DISABILITY ADVENTURE 2

THE CRISPR BOOGALOO

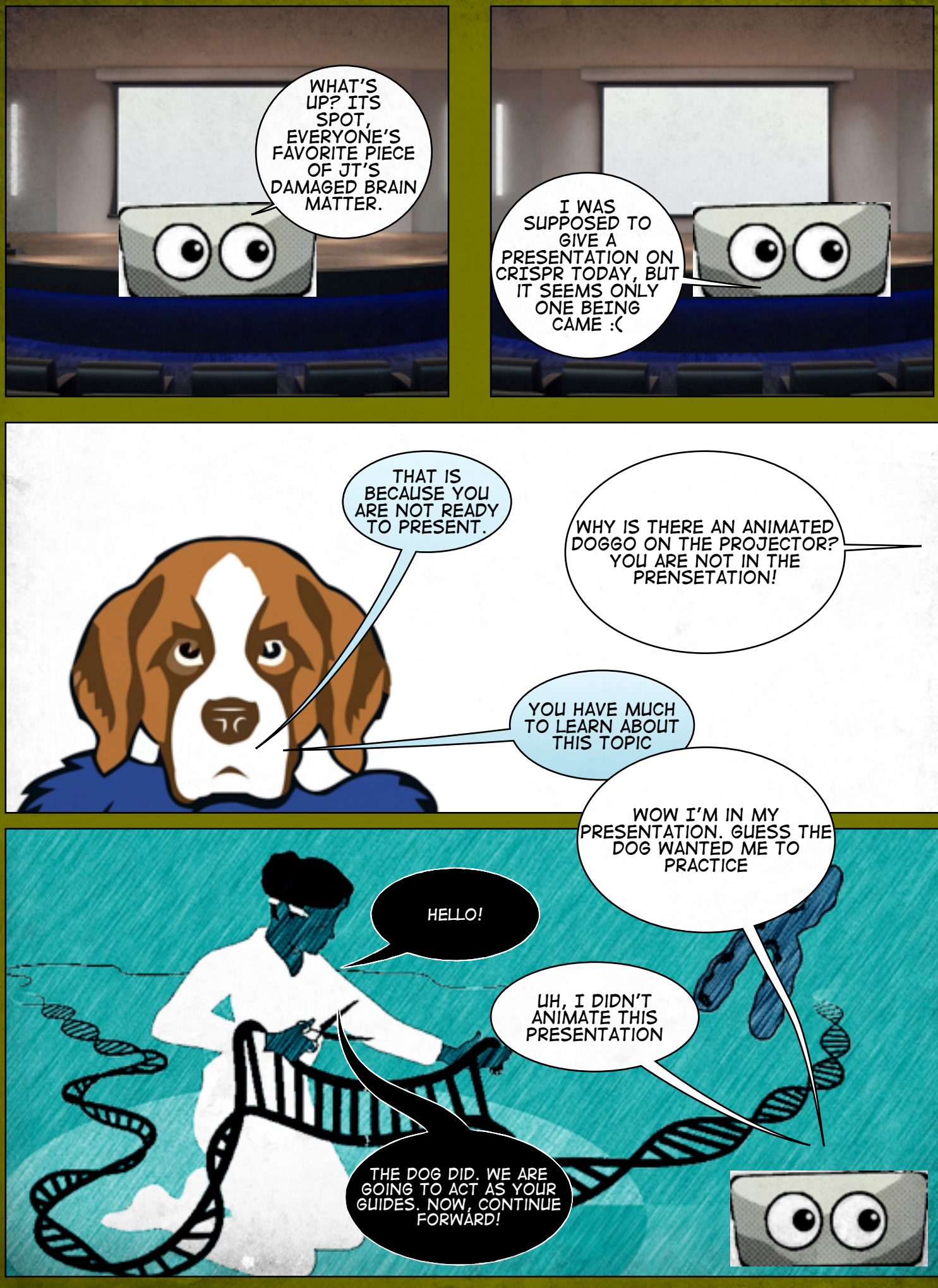
AUTHOR'S NOTE

WARNING: THIS TEXT INCLUDES ABLEISM, EUGENICS, HITLER REFERENCES, AND REFERENCES TO STRUGGLES OVER BODILY AUTONOMY.

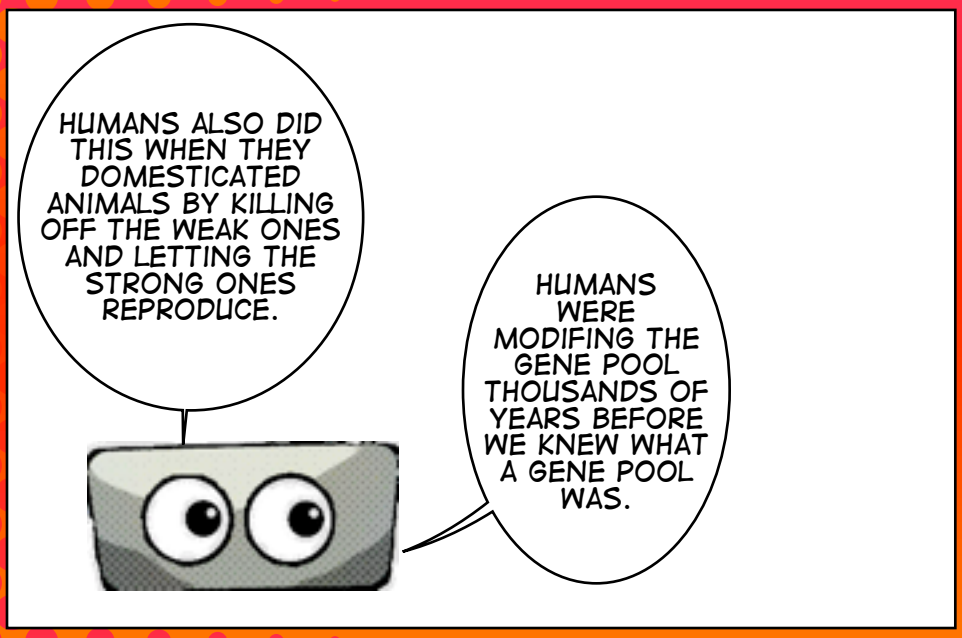
THIS COMIC, MUCH LIKE THE LAST ONE, WAS A JOY TO WRITE. I AM NOT A BIOLOGIST BY TRADE, SO I WAS LUCKY TO EXPLORE A CONCEPT I FOUND INTERESTING. I WILL MENTION THAT THE LITERATURE SURROUNDING BIOLOGY CONCEPTS APPEARS TO BE MORE ACCESSIBLE AT THE INTRODUCTORY LEVEL THAN MATH OR PHYSICS INFORMATION. HOWEVER, OVER THE COURSE OF THIS PROCESS, I BEGAN TO REALIZE HOW PERTINENT THIS ISSUE IS.

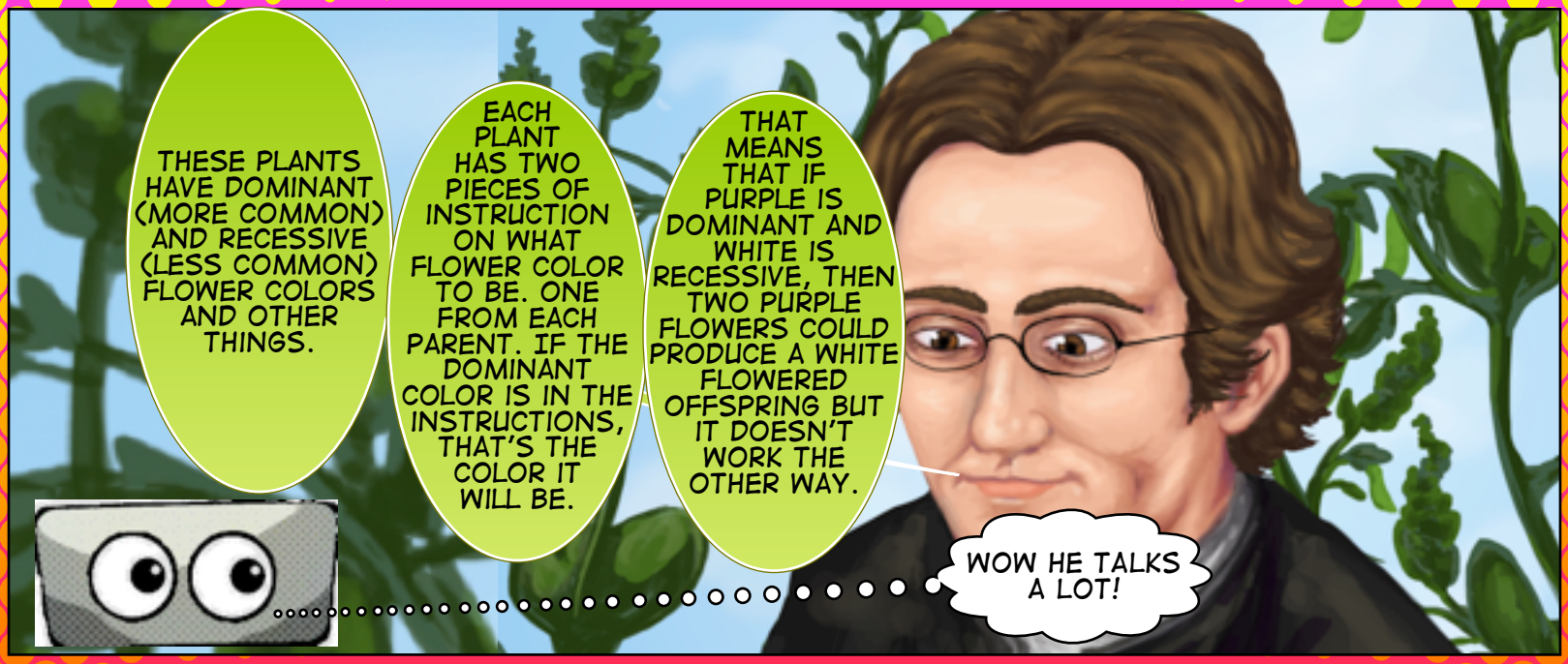
I INITIALLY THOUGHT THE ABILITY FOR GENE EDITING TO BE COMMONPLACE WOULD NOT HAPPEN FOR A FEW GENERATIONS. HOWEVER, WITH THE RAPID ADVANCEMENT OF BIOTECHNOLOGY, THE ERA OF GENE EDITING MAY BE SOONER THAN WE THINK. CONSIDERING THIS NATION IS HAVING DIFFICULTY WITH ROE V. WADE (AGAIN) WE ARE COLLECTIVELY NOT READY TO HAVE THE CONVERSATION ABOUT GENE EDITING. THIS IS CLEAR WITHIN THE SEARCH FOR RESOURCES I EMBARKED ON TO CREATE THIS COMIC. THE MAJORITY OF RESOURCES I FOUND ONLY TALKED ABOUT THE POSITIVE ASPECTS OF CRISPR WITHOUT TALKING ABOUT ANY POTENTIAL NEGATIVE IMPACT. EVEN THE NOBEL PRIZE WEBSITE ONLY MENTIONED THAT THIS MIGHT BE AN ETHICAL DILEMMA. EXCUSE ME, BUT THIS IS GOING TO BE A CRISIS LATER. ONLY TWO ARTICLES I FOUND INCLUDED DISABLED VOICES. THERE IS NO LEADERSHIP FROM THE MOST IMPACTED IN THIS DEBATE, AND THIS MUST HAPPEN IF WE WANT THE BEST OUTCOME FOR THE MOST PEOPLE.

