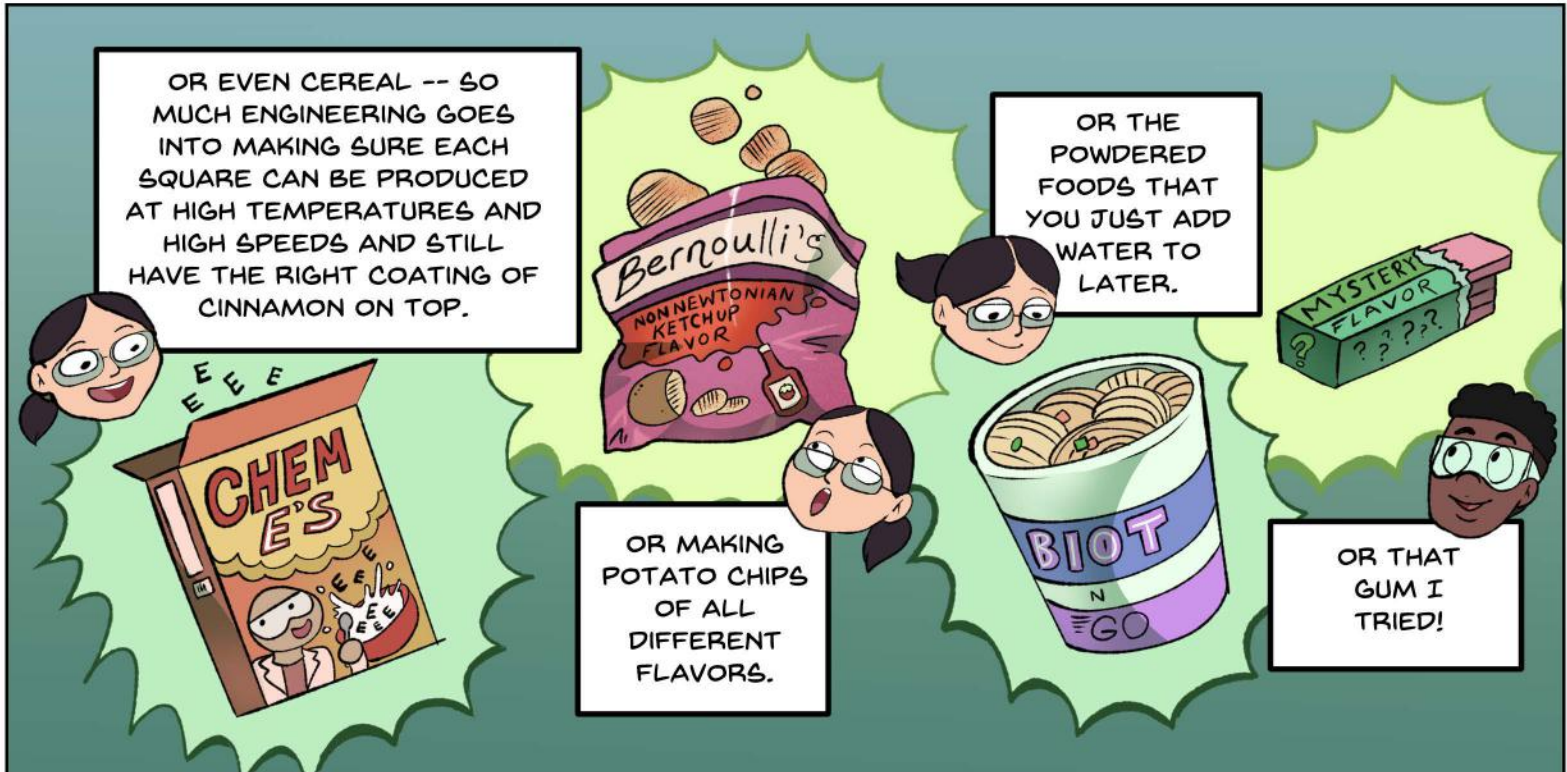
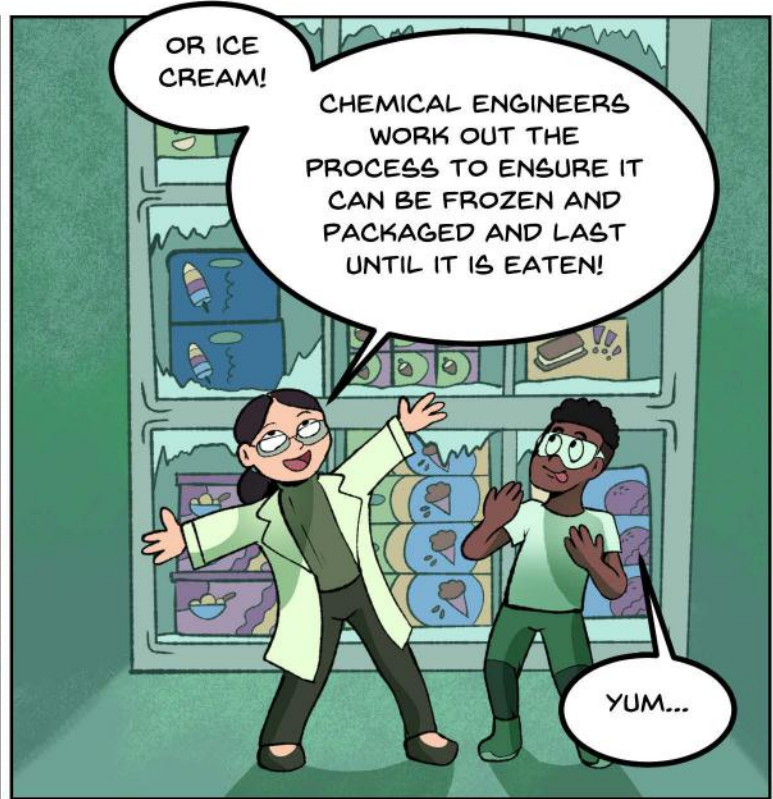
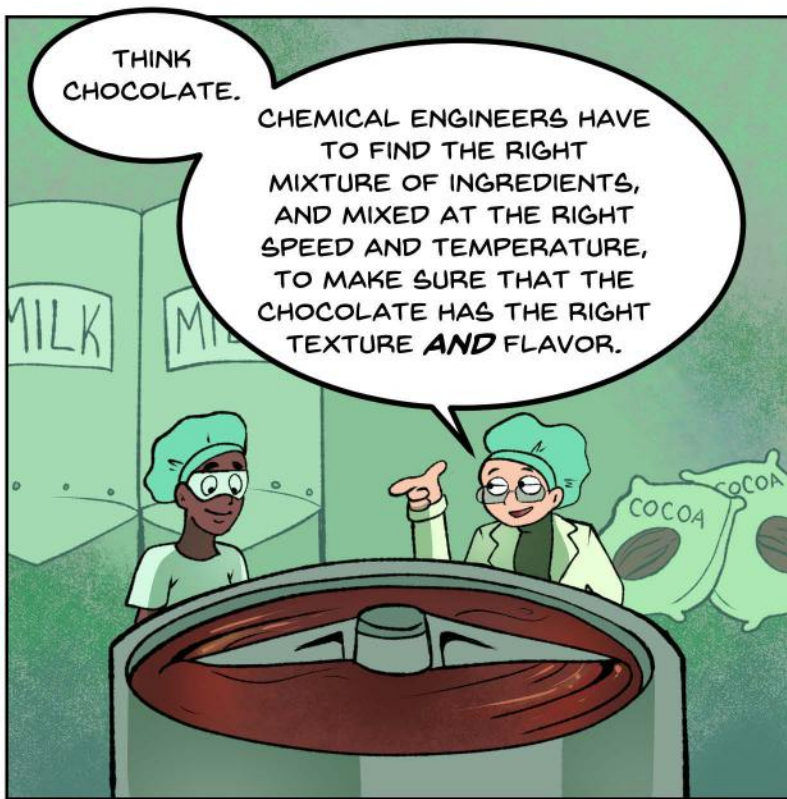
THERE CERTAINLY HAVE BEEN SOME INCREDIBLY TOXIC CHEMICALS PRODUCED IN THE PAST, HURTING BOTH PEOPLE AND BEES.

