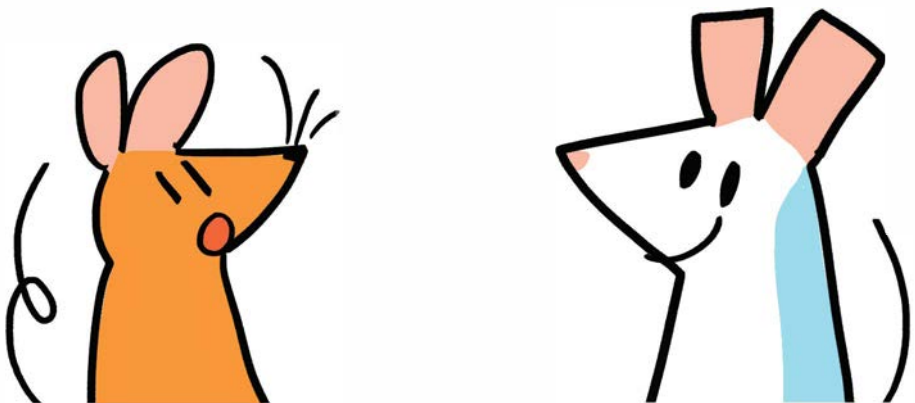


HOW DOES LIFE SCIENCE RESEARCH WORK?

IN THE UNITED STATES



presented by **cglife**[®]

PART ONE

THE SCIENCE

WITH LAB RATS!



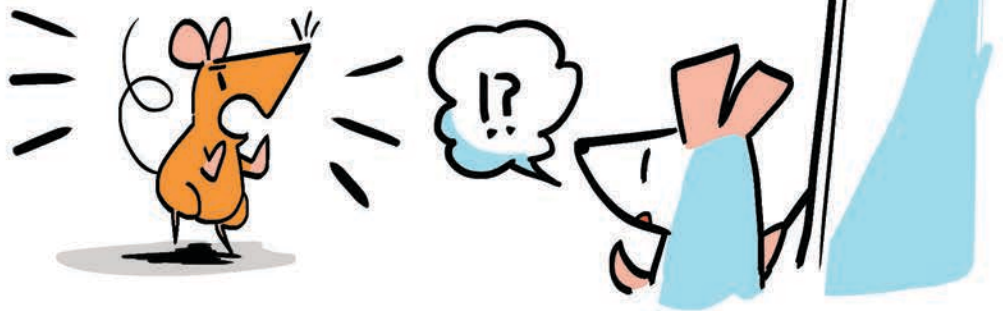
I GUESS I MEAN TO SAY...

HOW DOES SCIENCE GET DONE ANYWAY?



HANG ON
HANG ON

I ALREADY **KNOW**
THE SCIENTIFIC METHOD!!



FIRST YOU ASK
A QUESTION



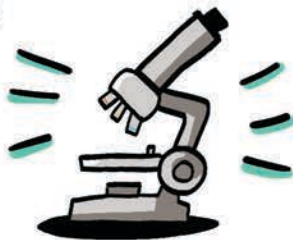
WHAT IS
THIS JUNK
ON MY
CHEESE?

MAKE A
HYPOTHESIS



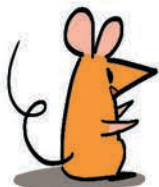
IT'S PROBABLY
MOLD

TEST YOUR
HYPOTHESIS




LET'S LOOK AT
IT UNDER THIS
MICROSCOPE

COLLECT
DATA...



WOW THEY SURE
DO HAVE THE
CHARACTERISTICS
OF MOLD



ANALYZE THE
RESULTS & DRAW
YOUR CONCLUSION

IT'S
MOLD!!



EASY!

HEY WAIT!
WHERE ARE YOU
TAKING THAT?

YOU KNOW
WHAT


YOUR EXPLANATION
IS RIGHT BUT

BUT??

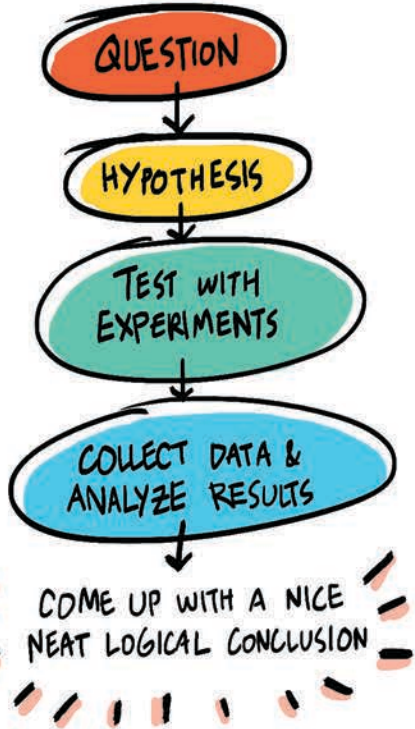


WELL COMPARED TO WHAT
ACTUALLY HAPPENS IN A
BIOLOGICAL RESEARCH FACILITY...

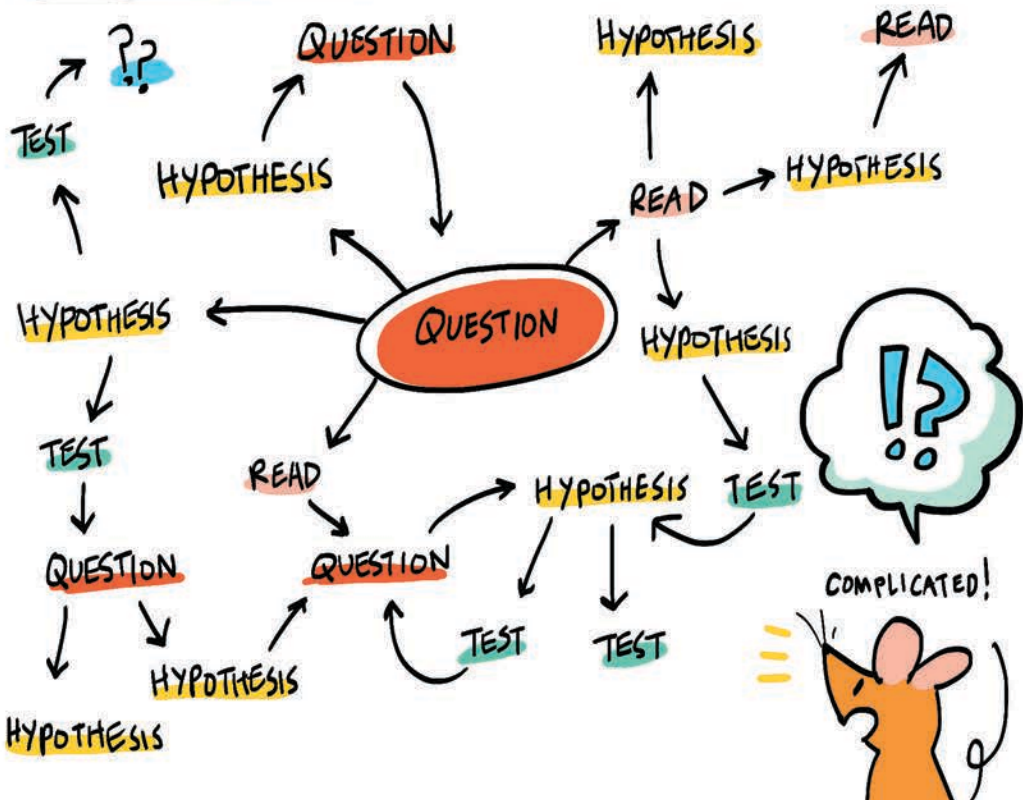
IT'S TOO SIMPLE!