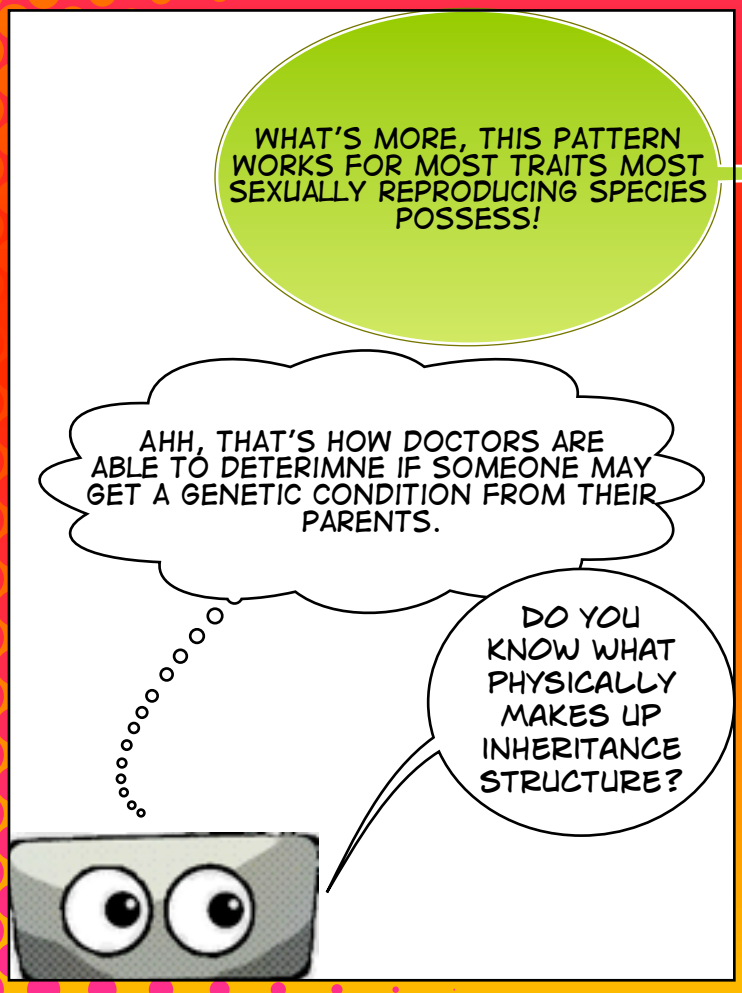
CRISPR HAS THE POWER TO CHANGE THE WORLD, BUT IF IT IS NOT UNIVERSALLY EXTREMELY REGULATED, ADDING CRISPR TO THE EQUATION WILL GO VERY POORLY FOR EVERYONE.


WHAT'S UP? ITS SPOT, EVERYONE'S FAVORITE PIECE OF JT'S DAMAGED BRAIN MATTER.
I WAS SUPPOSED TO GIVE A PRESENTATION ON CRISPR TODAY, BUT IT SEEMS ONLY ONE BEING CAME :(
THAT IS BECAUSE YOU ARE NOT READY TO PRESENT.
WHY IS THERE AN ANIMATED DOGGO ON THE PROJECTOR? YOU ARE NOT IN THE PRENSETATION!
YOU HAVE MUCH TO LEARN ABOUT THIS TOPIC
WOW I'M IN MY PRESENTATION. GUESS THE DOG WANTED ME TO PRACTICE
HELLO!
UH, I DIDN'T ANIMATE THIS PRESENTATION
THE DOG DID. WE ARE GOING TO ACT AS YOUR GUIDES. NOW, CONTINUE FORWARD!

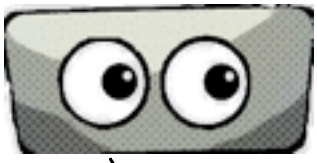
BEFORE WE CAN TALK ABOUT CRISPR, WE NEED TO TALK ABOUT SELECTIVE BREEDING AS A CONCEPT.



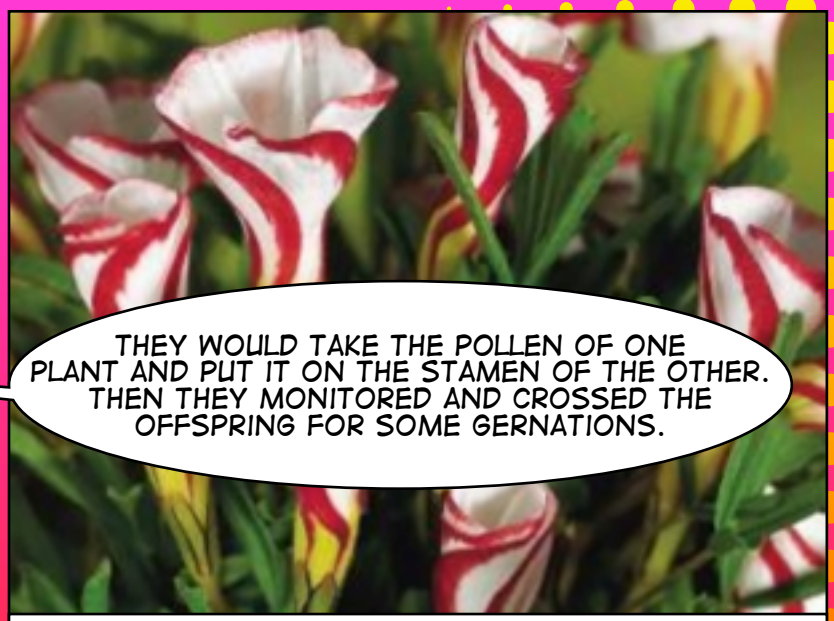

THESE PLANTS HAVE DOMINANT (MORE COMMON) AND RECESSIVE (LESS COMMON) FLOWER COLORS AND OTHER THINGS.
EACH PLANT HAS TWO PIECES OF INSTRUCTION ON WHAT FLOWER COLOR TO BE. ONE FROM EACH PARENT. IF THE DOMINANT COLOR IS IN THE INSTRUCTIONS, THAT'S THE COLOR IT WILL BE.
THAT MEANS THAT IF PURPLE IS DOMINANT AND WHITE IS RECESSIVE, THEN TWO PURPLE FLOWERS COULD PRODUCE A WHITE FLOWERED OFFSPRING BUT IT DOESN'T WORK THE OTHER WAY.
WOW HE TALKS A LOT!


WHAT'S MORE, THIS PATTERN WORKS FOR MOST TRAITS MOST SEXUALLY REPRODUCING SPECIES POSSESS!
AHH, THAT'S HOW DOCTORS ARE ABLE TO DETERIMNE IF SOMEONE MAY GET A GENETIC CONDITION FROM THEIR PARENTS.
DO YOU KNOW WHAT PHYSICALLY MAKES UP INHERITANCE STRUCTURE?


ONE COULD POTENTIALLY USE THIS WORK TO SELECTIVELY BREED FOR BETTER TRAITS.
NO I DON'T, BUT I THINK THE ANSWER IS ON YOUR NEXT SLIDE.



I SHOULD MENTION BEFORE WE MOVE ON THAT PLANT BREEDERS RAN WITH MENDEL'S THEORIES TO CREATE DIFFERENT PLANTS WITH DESIRABLE TRAITS.

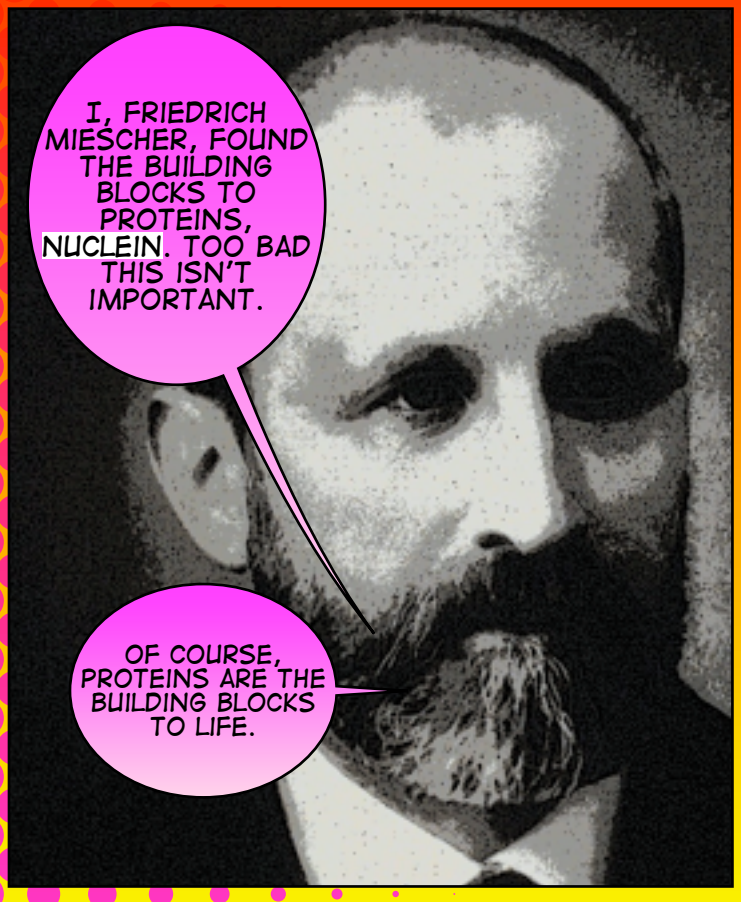


THEY WOULD TAKE THE POLLEN OF ONE PLANT AND PUT IT ON THE STAMEN OF THE OTHER. THEN THEY MONITORED AND CROSSED THE OFFSPRING FOR SOME GERNATIONS.

WHILE THIS METHOD HAD SOME SUCCESS, THERE WERE OFTEN UNEXPECTED RESULTS DUE TO ALL TRAITS BEING CROSSED IN THE OFFSPRING.

THE TECHNIQUES USED IN SELECTIVE BREEDING WOULDN'T CHANGE UNTIL WE FIGURED OUT WHAT EXACTLY ENCODED FOR TRAITS.

IN 1869, SOMEONE NEARLY HAD THEIR FINGER ON IT.