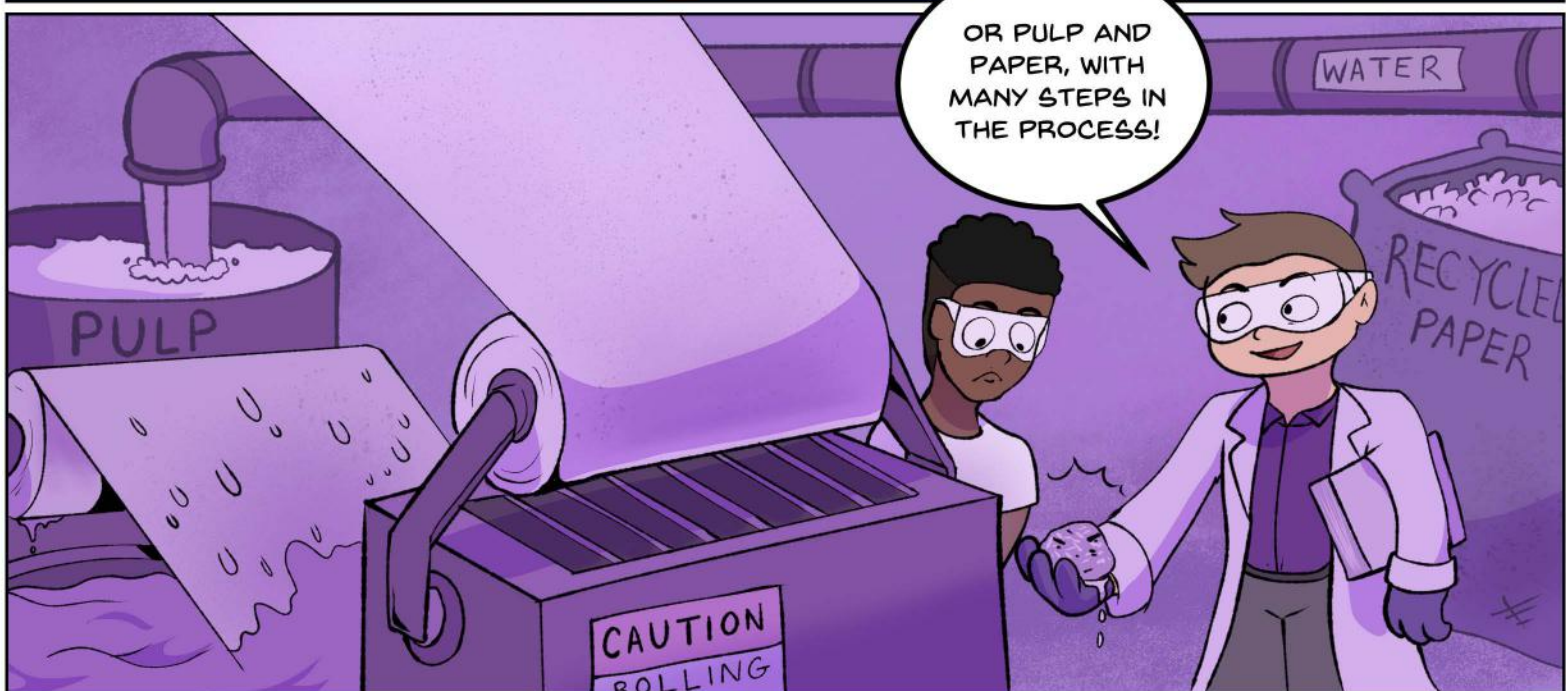
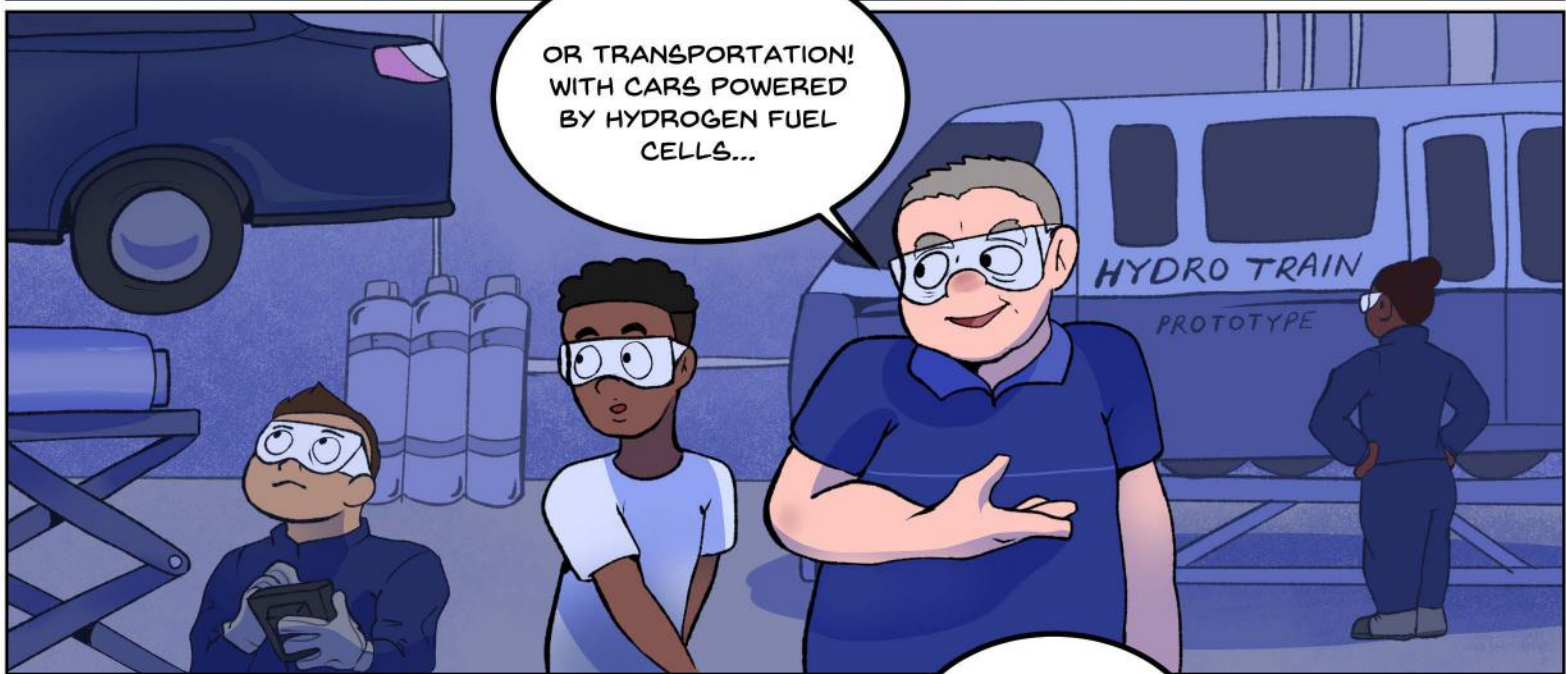