WHILE AT IT'S CORE, THE PROCESS DOES LOOK LIKE THIS



MOST OF THE TIME IT'S MORE LIKE THIS...

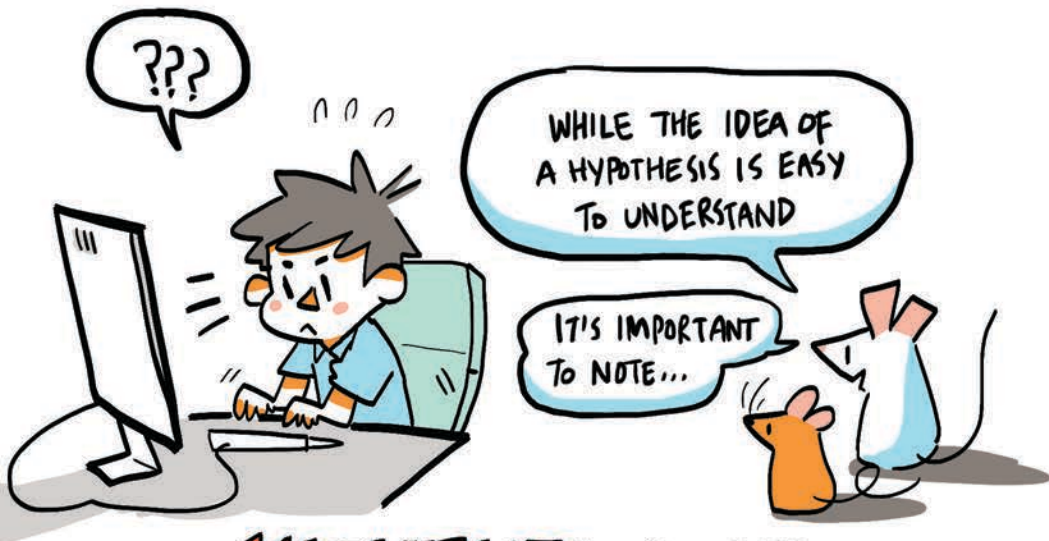


ASKING A GOOD QUESTION



OFTEN SCIENTISTS WILL FOCUS ON INVESTIGATING "HIGH PRIORITY" TOPICS, SUCH AS CANCER, AS DETERMINED BY FUNDING SOURCE

FORMING A HYPOTHESIS



SCIENTISTS DON'T KNOW EVERYTHING

WHEN STARTING A NEW RESEARCH PROJECT, THEY SPEND A SIGNIFICANT AMOUNT OF TIME **STUDYING** THEIR AREA OF INTEREST AND **LEARNING** MORE ABOUT IT THROUGH PREEXISTING RESEARCH ON A TOPIC.

AFTER READING ALL THESE PAPERS, I'VE CONCLUDED THAT



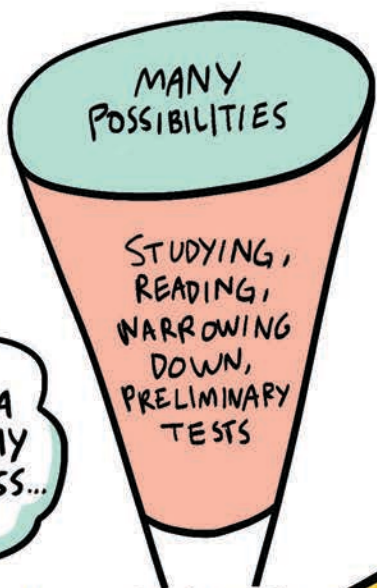
THERE ARE 5000 POSSIBILITIES TO CONSIDER!!



IT CAN DEFINITELY TAKE A FEW WEEKS TO DO ENOUGH BACKGROUND RESEARCH TO FORMULATE A SOLID HYPOTHESIS

GOTTA WHITTLE IT DOWN

WHAT A LENGTHY PROCESS...



I CAME UP WITH FIFTY NEW QUESTIONS THOUGH...



PUTTING IT TO THE TEST

COMPARED TO OTHER
AREAS OF SCIENCE



IT'S RELATIVELY
STRAIGHTFORWARD TO
RUN A SINGLE EXPERIMENT
IN THE LIFE SCIENCES

IN GENERAL



INDUSTRY

BIOTECH,
PHARMACEUTICAL,
LIFE SCIENCE
COMPANIES!

MAKE TOOLS TO
ENABLE MORE RESEARCH



GENERATE NEW
FINDINGS THAT
INSPIRE NEW
TECHNOLOGY



ACADEMIA

RESEARCH
INSTITUTES,
UNIVERSITIES!

WORKS OUT
NICELY HUH



IT'S A
SYMBIOTIC
RELATIONSHIP

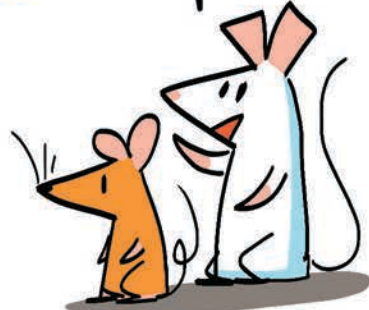
DISPOSABLES



TOOLS

ASSAY TO RUN?
JUST BUY ALL THE PARTS

SPECIALIZED MACHINERY & SOFTWARE



ASSAY KITS



SERVICES

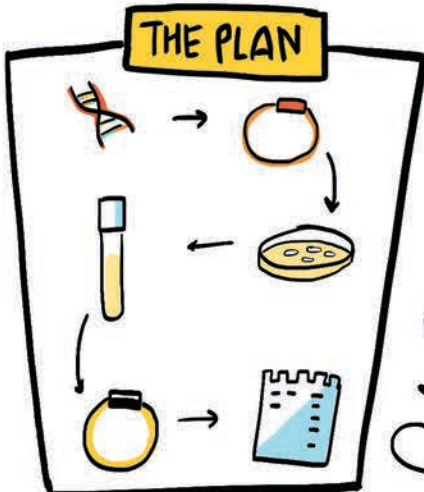


REAGENTS & CHEMICALS



CUSTOM MOLECULES

THE PLAN



THE HARD PART IS THE EXPERIMENTAL DESIGN



CAN SCIENTISTS DO
ANYTHING
THEY WANT?

???



ACTUALLY

NO!



DEPENDING ON THE
KIND OF RESEARCH
DIFFERENT **REGULATORY**
BODIES OVERSEE AND
APPROVE OF THE PROTOCOLS
THAT SCIENTISTS PROPOSE

SOME OF THE MOST
TIGHTLY REGULATED ARE



ANIMAL EXPERIMENTS

AND

CLINICAL TRIALS



THE FDA

REGULATES CLINICAL TRIALS
TO MAKE SURE EXPERIMENTS WITH
HUMANS ARE AS SAFE AS POSSIBLE



THERE ARE MANY STEPS THAT SCIENTIST
HAVE TO PASS IN ORDER TO GET PERMISSION
TO CARRY OUT THEIR PROTOCOL

A LOT OF
PEOPLE ARE
INVOLVED



THE LAW

GOVERNMENT
AGENCIES

ETHICS
COMMITTEES

INSTITUTIONAL
REGULATION

THEY DETERMINE THE
LEAST HARMFUL WAY
SOMETHING CAN BE DONE,
IF ANIMALS **HAVE** TO
BE USED

THANK
GOODNESS

SIMILARLY ANIMAL
EXPERIMENTS ARE HEAVILY
SCRUTINIZED BY INSTITUTIONAL
COMITTEES, SUCH AS
IACUC



DIGESTING THE RESULTS



IT MIGHT BE GREAT FOR AN EXPERIMENT TO GO AS PLANNED BUT THINGS GET A BIT INTERESTING WHEN YOUR RESULTS ARE **UNEXPECTED**