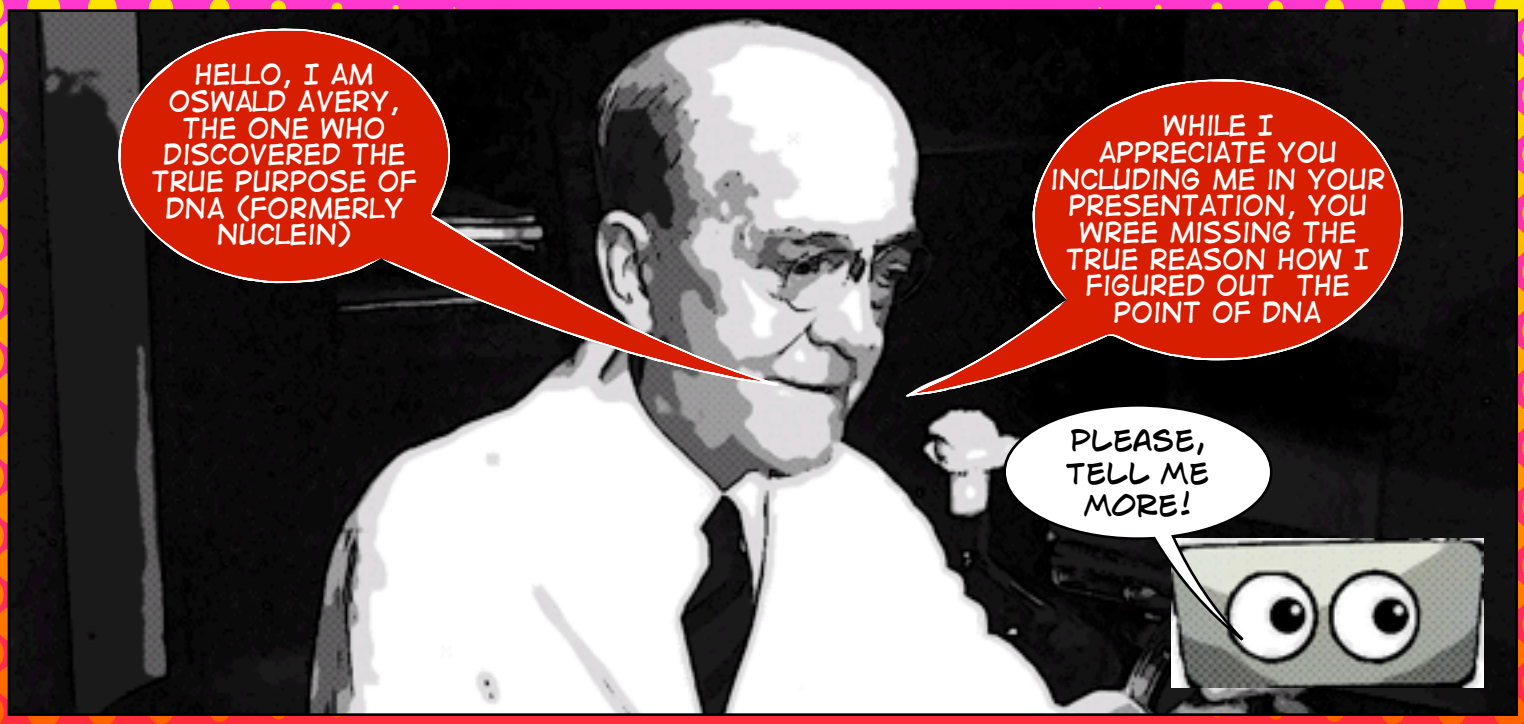


I, FRIEDRICH MIESCHER, FOUND THE BUILDING BLOCKS TO PROTEINS, NUCLEIN. TOO BAD THIS ISN'T IMPORTANT.

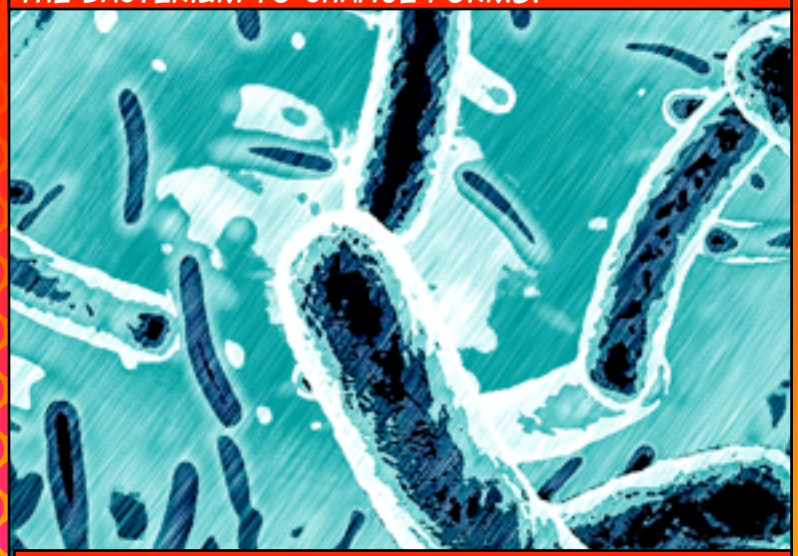
OF COURSE, PROTEINS ARE THE BUILDING BLOCKS TO LIFE.

WELL, HE WAS WRONG ABOUT THAT ONE BUT THE MISTAKE WAS FIXED IN 1940.

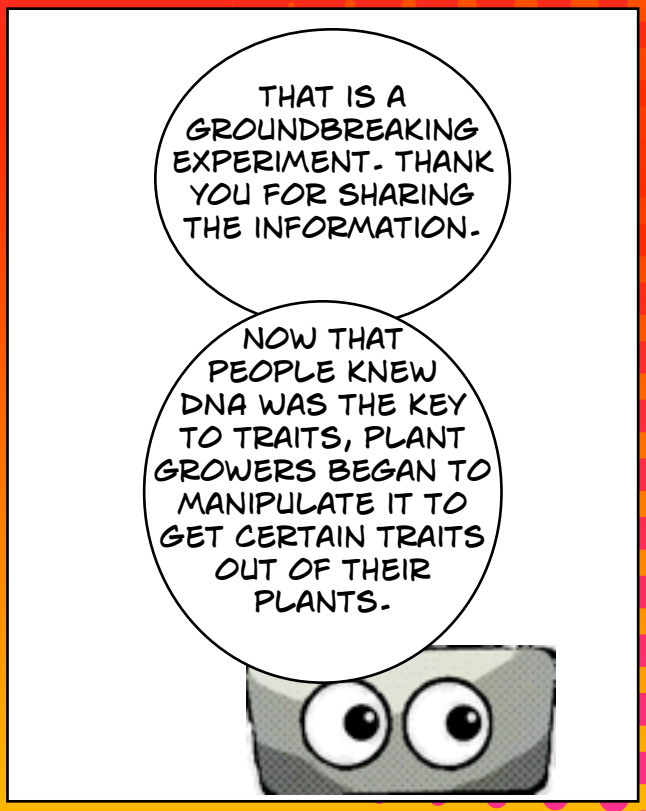
OH MY GOD I JUST REALIZED IT SERIOUSLY TOOK 70 YEARS TO FIGURE THAT OUT?! (LOOK, I'M BAD AT MATH, OKAY?)



I WAS WORKING WITH TWO VARIANTS OF A BACTERIUM THAT CAUSES PNEUMONIA. THE S TYPE HAD A HARD CAPSULE AND THE R TYPE DID NOT. I REALIZED THAT IF I CHANGED THE SEQUENCING OF COMPONENTS (BASES) IN THE DNA I COULD CAUSE THE BACTERIUM TO CHANGE FORMS.

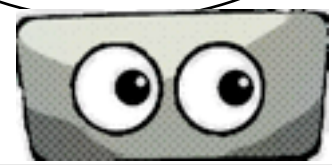


SINCE I REALIZED THE BACTERIUM CHANGED FORM ONLY WHEN I CHANGED THE DNA AND NOT THE PROTEINS, THE DNA MUST BE WHAT ENCODES FOR THE PHYSICAL TRAITS OF AN ORGANISM.

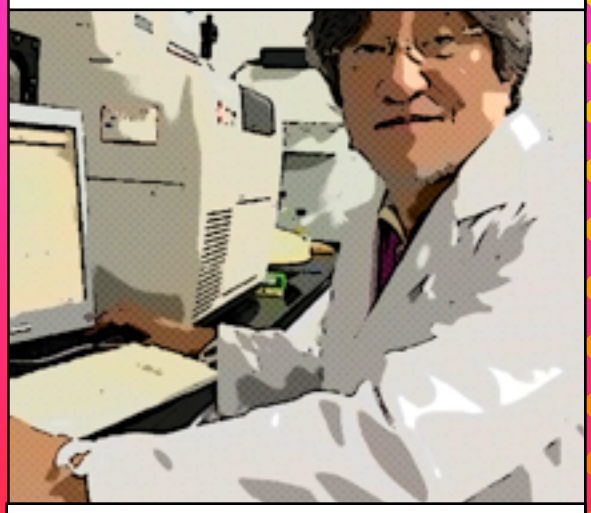


IN A PROCESS CALLED MUTAGENESIS, PLANTS ARE BATHED IN EITHER RADIATION OR CHEMICALS SO MUTATIONS CAN OCCUR.

THIS METHOD PRODUCED OVER 2500 SUCCESSFUL CROSSBREEDS, BUT COUNTLESS MORE FAILED ATTEMPTS.

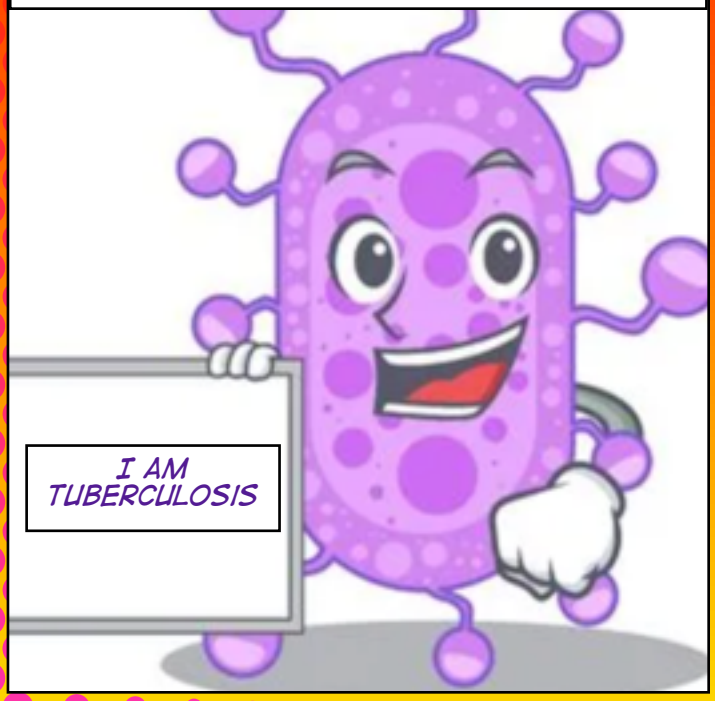


THE NEXT STEP IN DECONSTRUCTING DNA IS TO INTERPRET ITS BASE ORDER. IN 1987, YOSHIZUMI ISHINO WAS STUDYING SOME ECOLI.