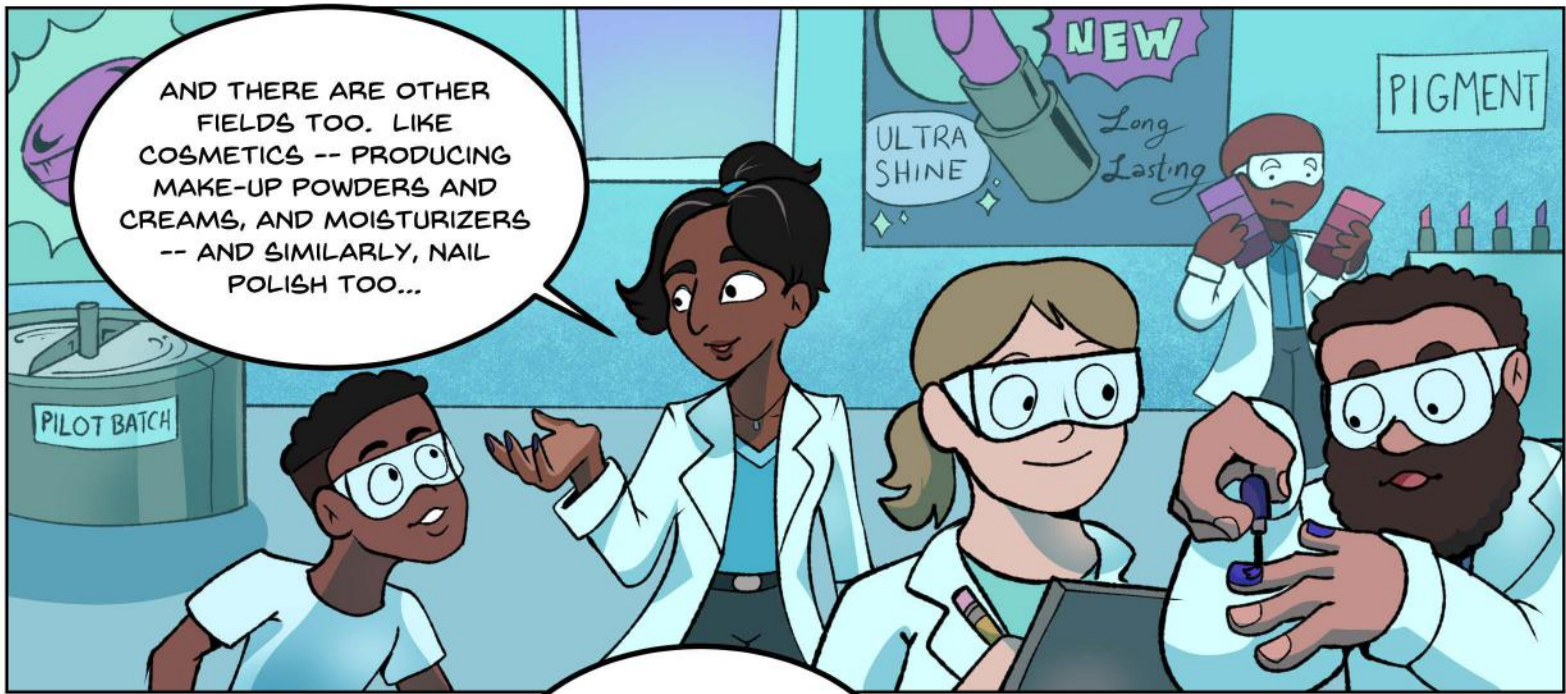
SO CHEMES TRY TO PRODUCE VERSIONS THAT ARE BETTER CONTROLLED.