THE ORIGINAL PLAN

A
GET SPECIFIC RESULTS HERE



B
MOVE ONTO NEXT STEP

WHAT ACTUALLY HAPPENED



DIDN'T GET THE RESULTS AS PREDICTED

CAN'T GO ONTO THIS STEP, REEVALUATE

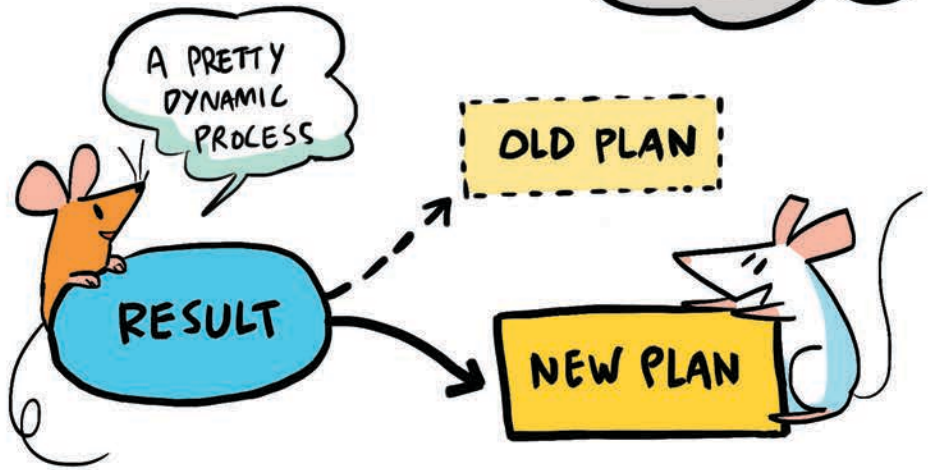
IT DOESN'T FIT WITH MY HYPOTHESIS

THIS RULES OUT TWO OF MY POSSIBILITIES

DID I MAKE AN ASSUMPTION THAT I SHOUDN'T HAVE?

DO I NEED TO REVISE MY METHODS? OPTIMIZE CONDITIONS?

HOW CAN I FOLLOW UP WITH THESE RESULTS?



CONCLUSIONS

TADAH!!!

YEARS OF WORK
DISTILLED
INTO WORDS



AT LONG LAST!
I'VE DONE IT!
A PAPER I
WROTE HAS
BEEN PUBLISHED!

WELL
THAT'S
NOT VERY
EXCITING



CONCLUSION:
A CORRELATES
WITH B

AH...



A LOT OF RESULTS DON'T
MAKE FOR GREAT HEADLINES
AND THE OFTEN GET
MISCONSTRUED...

JOURNAL OF AWESOME SCIENCE

THIS COMPOUND FOUND IN
BANANAS IS CORRELATED
WITH LEVELS OF A MOLECULE
FOUND TO BE A GOOD
PREDICTOR OF THE PRESENCE
OF TUMOR CELLS UNDER
THESE SPECIFIC CONDITIONS



THE DAILY GOOBER ||
BREAKING!!!
BANANAS
CAUSE
CANCER!!

* NOT WHAT THE PAPER
SAYS AT ALL



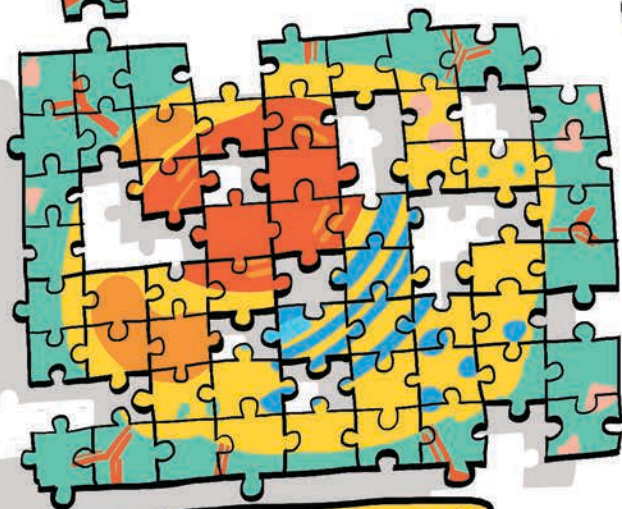
I GET THAT THIS RESEARCH IS PROBABLY IMPORTANT BUT...



I JUST DON'T SEE WHY I SHOULD CARE...

SEEMS IRRELEVANT?

YEAH



YOU CAN THINK OF A SINGLE SCIENTIST'S FINDINGS LIKE ONE PIECE IN A BIG JIGSAW PUZZLE

THE CANCER PUZZLE

OTHERS HAVE YET TO BE CONNECTED

SOME PUZZLE PIECES ARE FOUND

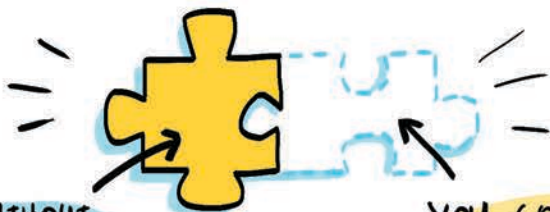
AND OTHERS ARE STILL COMPLETELY MISSING



SCIENTISTS ALL OVER
THE WORLD COLLABORATE
TO FILL IN
THE BIG PICTURE



YOU NEVER KNOW HOW ONE
FINDING MIGHT AFFECT ANOTHER



WITHOUT
THIS

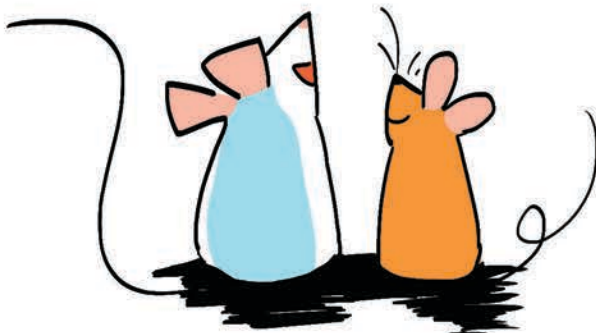
YOU COULDN'T
CONNECT THIS

SCIENCE BY NATURE IS BUILT
ON PREVIOUS KNOWLEDGE

AND WHILE IT'S
IMPORTANT FOR SCIENTISTS
TO TALK TO EACH OTHER...



IT'S JUST AS IMPORTANT TO
EFFECTIVELY COMMUNICATE
THEIR FINDINGS TO EVERYONE!



END OF PART ONE

PART 2

THE PEOPLE

SO NOW YOU KNOW
HOW THE SCIENCE IS DONE
BUT DO YOU KNOW ABOUT
THE PEOPLE WHO DO IT?



NOPE



DON'T THEY ALL
LOOK LIKE THIS?