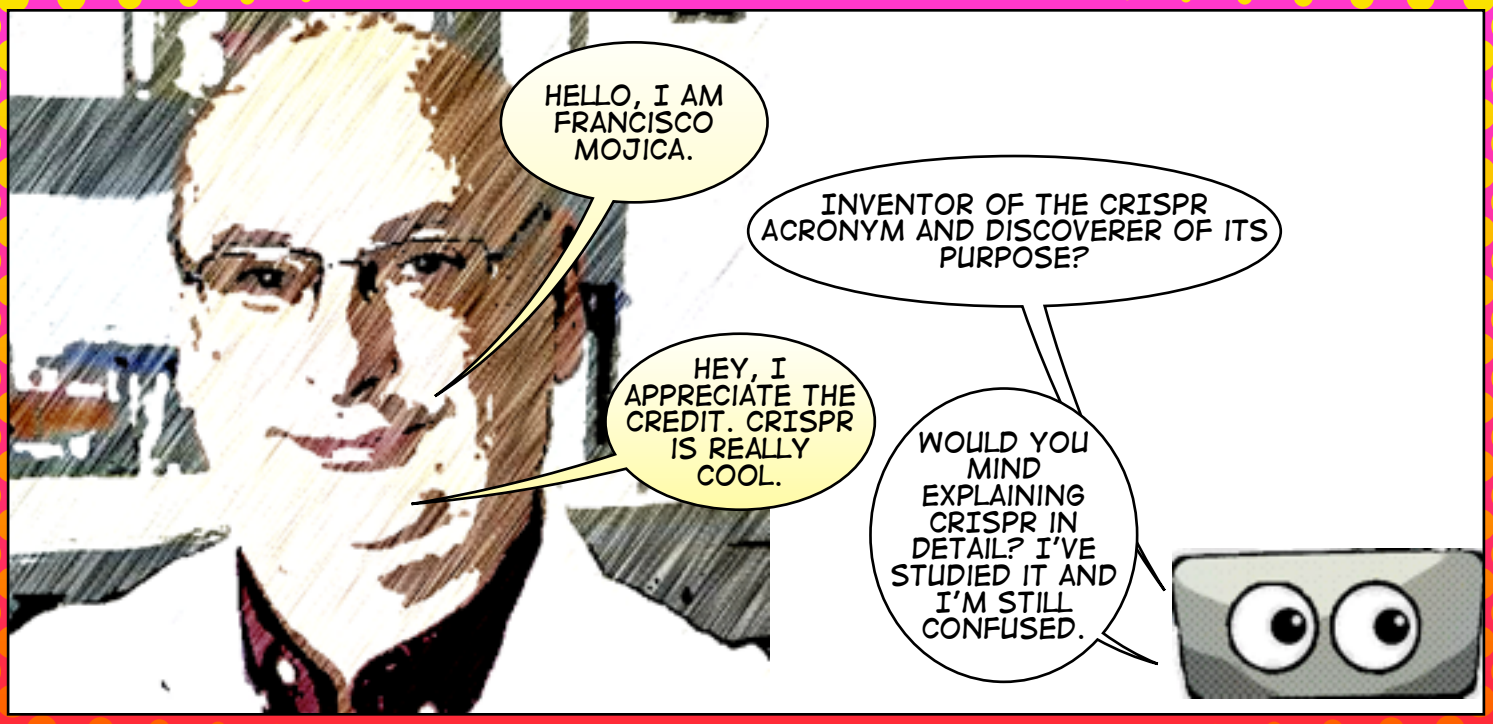


HE NOTICED THAT THERE WERE MANY REPEATED SEQUENCES IN A CERTAIN SECTION OF THE DNA SPLIT BY SPACERS. HE DID NOT YET KNOW THE SIGNIFICANCE OF THESE SEQUENCES.

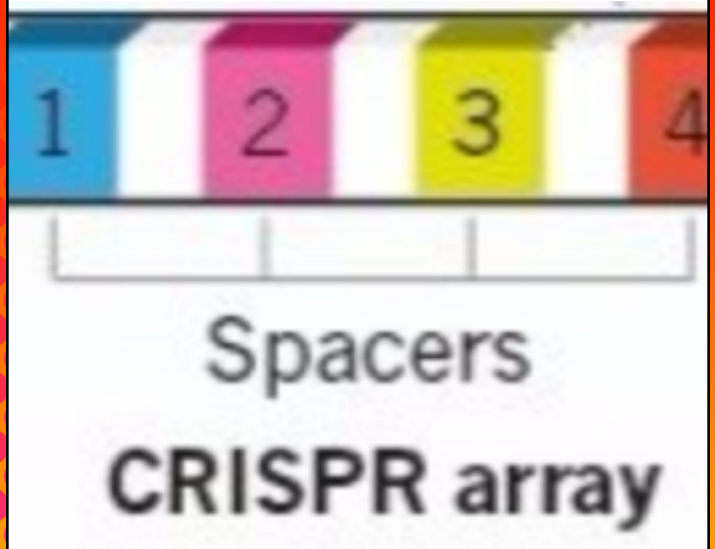
SIX YEARS LATER, J.D VAN EMBEDDEN AND HIS RESEARCH TEAM NOTICED THAT TUBERCULOSIS BACTERIA CONTAINED THESE REPEATING SEQUENCES. EACH STRAIN OF BACTERIA POSSESSED A DIFFERENT NUMBER OF SEQUENCES.



HOWEVER, THE MAN WHO MADE CRISPR RELEVANT WOULD UNLOCK ITS SECRETS IN 2000.

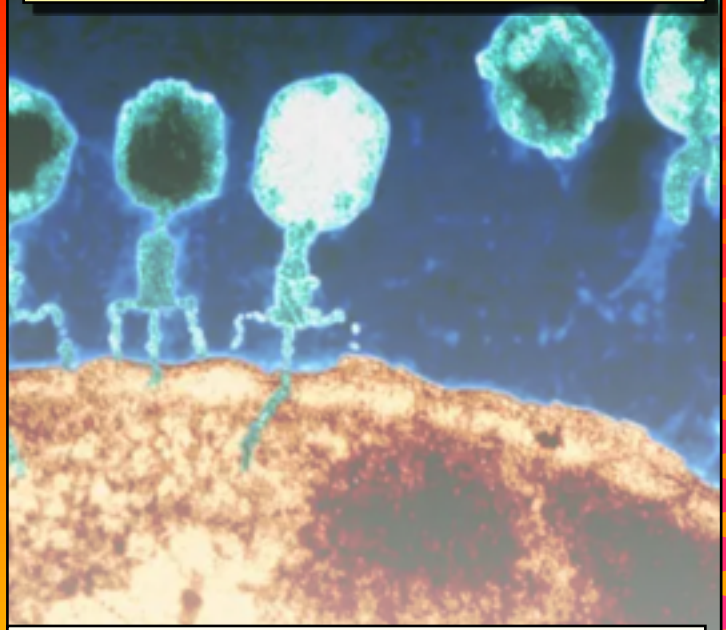


CRISPER IS SHORT FOR CLUSTERED REGULARLY INTERSPACED SHORT PALINDROMIC REPEATS. THEY ARE FOUND IN ALL SORTS OF BACTERIA AND ARCHEA.

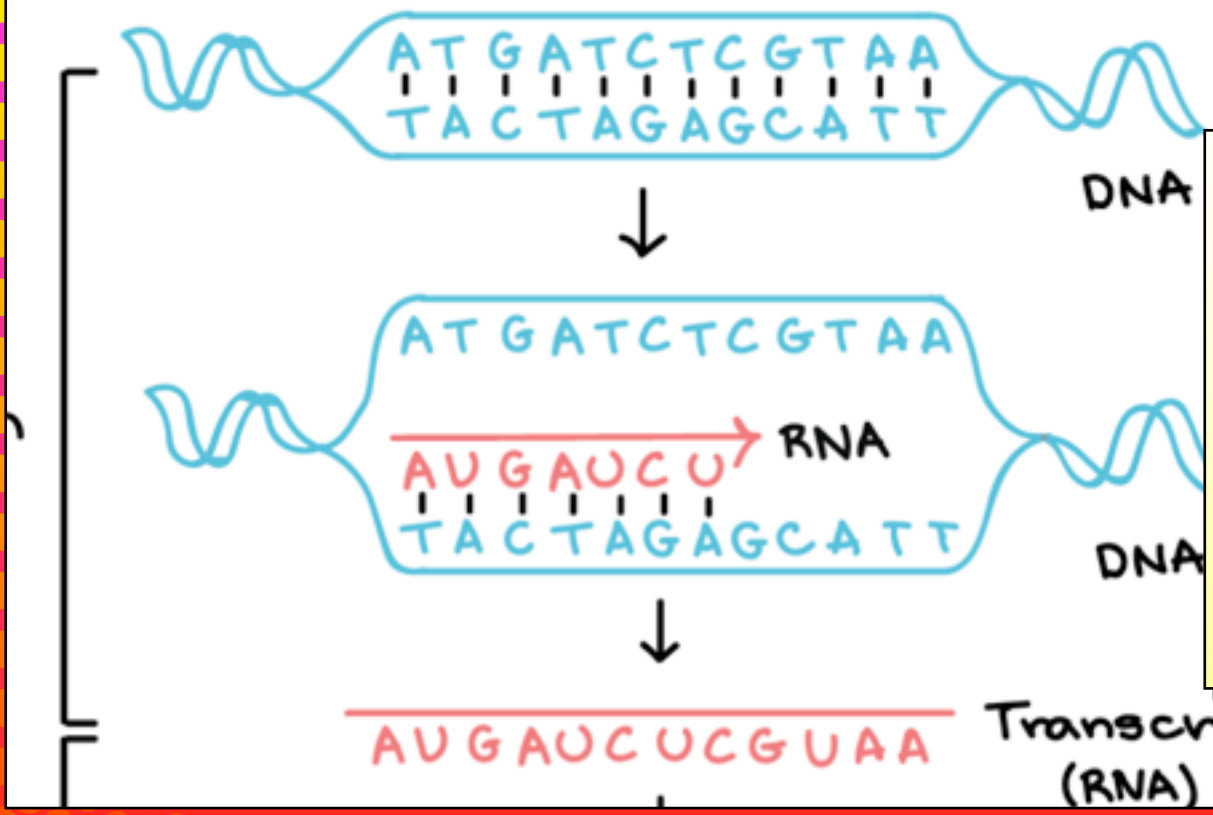


CRISPR GENES ARE MADE TWO TYPES OF DNA COMBINED: THE REPEATS (WHITE IN THE DIAGRAM) AND BITS OF VIRAL DNA (THE COLORS IN THE DIAGRAM) THEY SERVE AS THE ORGANISM'S DEFENSE SYSTEM.