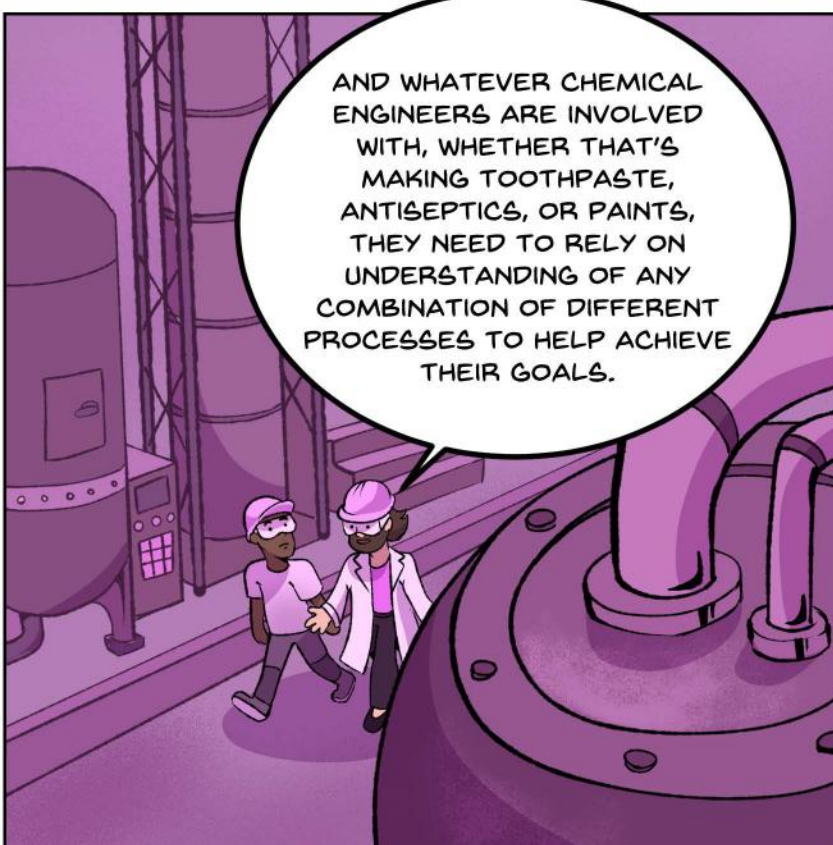


AND AFTER THE CROPS ARE GROWN?

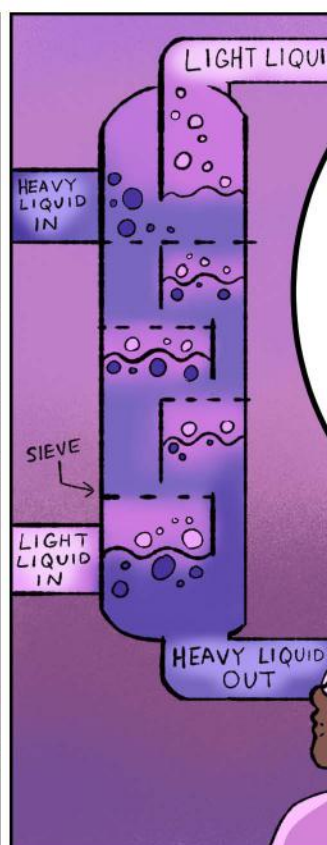
WELL, YOU CERTAINLY DON'T JUST EAT RAW PLANTS, RIGHT? ALL OF THAT GETS TURNED INTO DIFFERENT FOOD PRODUCTS -- AND FINDING THE PROCESSES ARE CRITICAL FOR EACH FINAL PRODUCT!