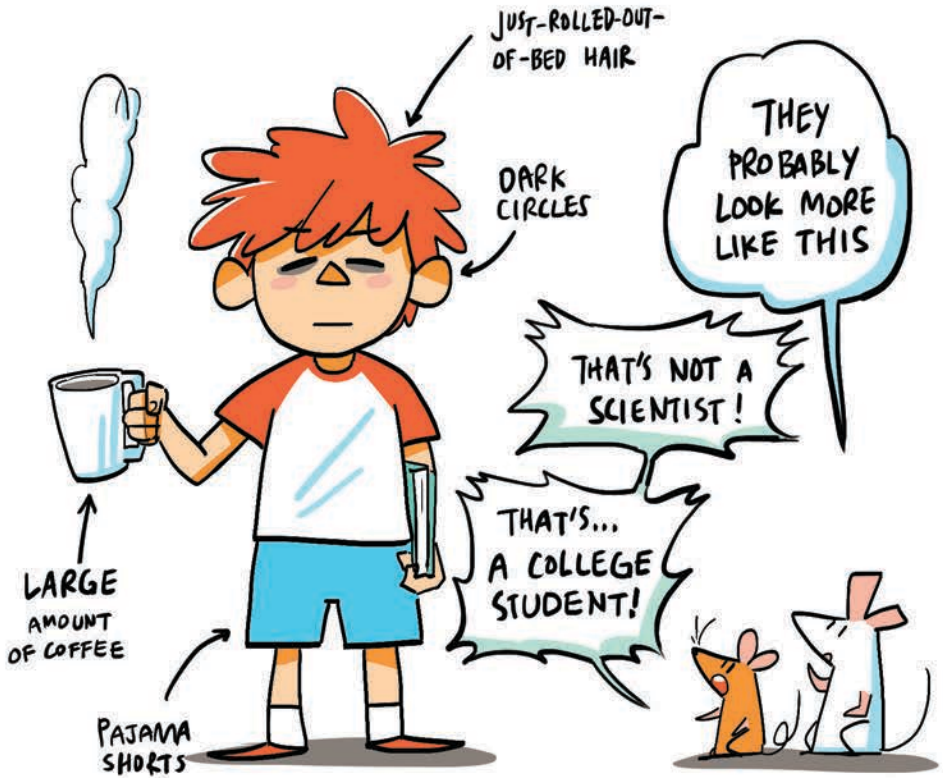


NOT
AT
ALL!

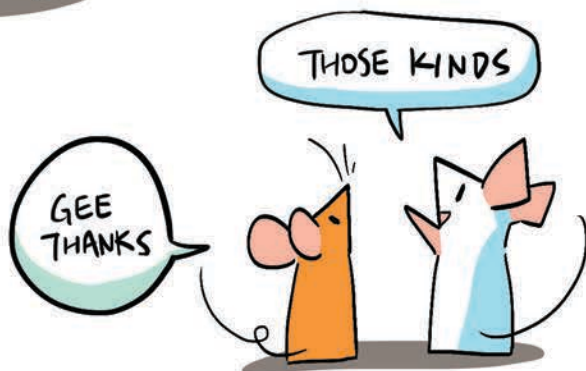


WHAT!
THE MOVIES
LIED TO ME?





WHAT KINDS OF PEOPLE WILL YOU FIND IN A LAB?



THE PRINCIPAL INVESTIGATOR

HOW'S IT GOING?

LET'S START AT THE TOP



- THE BOSS OF EVERYONE!
- THE LAB IS NAMED AFTER THEM
- DIRECTS RESEARCH FOCUS FOR THE LAB
- AN EXPERIENCED PHD

ACK!

NO!

GIVE ME MONEY!!

BENHWDRK?
WHAT'S THAT?



SPENDS MOST OF THEIR TIME WRITING GRANTS

TO ENSURE THAT THEIR LAB STAYS OPEN & FUNCTIONAL

THE POSTDOCTORAL SCHOLAR

HE'S A REAL WORKHORSE

TELL YOUR FRIENDS ABOUT ME

- HAS A PHD LIKE THE PI BUT NOT THE EXPERIENCE
- A REAL WORKING SCIENTIST IN CHARGE OF A RESEARCH PROJECT!
- A TEMPORARY POSITION
- CAN BE FOLLOWED UP WITH OTHER POSTDOC POSITIONS

SEEKING PERMANENT EMPLOYMENT

AFTER A POSTDOC (OR TWO, OR THREE) THE INDIVIDUAL SHOULD BE WELL PREPARED FOR A FACULTY POSITION

LAST NIGHT I HAD A DREAM THAT I WAS A TENURED PROFESSOR...

GOOD LUCK MAN...

THERE'S
SOMETHING
LIKE

63,800 POSTDOCS*
IN THE U.S.

AND 19,304 SPECIFICALLY IN BIOLOGY!



AFTER THE COMPLETION OF THEIR
FELLOWSHIP, POSTDOCS CAN ALSO OPT
TO GO INTO INDUSTRY AND LEAVE
ACADEMIC RESEARCH ENTIRELY

*NSF SCIENCE & ENGINEERING INDICATORS 2015

THE GRADUATE STUDENT



- WORKING ON AN MS OR PHD
- THEY CALL YOU A STUDENT BUT IT'S MORE LIKE A JOB
- TAKES A FEW CLASSES
- MOSTLY DOING A RESEARCH PROJECT FOR THESIS OR DISSERTATION
- OFTEN SEEN AROUND CAMPUS AS A TEACHING ASSISTANT



THE UNDERGRADUATE

YEAH!

TEACH ME!

A TRUE BABY

AWW



- LEARNING FOUNDATIONAL CONCEPTS IN CLASSES
- HAS NO IDEA HOW TO APPLY KNOWLEDGE IN A PRACTICAL LAB SETTING
- IN THE LAB FOR AN INTRODUCTORY EXPERIENCE

TENDS TO BE IDEALISTIC ABOUT WHAT RESEARCH IS

THERE THERE

I'LL SHOW YOU THE LIGHT

DELUDED

???

WE'LL MAKE A PROPER WESTERN BLOTTING ROBOT OUT OF YOU

TAKEN CARE OF BY GRAD STUDENT OR POSTDOC



WOW RUDE



THE LAB MANAGER



NO SHORTS IN THE LAB!



- SURPRISE!! THEY MANAGE THE LAB!
- THEY DO EVERYTHING FROM ORDERING SUPPLIES TO ENFORCING SAFETY REGULATION TO DOING TRAINING AND COMMUNICATING INSIDE & OUTSIDE THE LAB

WE NEED THIS TODAY!



A SEMINAR? LET ME CHECK HER SCHEDULE



WE RAN INTO SOME BUDGET PROBLEMS—

DDN'T SAY THOSE WORDS!!



CRK

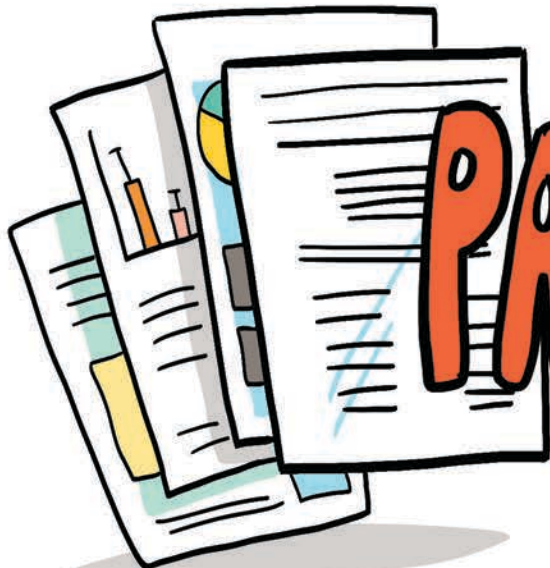


SO... WHAT DETERMINES IF
THESE PEOPLE ARE ANY GOOD?

THAT'S A
QUESTION OF
CREDIBILITY



WHICH IS DETERMINED
IN PART BY ...



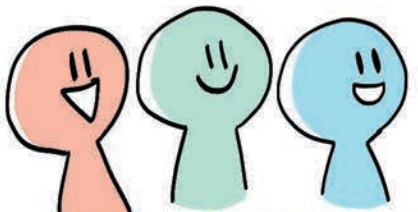
PAPERS!