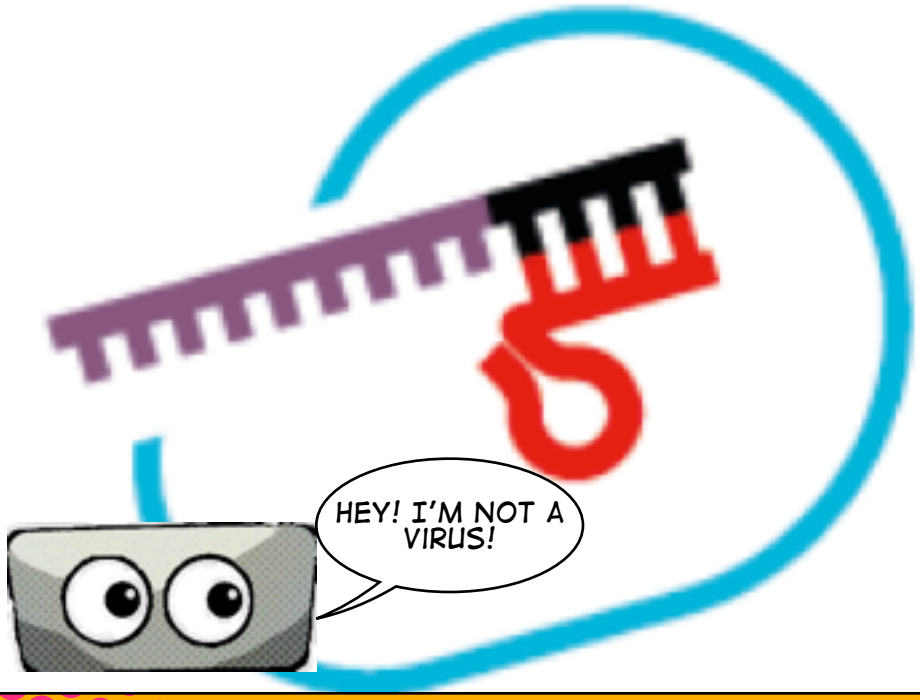
WHEN A VIRUS ATTACKS A BACTERIUM, THE VIRUS ATTEMPTS TO HIJACK THE BACTERIUM BY INSERTING THEIR DNA OR RNA (HALF A DNA MOLECULE WITH SOME CHANGES) INTO THE HOST GENES, TRICKING THE BACTERIUM INTO MAKING MORE VIRUSES.



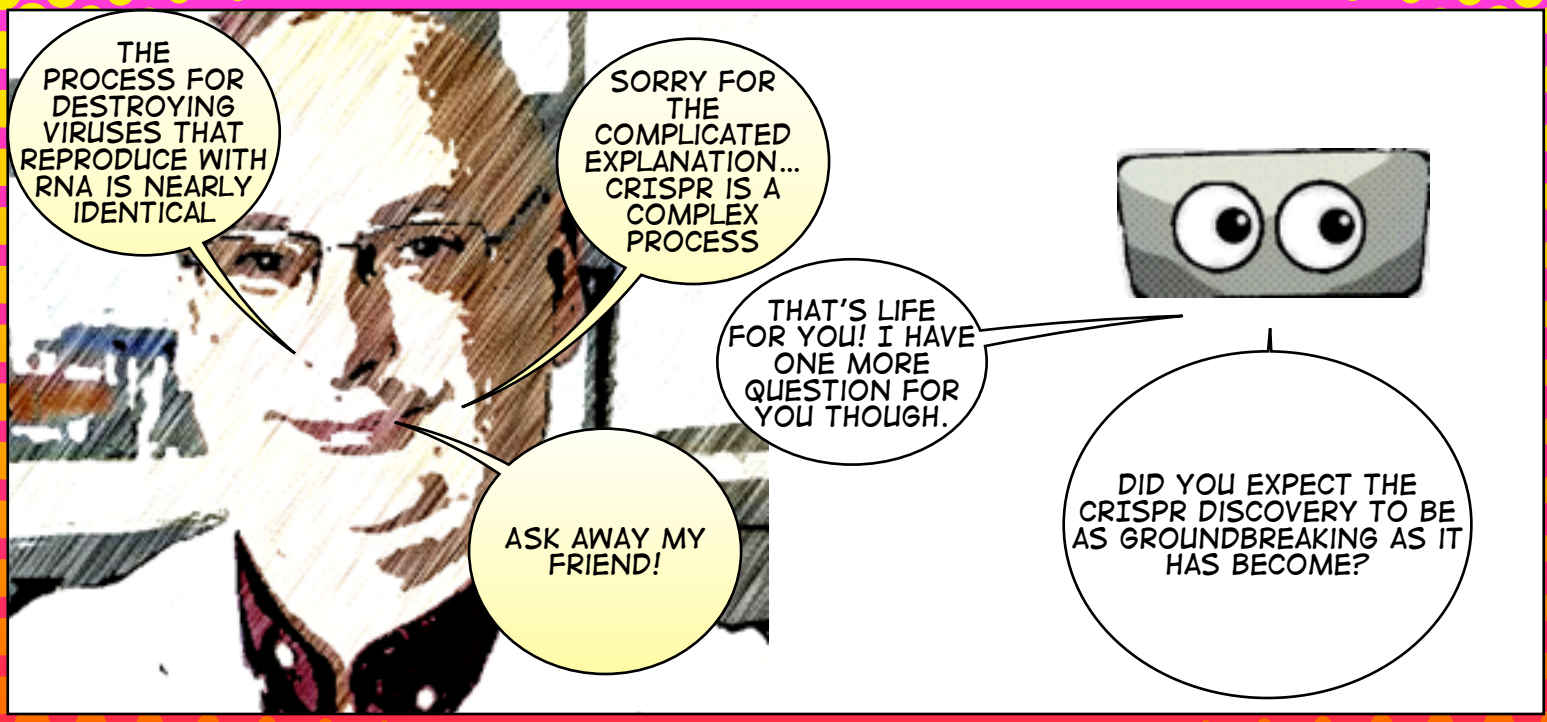
IF THE BACTERIUM SURVIVES THE VIRAL INVASION, THE VIRAL GENETIC MATERIAL IS INCORPORATED INTO THE CRISPR SECTION OF THE BACTERIUM'S GENOME.

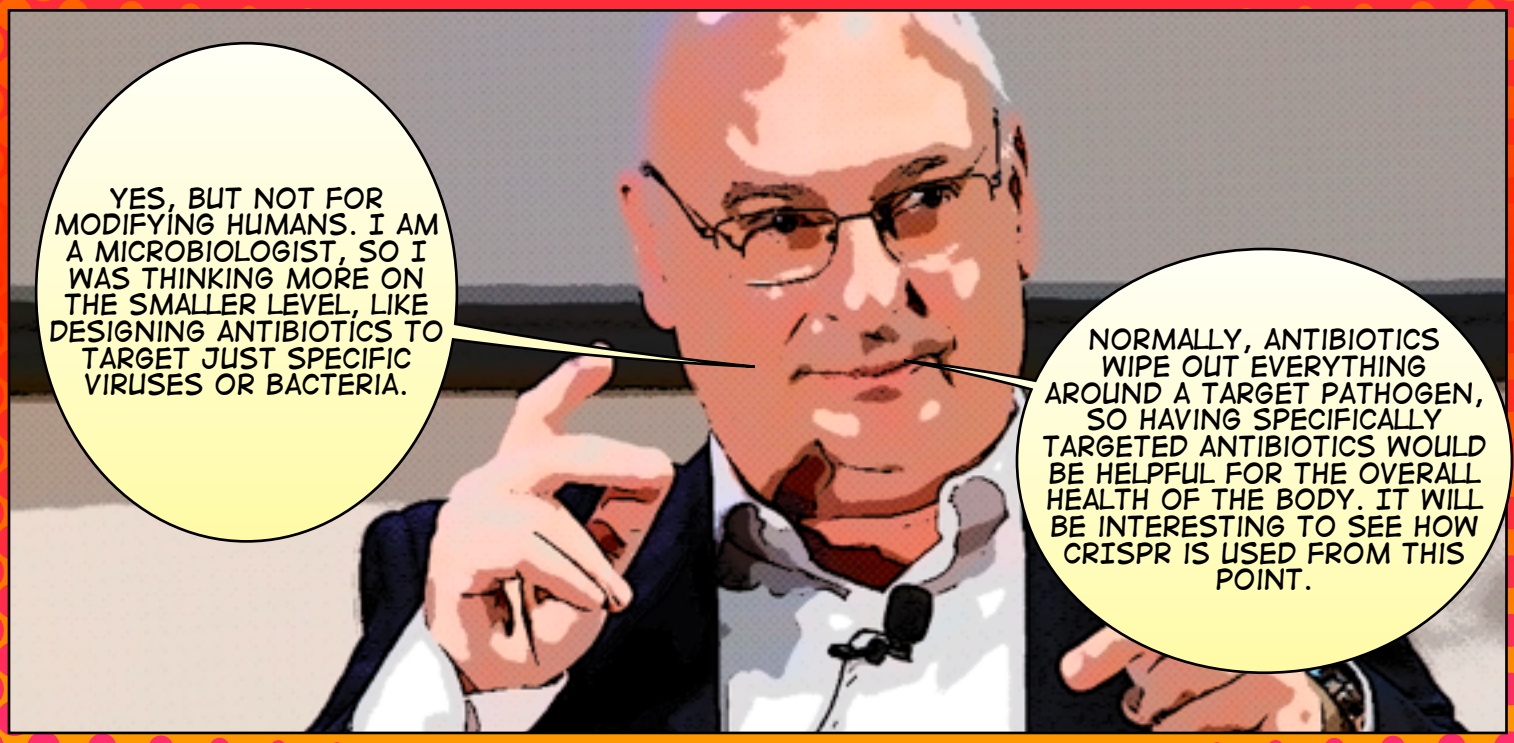


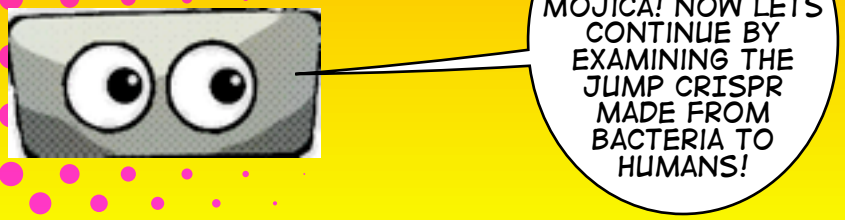
THE DNA IS USED TO MAKE A STRAND OF RNA WHICH IS SPLIT INTO PIECES SO THAT EACH PIECE EXACTLY MATCHES THE CODE OF ONE VIRUS THE BACTERIUM SURVIVED. THE SPLITS OCCUR WITH THE HELP OF TRACER RNA AT EACH REPETITION OF THE ORIGINAL SEQUENCE.



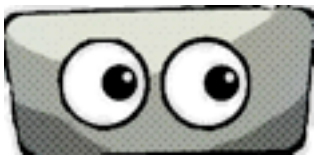
THE RNA FRAGMENT, ALONG WITH THE TRACER RNA CONNECTS TO A PROTEIN CALLED CAS-9 TO CREATE SOMETHING I LIKE TO CALL "GENETIC SCISSORS". IF A VIRUS THAT MATCHES THE BACTERIUM'S LIBRARY OF SCISSORS ENTERS THE CELL, THE SCISSORS RECOGNIZE THE APPROPRIATE DNA SEQUENCE AND CUTS THE VIRAL DNA APART, MAKING THAT CODE IMPOSSIBLE TO USE IN VIRAL REPRODUCTION!