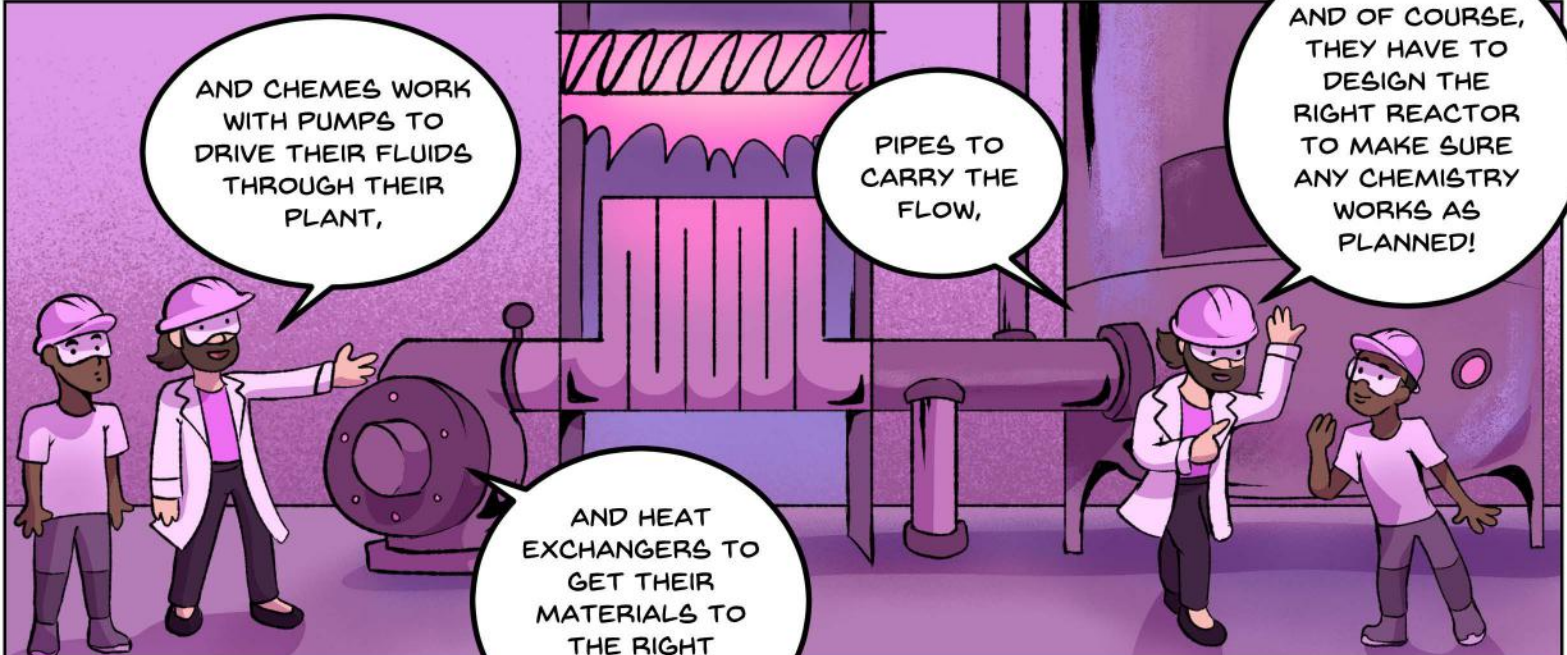




AND WHATEVER CHEMICAL ENGINEERS ARE INVOLVED WITH, WHETHER THAT'S MAKING TOOTHPASTE, ANTISEPTICS, OR PAINTS, THEY NEED TO RELY ON UNDERSTANDING OF ANY COMBINATION OF DIFFERENT PROCESSES TO HELP ACHIEVE THEIR GOALS.



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.