PAPERS PUBLISHED
IN PEER REVIEWED
JOURNALS ARE LIKE
MEDALS FOR SCIENTISTS



THEY EXPLAIN THE CONCLUSIONS
FROM A SCIENTIST'S EXPERIMENTS; THE FACT THAT
IT'S BEEN PUBLISHED MEANS THAT OTHER SCIENTISTS
HAVE VOUCHER FOR THIS WORK.



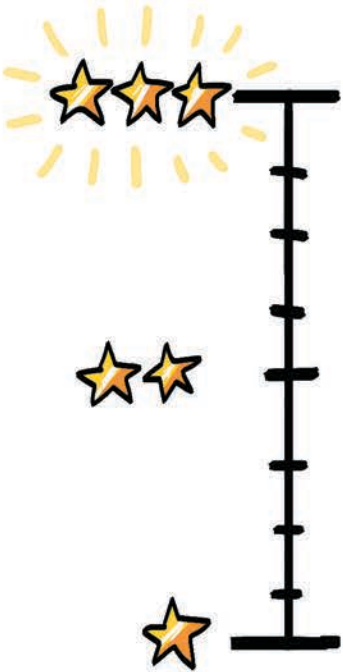
OTHER SCIENTISTS



NATURALLY
PUBLISHING MORE
MEANS YOU HAVE MORE
WORK TO
YOUR NAME

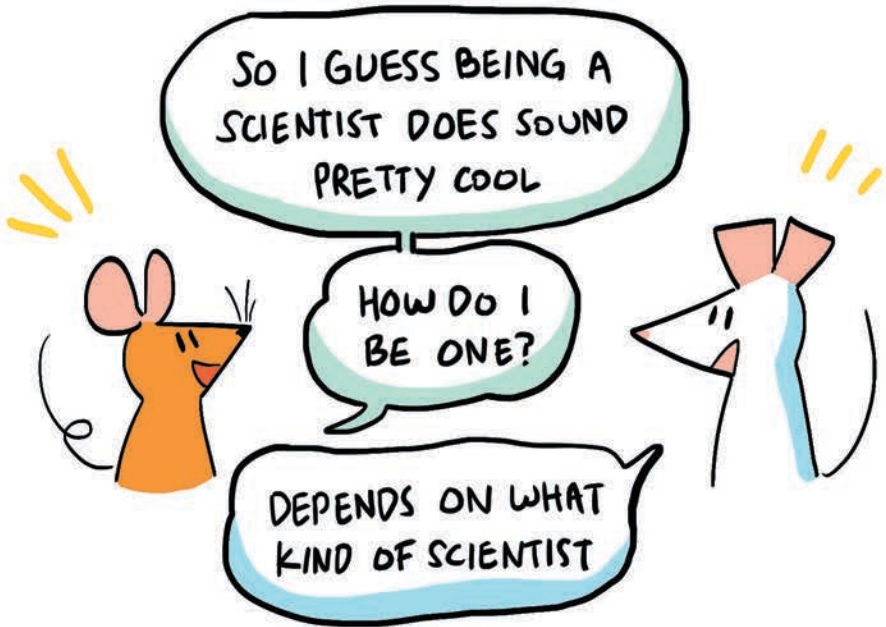
GRAD STUDENTS
ARE JUST STARTING

PIs HAVE BEEN
AROUND LONGER



THE **IMPACT** OF A
JOURNAL IS ALSO RANKED,
SO FOR A SCIENTIST TO BE
PUBLISHED IN BIG NAME
JOURNALS ALSO ADDS TO
THEIR CREDIBILITY AND
REPUTATION





IF YOU WANT TO BE SOMEONE WHO SYSTEMATICALLY STUDIES REAL WORLD PRINCIPLES



ANYONE CAN DO IT! A QUICK WEB SEARCH FOR CITIZEN SCIENCE WILL TURN UP TONS OF OPPORTUNITIES

THERE ARE JOBS IN
SCIENCE FOR PEOPLE AT
ALL LEVELS OF EDUCATION
AND EXPERIENCE



BUT



TO DO YOUR OWN
RESEARCH
START BY GETTING
A BACHELOR'S
DEGREE IN SCIENCE

ME!!



WE ALREADY HAVE THAT



ME!