THE PROCESS FOR DESTROYING VIRUSES THAT REPRODUCE WITH RNA IS NEARLY IDENTICAL
SORRY FOR THE COMPLICATED EXPLANATION... CRISPR IS A COMPLEX PROCESS
ASK AWAY MY FRIEND!
THAT'S LIFE FOR YOU! I HAVE ONE MORE QUESTION FOR YOU THOUGH.
DID YOU EXPECT THE CRISPR DISCOVERY TO BE AS GROUNDBREAKING AS IT HAS BECOME?

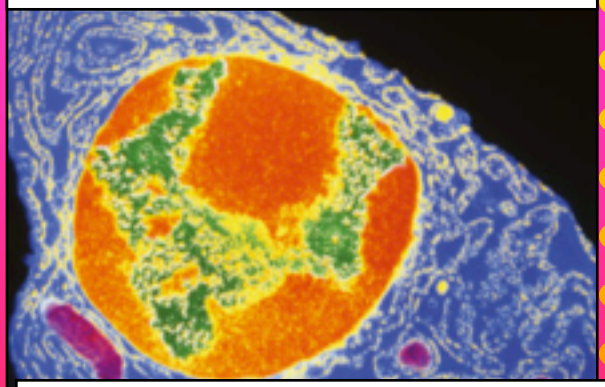

YES, BUT NOT FOR MODIFYING HUMANS. I AM A MICROBIOLOGIST, SO I WAS THINKING MORE ON THE SMALLER LEVEL, LIKE DESIGNING ANTIBIOTICS TO TARGET JUST SPECIFIC VIRUSES OR BACTERIA.
NORMALLY, ANTIBIOTICS WIPE OUT EVERYTHING AROUND A TARGET PATHOGEN, SO HAVING SPECIFICALLY TARGETED ANTIBIOTICS WOULD BE HELPFUL FOR THE OVERALL HEALTH OF THE BODY. IT WILL BE INTERESTING TO SEE HOW CRISPR IS USED FROM THIS POINT.


THANK YOU FOR YOUR INSIGHT DR. MOJICA! NOW LETS CONTINUE BY EXAMINING THE JUMP CRISPR MADE FROM BACTERIA TO HUMANS!

THE REASON CRISPR TECHNOLOGY CAN BE APPROPRIATED FOR HUMAN USE IS BECAUSE HUMAN CELLS WORK VERY DIFFERENTLY THAN SINGLE CELL ORGANISMS.



IN SINGLE CELL ORGANISMS, WHEN YOU CUT THEIR DNA, YOU KILL THEM. THIS IS WHY CRISPR IS A VIABLE DEFENSE MECHANISM.



HOWEVER, IN MULTICELLULAR ORGANISMS, CUTTING THE DNA CAUSES THE CELL TO TRY AND REPAIR THE DAMAGE. HOWEVER, THIS PROCESS IS OFTEN RUSHED, SO THERE ARE MANY ERRORS.

NOW USING THIS TECHNIQUE ON HUMANS WAS POSSIBLE, BUT THE HUMAN GENOME IS SO LARGE, WHERE WOULD PEOPLE BEGIN?

THE ENTIRE HUMAN GENOME WAS SEQUENCED IN 2003. IF PEOPLE FIGURE OUT WHICH GENES LINK TO WHICH TRAITS, CRISPR COULD BE USED TO MODIFY HUMANS.

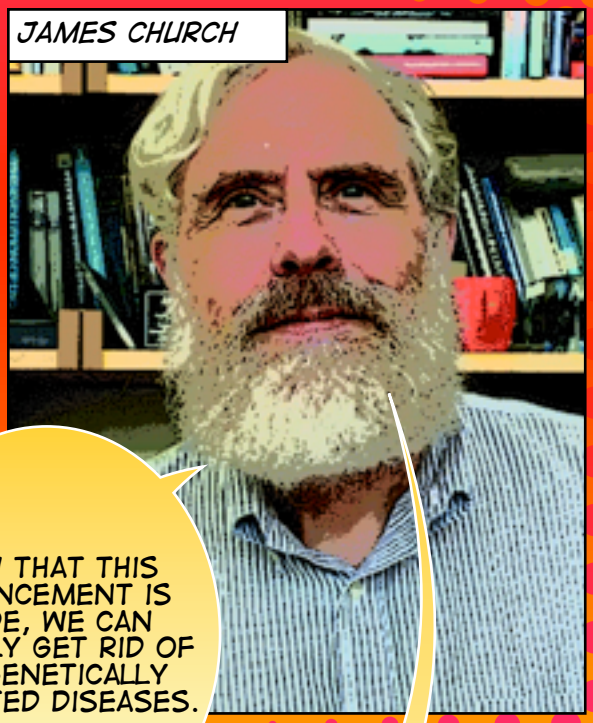
THE TRANSFORMATION OF CRISPR FROM DEFENSIVE TOOL TO OFFENSIVE WEAPON WAS PIONEERED IN 2012 BY FOUR INDIVIDUALS:

JENNIFER DOUDNA,
EMANULLE CHARPENTIER,
FENG ZHANG, AND
GEORGE CHURCH.

IF YOU KNOW WHICH GENE CAUSES A CERTAIN TRAIT, YOU CAN CODE THE RNA PIECE IN THE GENETIC SCISSORS TO MATCH THE GENE. WHEN THE GENE IS CUT, THERE IS A LARGE CHANCE THERE IS A "MISTAKE" IN THE REPAIR PROCESS, WHICH WILL CAUSE THAT TRAIT TO NOT BE EXPRESSED.

CHURCH, ZHANG, DOUDNA, AND CHARPENTIER FIGURED OUT HOW TO ENGINEER EXAMPLE MODIFIED CAS-9 PROTEINS THAT WOULD WORK FOR THE HUMAN GENOME. THIS TECHNOLOGY HAS LIMITED USE TODAY IN CLINICAL TRIALS SUCH AS RIDDING SOMEONE OF SICKLE CELL BLOOD AND GIVING PEOPLE GAINS IN VISION. FOR THEIR EFFORTS, THESE SCIENTISTS WERE AWARDED A NOBEL PRIZE IN CHEMISTRY IN 2020.

THIS CONCLUDES THE MATERIAL THAT I HAD PLANNED FOR THE PRESENTATION... BUT I GUESS IT WOULD BE COOL TO SEE WHAT SOME OF THESE SCIENTISTS THOUGHT OF THEIR ACHIEVEMENT.



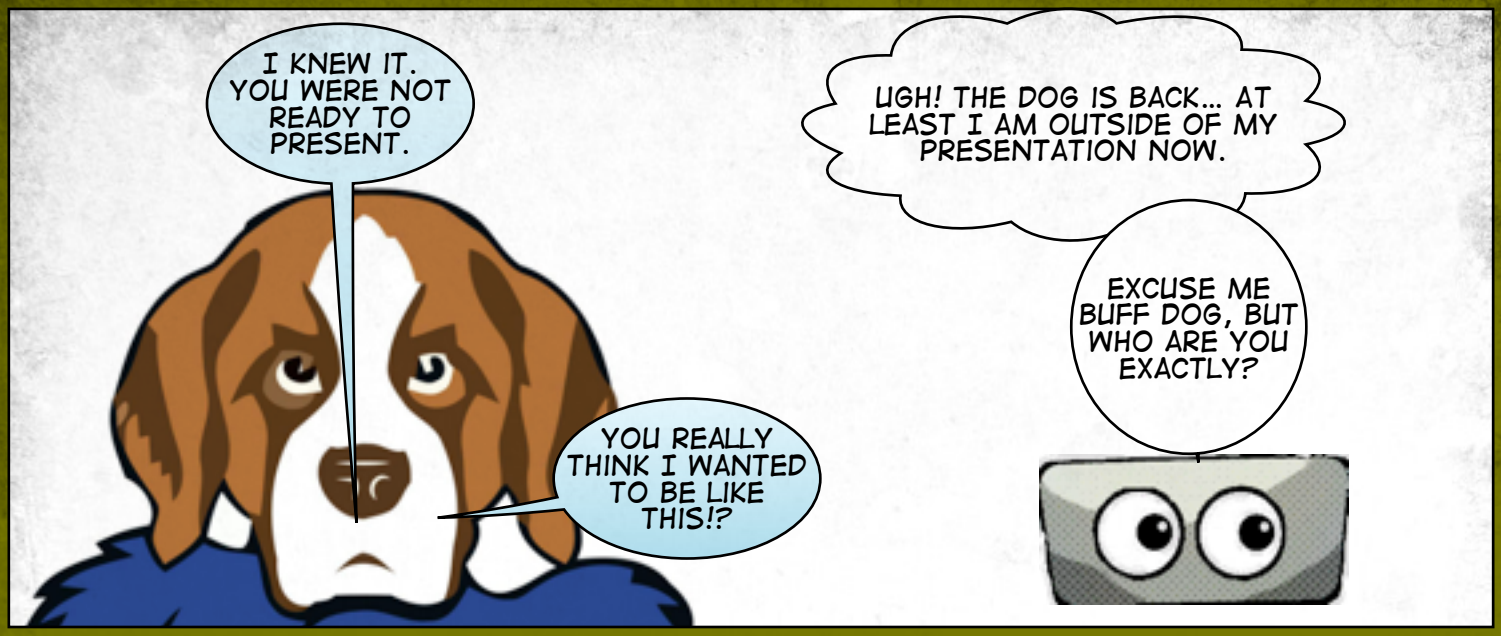
NOW THAT THIS ADVANCEMENT IS MADE, WE CAN TOTALLY GET RID OF ALL GENETICALLY INHERITED DISEASES.