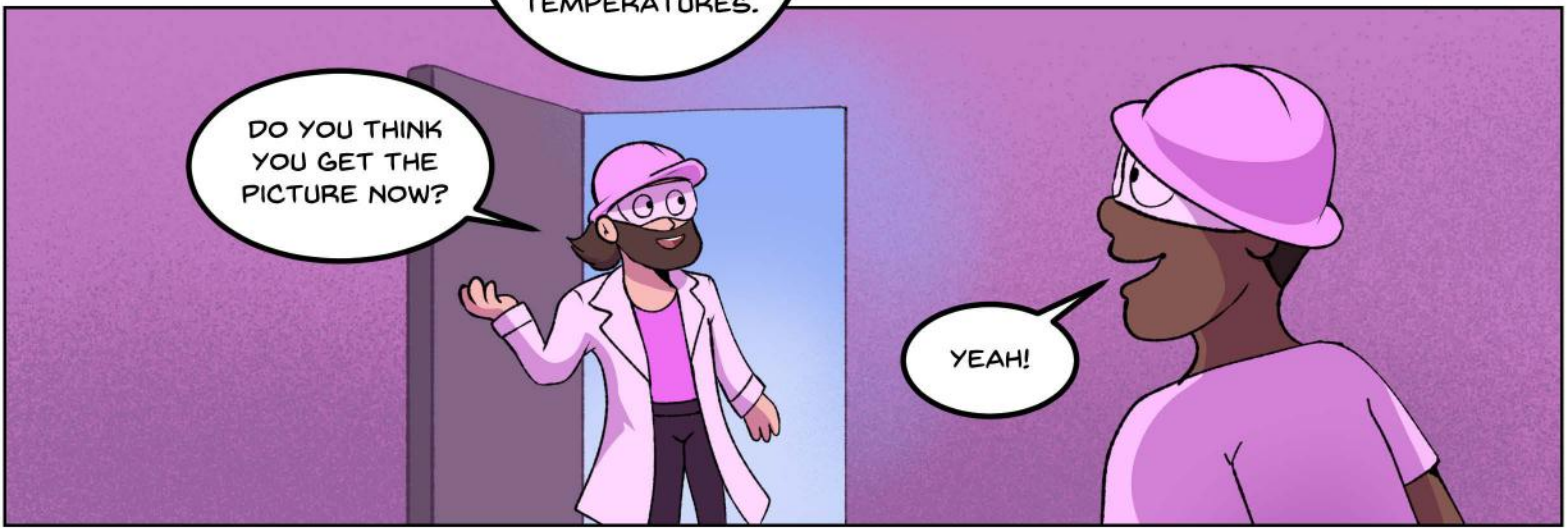


AND CHEMES WORK WITH PUMPS TO DRIVE THEIR FLUIDS THROUGH THEIR PLANT,

PIPES TO CARRY THE FLOW,

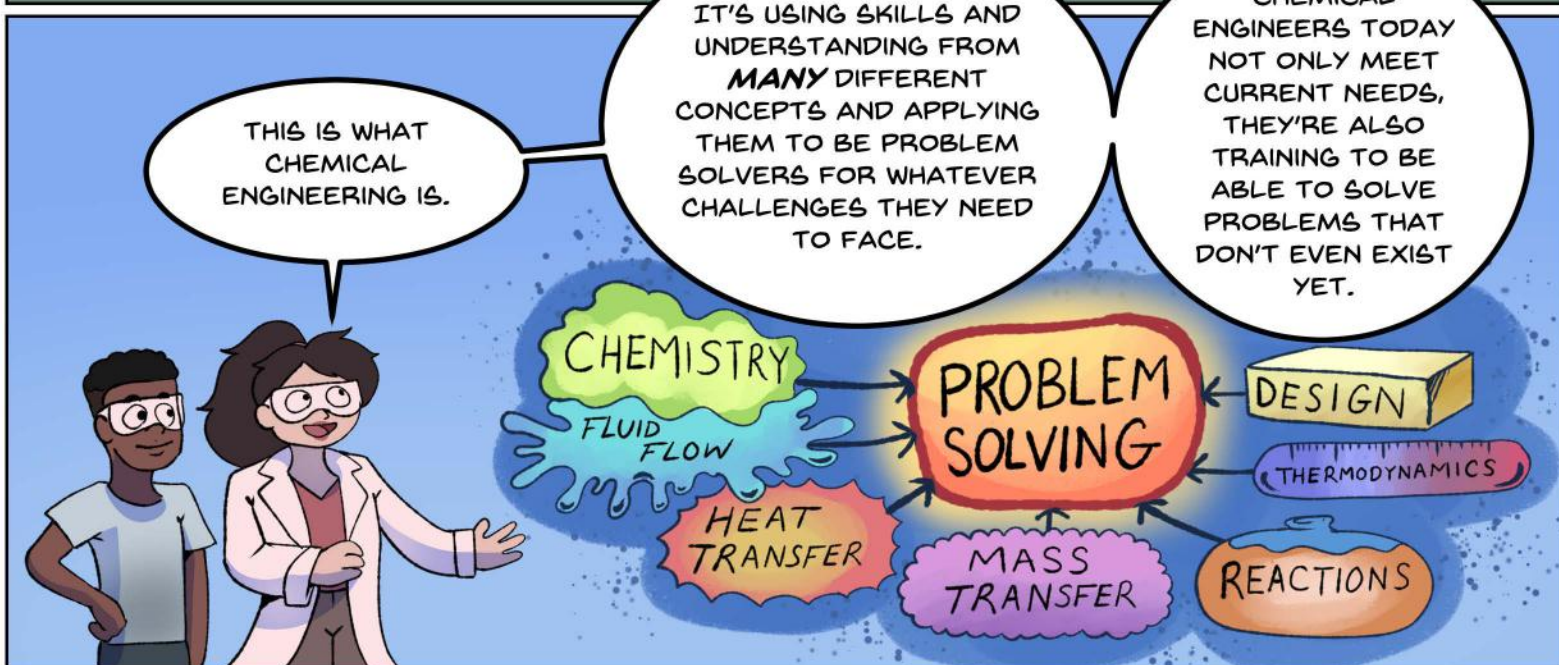