THEN YOU CAN HEAD TO
GRAD SCHOOL

AND DO A RESEARCH PROJECT
WHILE WORKING ON AN
ADVANCED DEGREE

GENERALLY,
THE MORE SCHOOLING
YOU GET, THE MORE CHANCES
YOU HAVE TO DO IN DEPTH RESEARCH



THE HIGHER UP YOU GO, THE
DEEPER AND NARROWER YOUR
EXPERTISE BECOMES

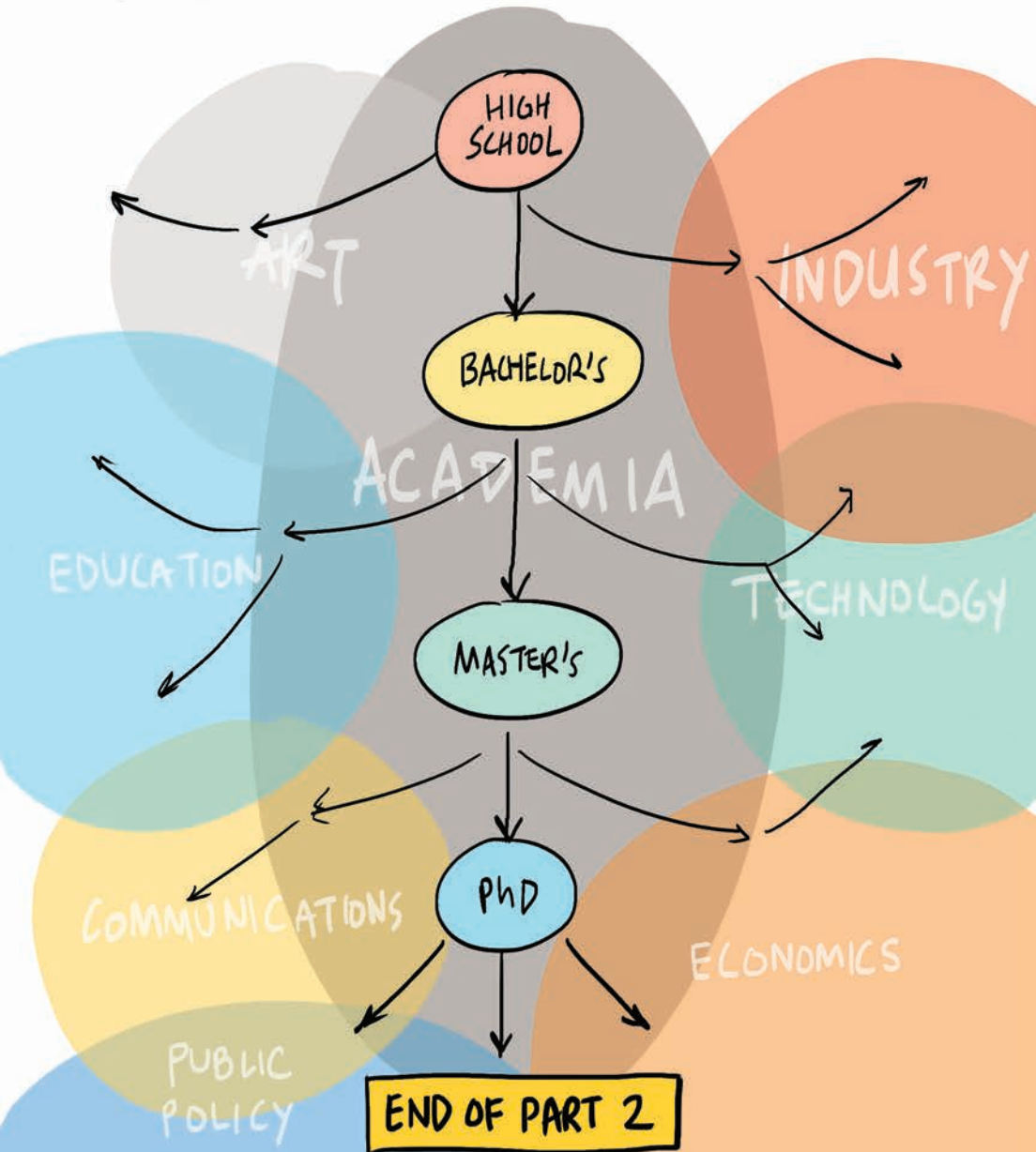
WHAT A LONG
CAREER PATH



THAT'S OKAY
BECAUSE



THERE ARE A LOT OF DIFFERENT
OPTIONS TO CHOOSE FROM IN SCIENCE
AT EVERY LEVEL, SO TRY SOMETHING!

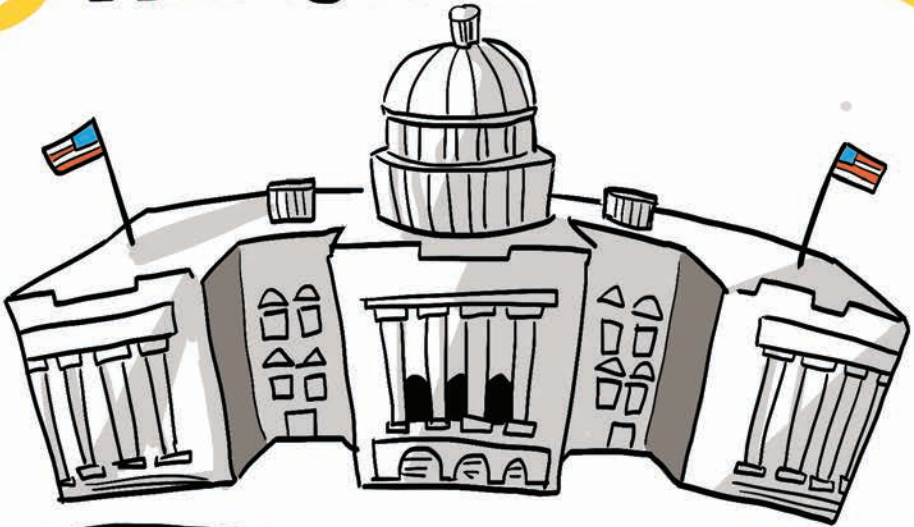


PART 3

THE MONEY

LIFE SCIENCE RESEARCH IS FUNDED IN
A FEW DIFFERENT WAYS BUT THE MAJORITY
OF FUNDING COMES FROM

THE GOVERNMENT



WHICH ACTUALLY
MEANS **YOU**
PAY FOR SCIENCE



YAY
YOU!



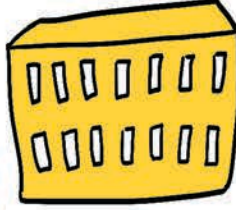
THE NIH

GETS ITS BUDGET FROM CONGRESS AND DISTRIBUTES IT TO SCIENTISTS THROUGH GRANTS

CONGRESS



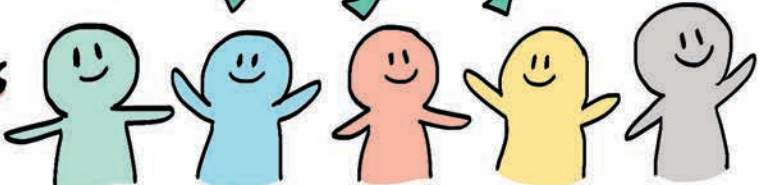
DEPARTMENT OF HEALTH & HUMAN SERVICES



NATIONAL INSTITUTES OF HEALTH

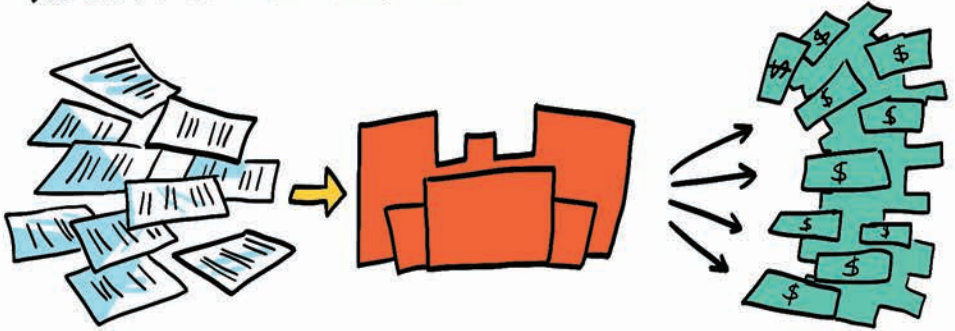


SCIENTISTS



IN 2018

THE NIH REVIEWED **54,834**
RESEARCH PROJECT GRANT APPLICATIONS



AND ACCEPTED **11,071** PROPOSALS

DISTRIBUTING

\$19,869,684,598



OH
GEEZ!!



YUP, PART
OF THE
26 BILLION
THEY SPENT
ON RESEARCH
IN 2018

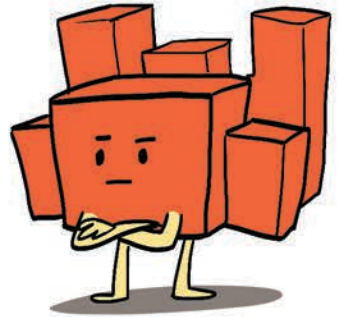
TOTAL BUDGET FOR
FY 2018 : \$ 26.9 BILLION



GRANTS!

WHAT EXACTLY IS A GRANT?

WHY SHOULD I?



IN ORDER TO GAIN SOME FUNDING FROM THE NIH, SCIENTISTS HAVE TO SUBMIT A WRITTEN APPLICATION ABOUT WHY THEY NEED THE MONEY!

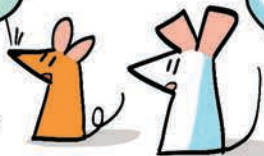
THIS IS THE **GRANT PROPOSAL.**

IN THIS PROPOSAL,
SCIENTISTS JUSTIFY AND
EXPLAIN SOME VERY SPECIFIC
ASPECTS OF THEIR PROJECT



WHY IS IT SO
LONG THOUGH?

I DIDN'T
DECIDE
THAT...



SMASH!!

WHAT ARE YOUR
RESEARCH GOALS?

WHO EVEN
ARE YOU?

DO YOU HAVE
PRELIMINARY
DATA?

WHAT WILL YOU
DO WITH THE
MONEY?

HOW WILL YOU KNOW
IF WHAT YOU'RE
DOING WORKS?

HOW WILL THIS IMPROVE
HUMAN HEALTH?