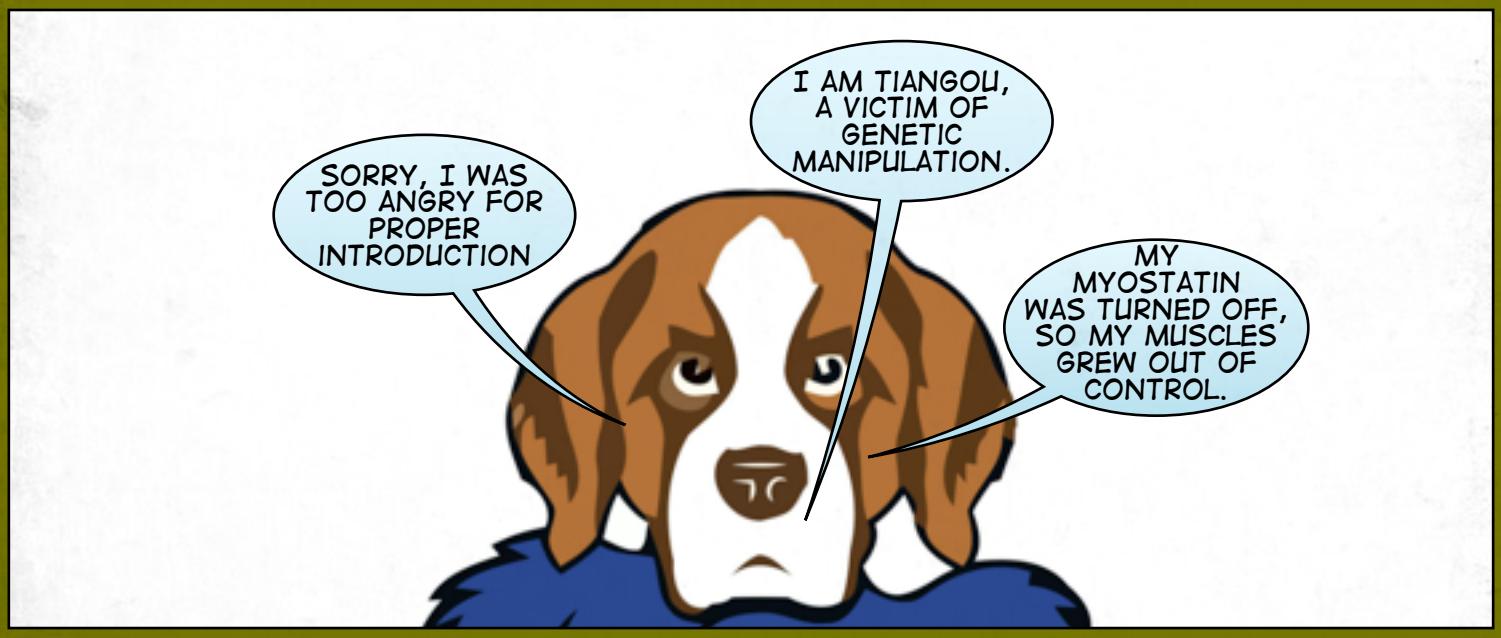
JAMES, YOU CAN'T BELIEVE STUFF LIKE THAT. DID YOU NOT HAVE THE WEIRD DREAM WHERE HITLER SAID HE WAS PROUD OF YOU FOR DOING EUGENICS WORK?

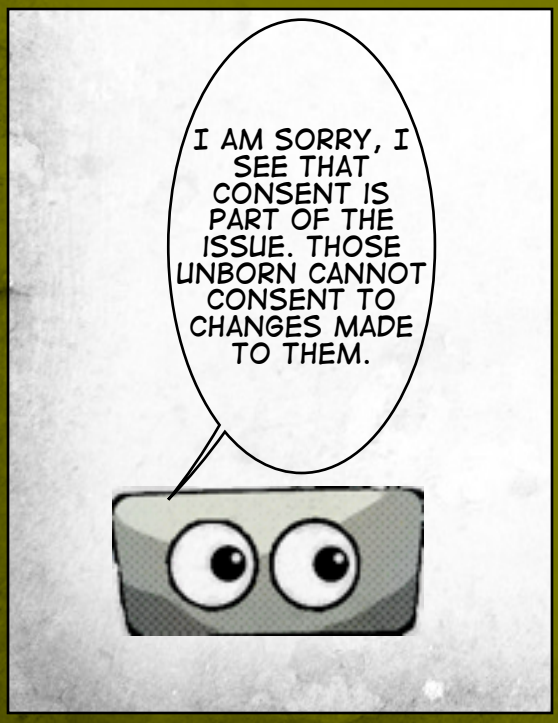
HOLD ON, DR. DOUDNA IS RIGHT! DR CHURCH IS TAKING CRISPR WAY TOO FAR INTO EUGENICS TERRITORY.

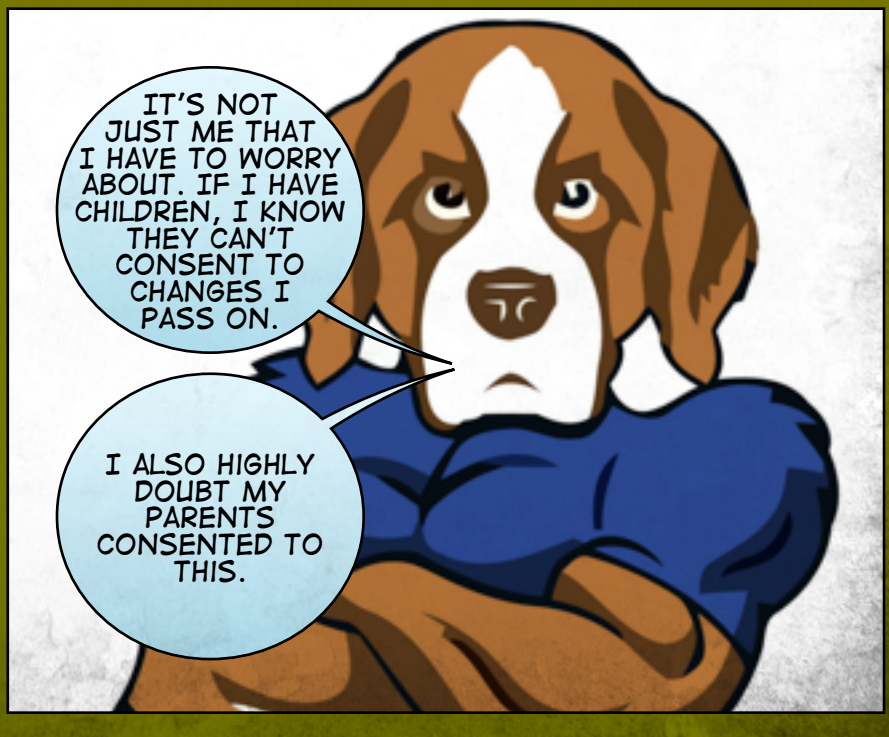
I DON'T FEEL SO GOOD ABOUT MY PRESENTATION NOW.

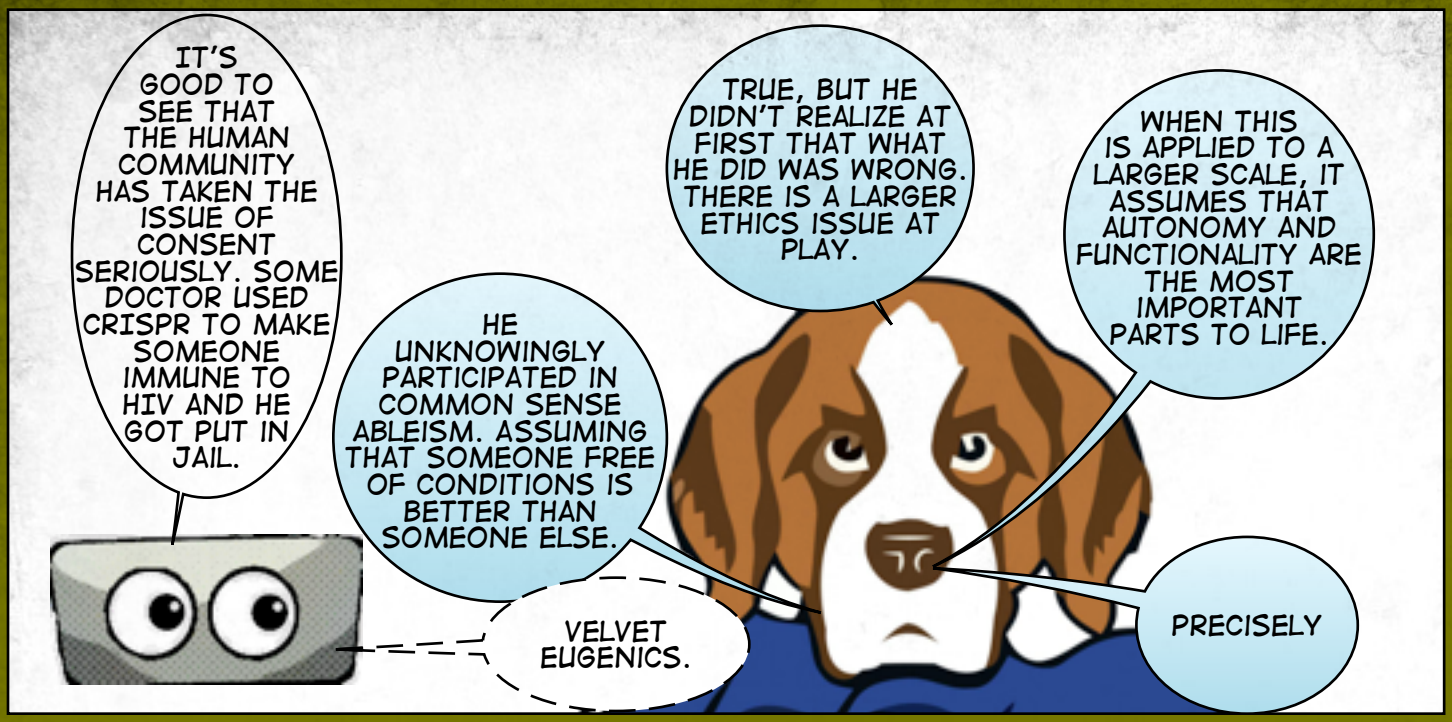
NO, I THINK YOU'RE THE ODD ONE.

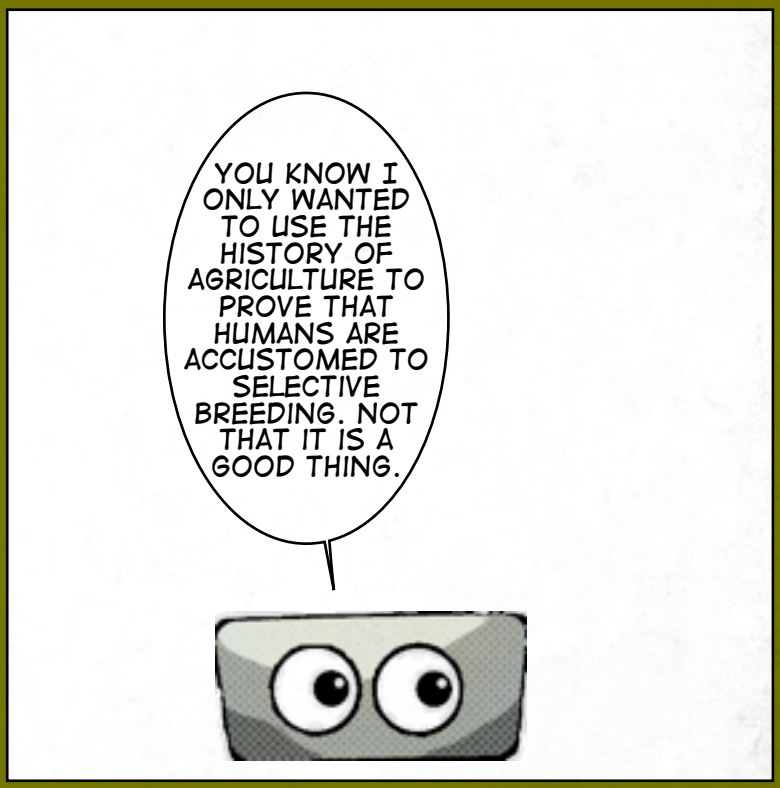

I KNEW IT. YOU WERE NOT READY TO PRESENT.
YOU REALLY THINK I WANTED TO BE LIKE THIS!?
UGH! THE DOG IS BACK... AT LEAST I AM OUTSIDE OF MY PRESENTATION NOW.
EXCUSE ME BUFF DOG, BUT WHO ARE YOU EXACTLY?