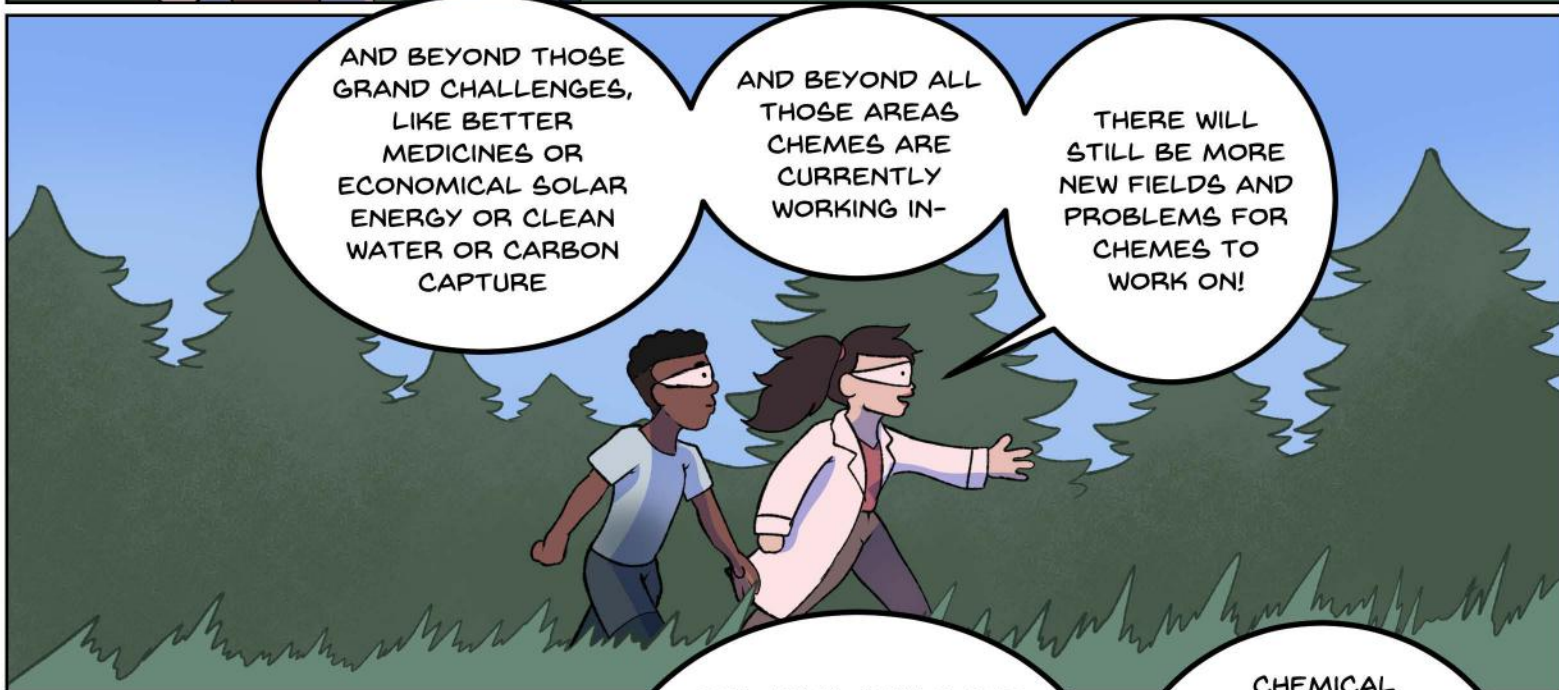
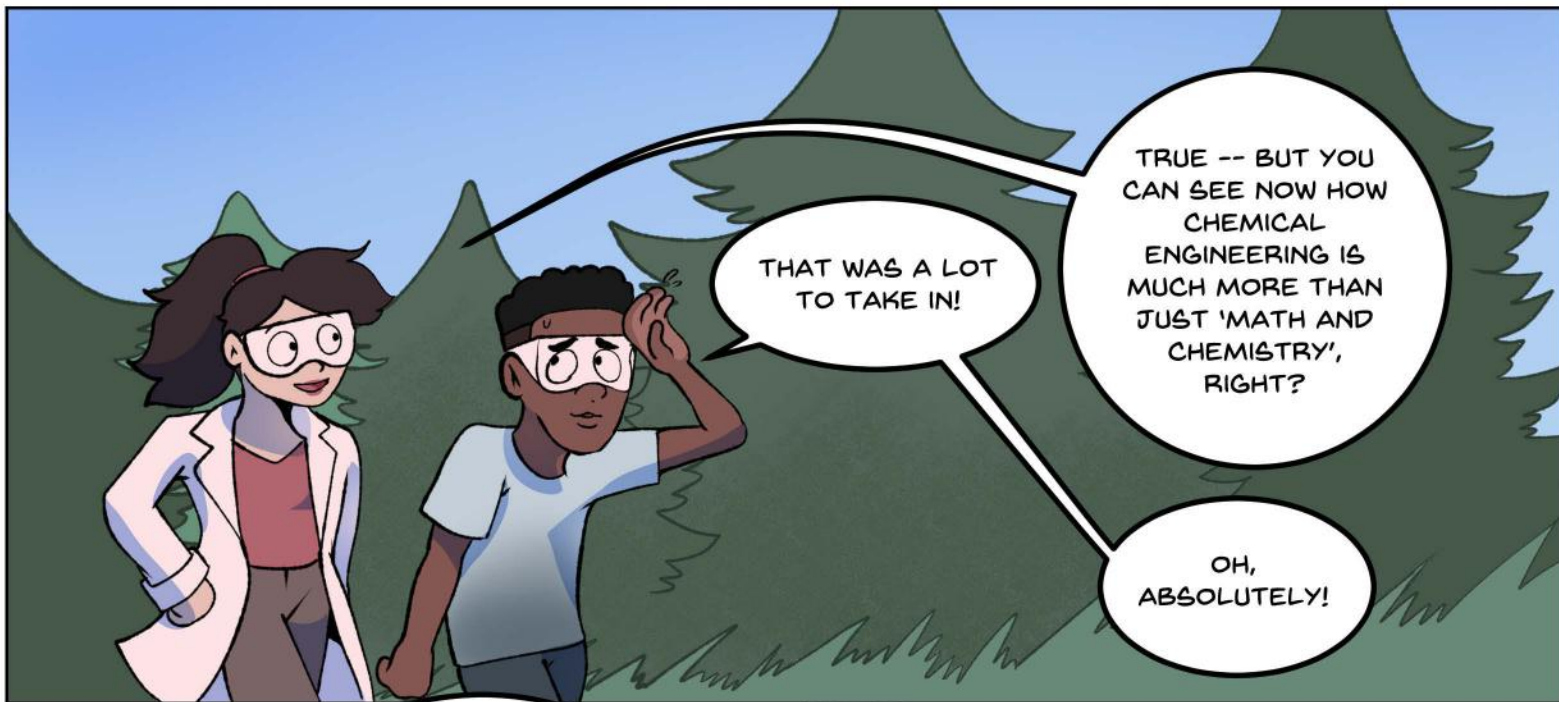
AND HEAT EXCHANGERS TO GET THEIR MATERIALS TO THE RIGHT TEMPERATURES.