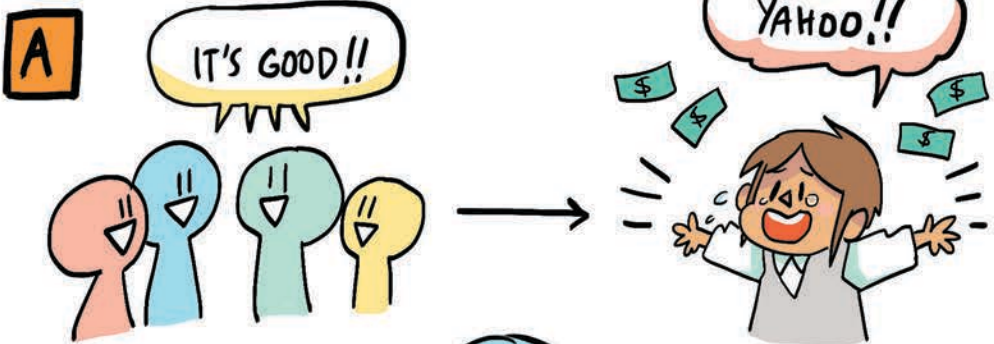


AAAA AAHH!

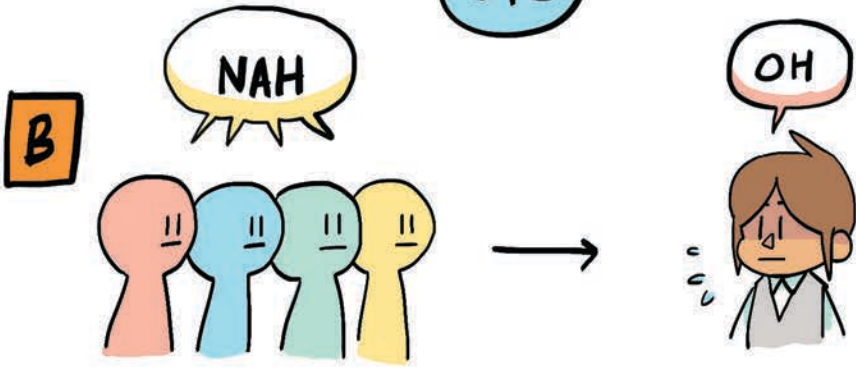
AFTER WRITING A GRANT PROPOSAL, IT GETS SUBMITTED FOR REVIEW



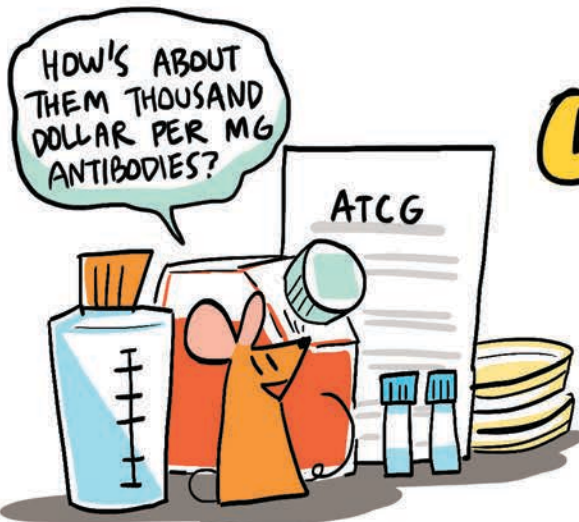
MONTHS LATER



OR



HOW IS GRANT MONEY SPENT?



1 SUPPLIES EQUIPMENT SERVICES

BELIEVE IT OR NOT,
THE THINGS USED IN AN
EXPERIMENT CAN COST
A LOT OF MONEY

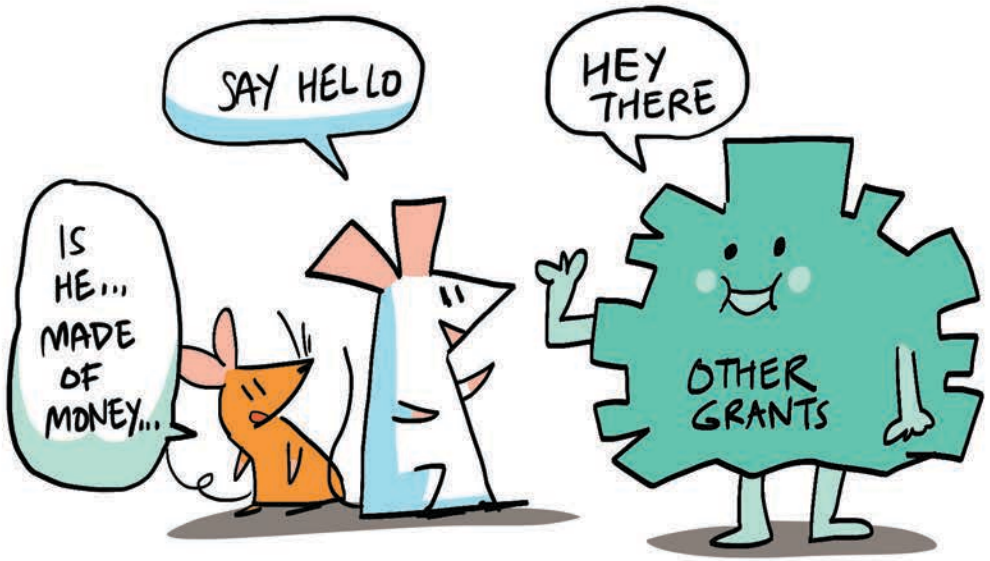
2 PAYCHECKS

SCIENTISTS HAVE
TO BE PAID!



3 OTHER

CERTAIN TRAVEL COSTS, CONSULTING, AND OTHER MISC. FEES



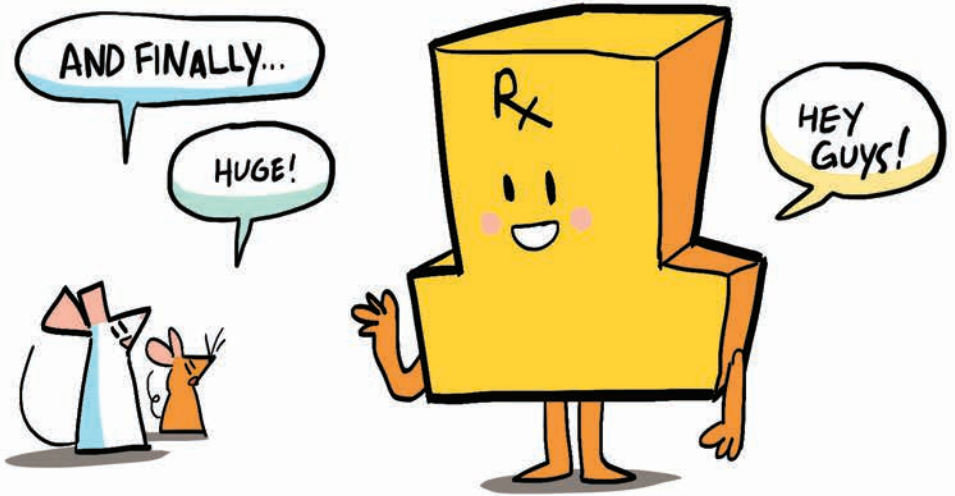
ANOTHER SOURCE OF FUNDING
COMES FROM SPECIFIC FOUNDATIONS AND
ASSOCIATIONS THAT ADVOCATE FOR
SPECIFIC DISEASES AND POPULATIONS



THESE ORGANIZATIONS RAISE MONEY & AWARENESS FOR THEIR SPECIFIC CAUSE AND OFFER GRANTS TO SCIENTISTS DOING RELEVANT RESEARCH