I AM TIANGOU, A VICTIM OF GENETIC MANIPULATION.
SORRY, I WAS TOO ANGRY FOR PROPER INTRODUCTION
MY MYOSTATIN WAS TURNED OFF, SO MY MUSCLES GREW OUT OF CONTROL.


I AM SORRY, I SEE THAT CONSENT IS PART OF THE ISSUE. THOSE UNBORN CANNOT CONSENT TO CHANGES MADE TO THEM.


IT'S NOT JUST ME THAT I HAVE TO WORRY ABOUT. IF I HAVE CHILDREN, I KNOW THEY CAN'T CONSENT TO CHANGES I PASS ON.
I ALSO HIGHLY DOUBT MY PARENTS CONSENTED TO THIS.





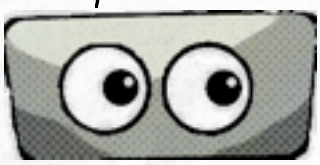
LET'S TAKE THAT STORY TO IT'S CONCLUSION...

IF WE BRING THE STORY OF PLANT BREEDING UP TO TODAY, THERE ARE MANY THOUSANDS OF SPECIFICALLY BRED PLANTS EACH WITH SOMEONE WHO OWNS RIGHTS TO THE GENETIC COMBINATION OF THE CROSSING. COURTS HAVE RULED THAT OTHER PEOPLE CANNOT MAKE PLANTS WITH THAT GENETIC CODE.

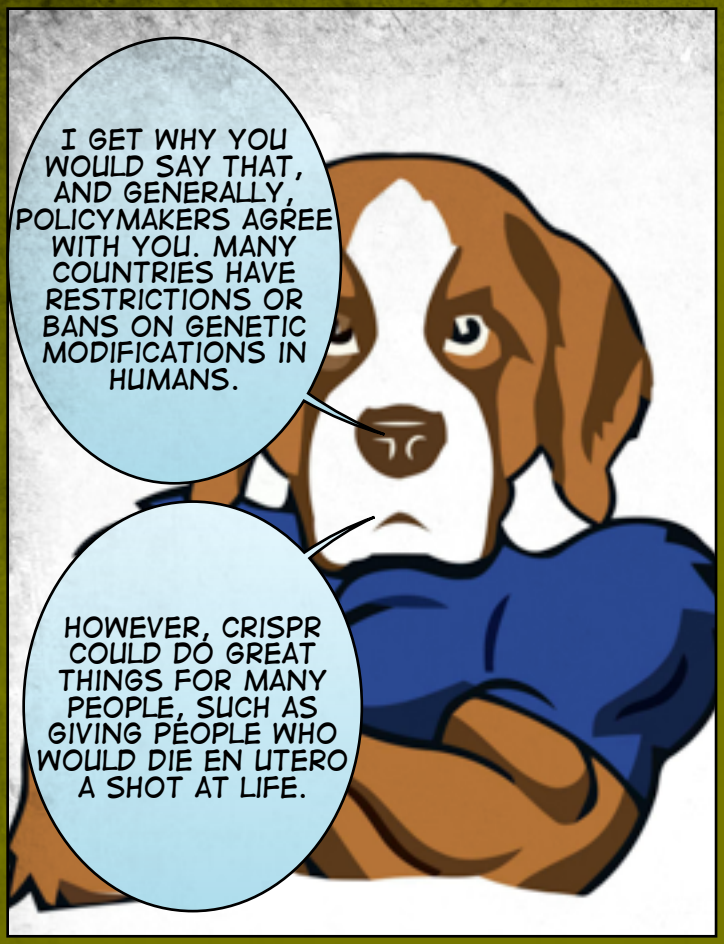
WAIT DOES THAT MEAN...

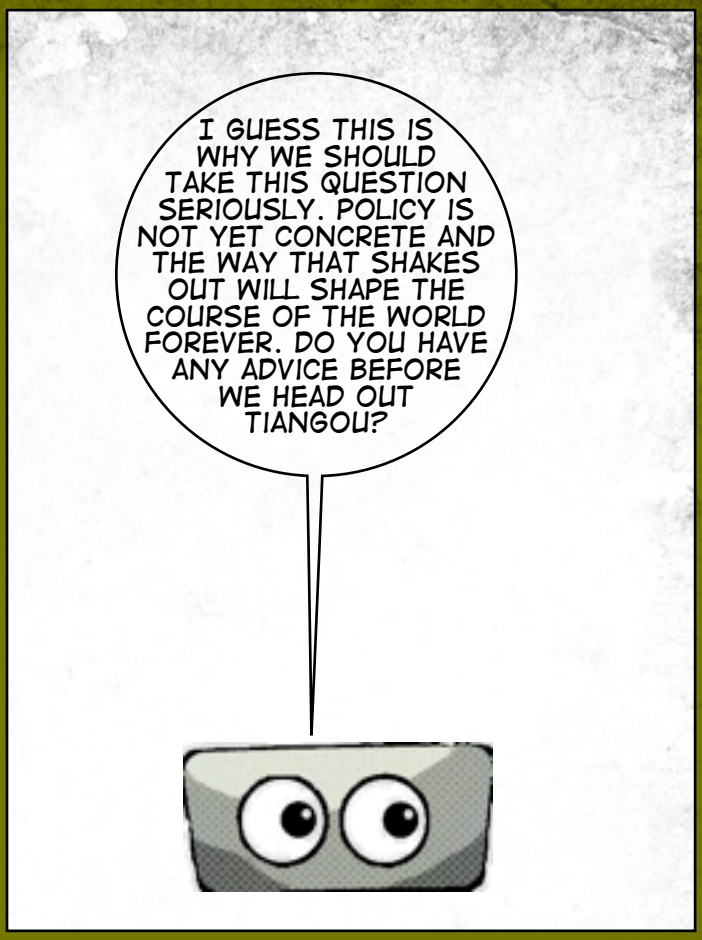
PEOPLE COULD POTENTIALLY LOSE (MORE) AUTONOMY OVER THEIR OWN BODIES. IN 2013, THE SUPREME COURT RULED THAT GENES THAT ARE MODIFIED FROM THEIR ORIGINAL CONDITION COULD BE PATENTED BY THE MAKER.

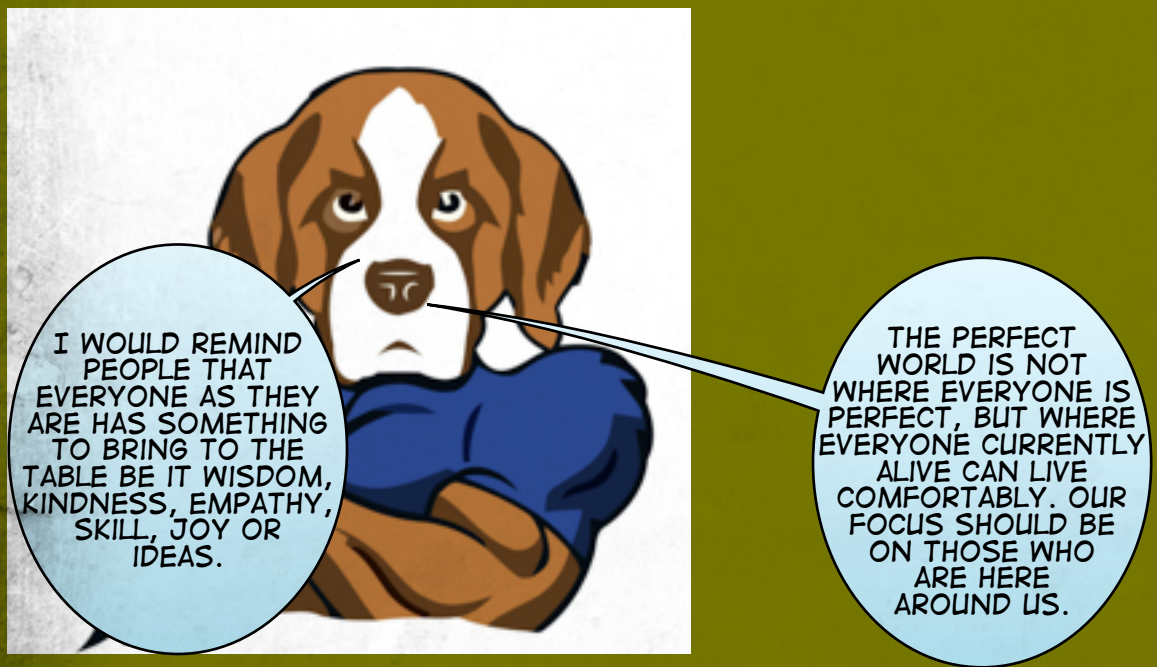
THE CRISPR ERA LOOKS LIKE ITS OFF TO A BAD START ALREADY. IF GENES CAN BE PATENTED, THEN THERE IS ALREADY COMPETITION FOR THE BEST GENES WHICH COULD LEAD TO AN INEQUALITY IN ACCESS IF THEY ARE NOT REGULATED. THIS COULD LEAD TO EVEN MORE INEQUALITY AND ABLEISM.



HONESTLY, I AM STARTING TO QUESTION IF CRISPR IS EVEN WORTH ALL THE TROUBLE IT MAY CAUSE, EVEN WITH ALL THE POTENTIAL BENEFITS.


I GET WHY YOU WOULD SAY THAT, AND GENERALLY, POLICYMAKERS AGREE WITH YOU. MANY COUNTRIES HAVE RESTRICTIONS OR BANS ON GENETIC MODIFICATIONS IN HUMANS.
HOWEVER, CRISPR COULD DO GREAT THINGS FOR MANY PEOPLE, SUCH AS GIVING PEOPLE WHO WOULD DIE EN UTERO A SHOT AT LIFE.


I GUESS THIS IS WHY WE SHOULD TAKE THIS QUESTION SERIOUSLY. POLICY IS NOT YET CONCRETE AND THE WAY THAT SHAKES OUT WILL SHAPE THE COURSE OF THE WORLD FOREVER. DO YOU HAVE ANY ADVICE BEFORE WE HEAD OUT TIANGOU?


I WOULD REMIND PEOPLE THAT EVERYONE AS THEY ARE HAS SOMETHING TO BRING TO THE TABLE BE IT WISDOM, KINDNESS, EMPATHY, SKILL, JOY OR IDEAS.
THE PERFECT WORLD IS NOT WHERE EVERYONE IS PERFECT, BUT WHERE EVERYONE CURRENTLY ALIVE CAN LIVE COMFORTABLY. OUR FOCUS SHOULD BE ON THOSE WHO ARE HERE AROUND US.

THE END