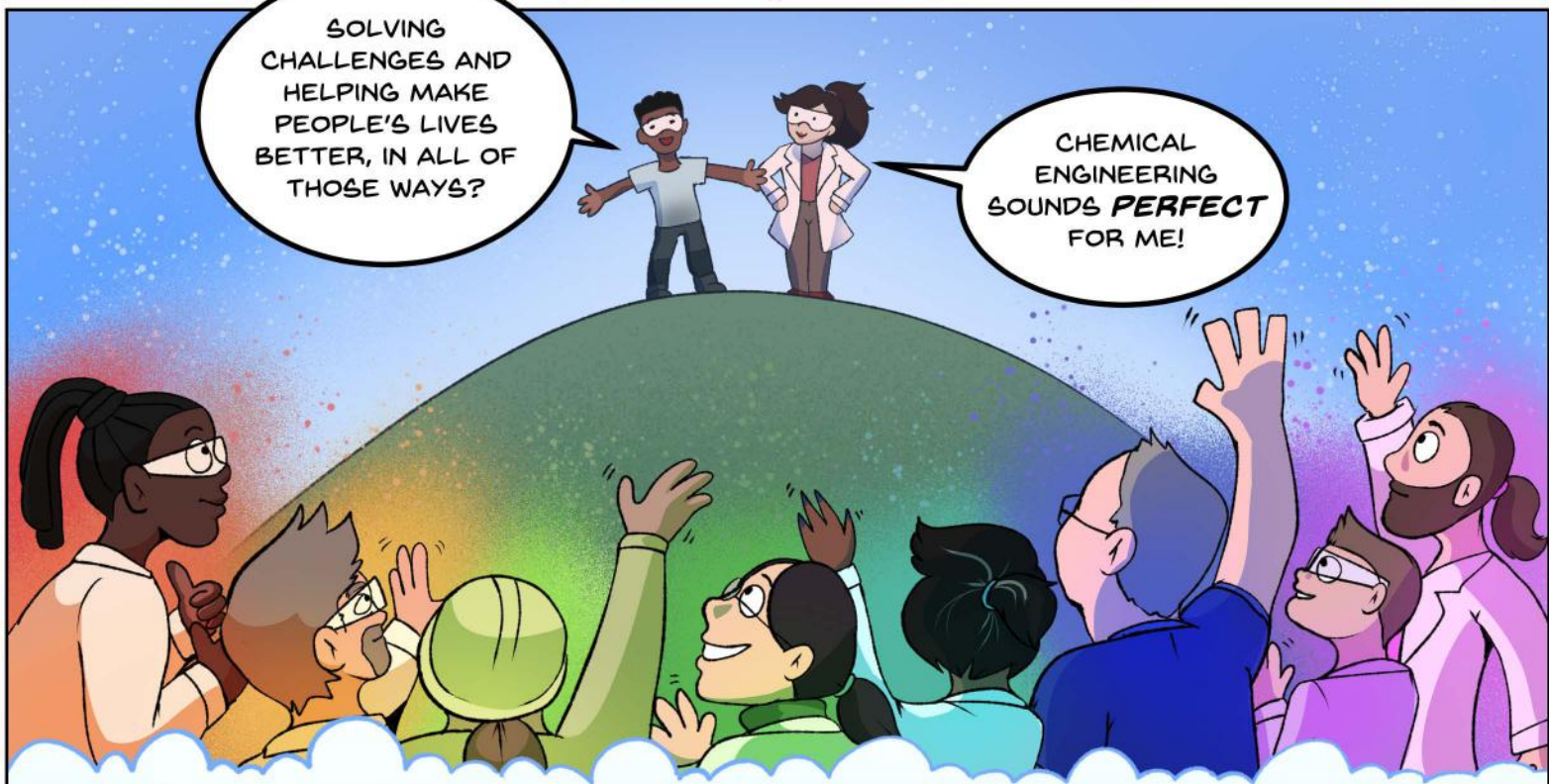
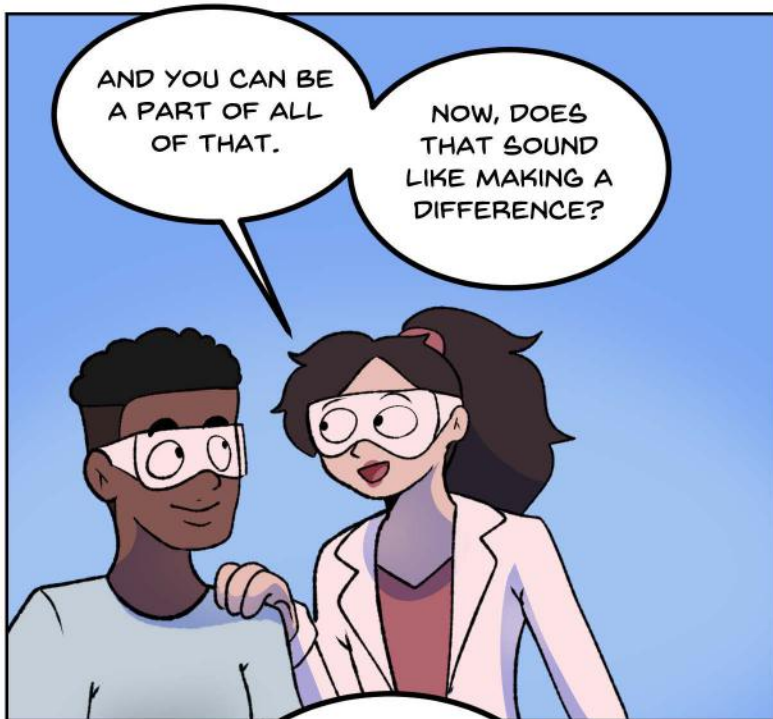
AND OF COURSE, THEY HAVE TO DESIGN THE RIGHT REACTOR TO MAKE SURE ANY CHEMISTRY WORKS AS PLANNED!



DO YOU THINK YOU GET THE PICTURE NOW?

YEAH!





THE WIDE WORLD OF CHEMICAL ENGINEERING

WRITTEN BY: IRA HYSI AND LUKE LANDHERR

DRAWN BY: MONICA KESZLER

AIChE
The Global Home of Chemical Engineers



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.

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.