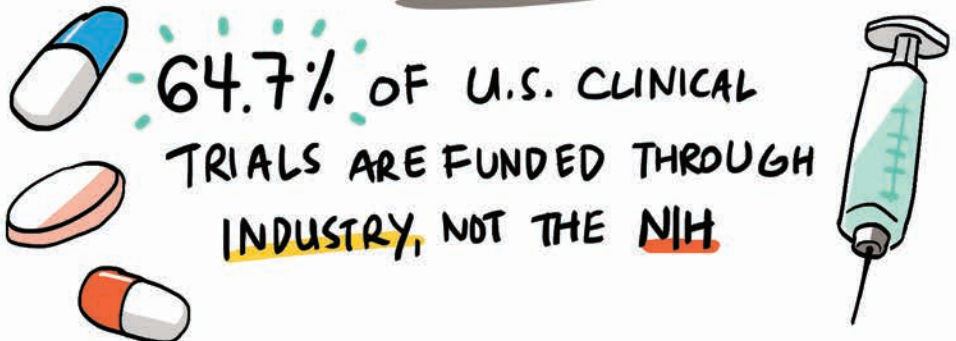
SIMILAR TO NIH GRANTS, A SPECIFIC PROPOSAL MUST BE SUBMITTED FOR REVIEW



COMPANIES, BACKED BY INVESTORS, CAN ALSO STRIKE UP PARTNERSHIPS WITH RESEARCH INSTITUTES TO FUND STUDIES.



CERTAIN KINDS OF STUDIES ARE PARTICULARLY SUITED TO THIS TYPE OF RELATIONSHIP



HOWEVER

THERE IS EVIDENCE THAT SHOWS FUNDING BIAS DOES EXIST



SO WE SHOULD JUST IGNORE ALL RESEARCH BACKED BY SPECIAL INTEREST GROUPS?



JUST READ PAPERS CRITICALLY

NOT AT ALL!

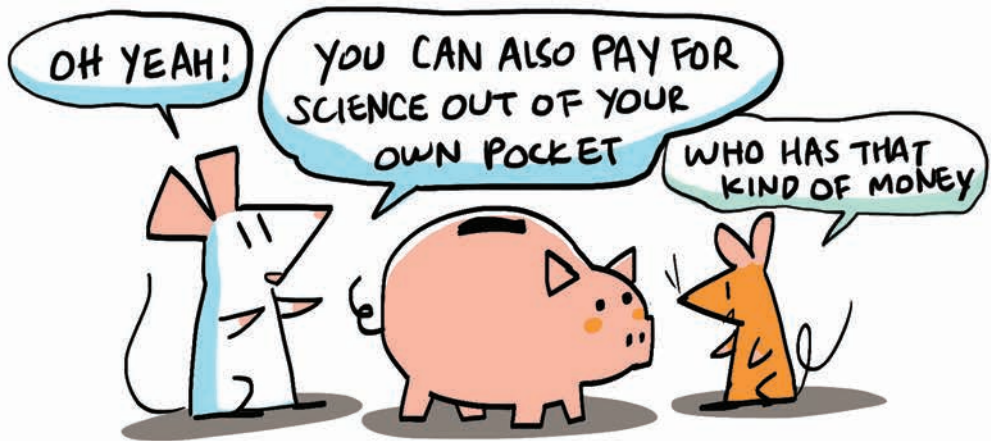
ALL SCIENCE SHOULD BE CAREFULLY SCRUTINIZED FOR ANY SOURCES OF ERROR OR BIAS; FUNDING SOURCE CAN DEFINITELY BE ONE PLACE TO FIND IT



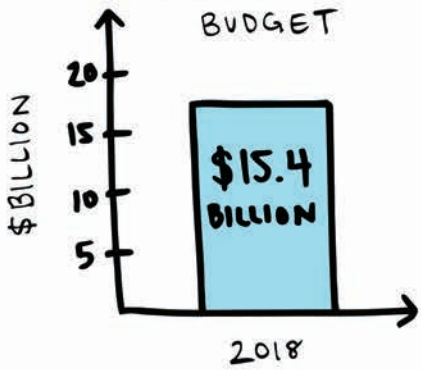
HEY! I DID THE SAME THING AS YOU BUT I DIDN'T GET THE SAME RESULTS



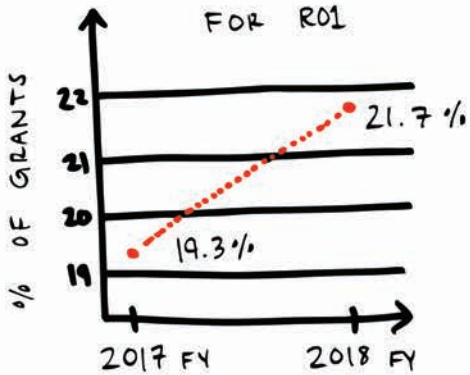
SCIENCE IS DESIGNED TO BE A SELF-CORRECTING PROCESS SO MISTAKES AND BIASES CAN BE REVEALED IN TIME

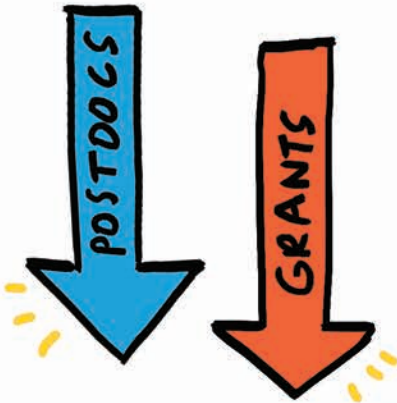


NIH AWARDED BUDGET



SUCCESS RATES FOR RO1





AFTER MORE THAN 30 YEARS OF STEADY GROWTH, THE NUMBER OF POSTDOCS IN THE BIOLOGICAL & BIOMEDICAL SCIENCES IS ON THE DECLINE IN THE UNITED STATES.

STUDY SHOWS THAT DESPITE CONTINUING INCREASES IN THE NUMBER OF PHD STUDENTS, THERE WAS A 5.5% LOSS IN THE POSTDOCTORAL POPULATION FROM 2010 - 2013.

WELL THAT DOESN'T SOUND GOOD FOR ME



I'M GOING TO SUBMIT AGAIN!

THE FINDINGS HAVE IMPORTANT IMPLICATIONS FOR THE BIOMEDICAL WORKFORCE — ACCORDING TO A NEW PAPER IN THE FASEB JOURNAL.

WAIT! THIS SITUATION
IS ACTUALLY PRETTY
AWFUL?!

DON'T WE
NEED MORE
SCIENCE RESEARCH
NOT LESS??

WHAT ABOUT THE
CANCER PUZZLE?
WHAT ABOUT ALL THE OTHER
DISEASES WE DON'T KNOW
ABOUT?

THERE THERE...

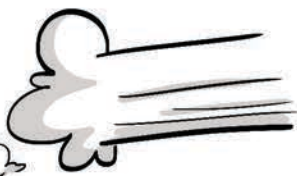
I'M GLAD YOU
THINK THAT SCIENCE
RESEARCH IS
IMPORTANT



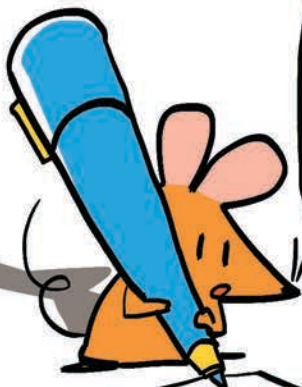
AND NOW YOU KNOW
WHAT REALLY GOES ON
BEHIND THE HEADLINES

HEY!
WHERE ARE
YOU GOING?

5¢ THE SCIENCE TIMES
SCIENTISTS
FINALLY CURE
DISEASE!!



WRITING MY
APPLICATION FOR
THE MOUSE SCHOOL
OF SCIENCE



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