



# THE SCIENCE OF MAGIC

LEARN TO DIFFERENTIATE SCIENCE FROM PSEUDOSCIENCE  
WITH ZACK FREDERICK

# WHAT IS PSEUDOSCIENCE?

- Pseudoscience: A belief in a process or product that uses science to grant legitimacy
- Features some or all of the following:
  - Find the study that is best for you
  - Does not self-correct
    - New finding does not raise new questions or further exploration
    - Just about any data point can be used to further a theory
  - Technical terms and logical process used to misdirect, confuse the audience
    - Terms such as "energy vibrations", "modern" or "proven" may sound impressive, but they are meaningless

# WHAT IS PSEUDOSCIENCE?

- Historical examples: ancient astrology and alchemy



# WHAT IS PSEUDOSCIENCE?

- As science has become a commercial interest, temptation to misapply science for financial gain has arisen
  - New form of “Pseudoscience”
  - Each form is slightly different, but many have common faults we will identify today



# WHAT IS PSEUDOSCIENCE?

- Interchangeable forms you may encounter: snake oil, junk science, deceptive science, alternative science, pathological science, protoscience, fringe science, commercial science, nonscience, hoax science, “fake news”
  - The practice of deceiving you has to evolve fast enough to outpace what you know about true science



# WHAT IS SCIENCE?

- Science defined by some: “Our way of describing, as best one can, how something works”
  1. Guess how something works
  2. Compute the consequences of the guess
  3. Compare to experiment
    - a) If guess disagrees with experiment - wrong
    - b) If guess agrees with experiment – failed to disprove
  4. If repeated tests fail to disprove – generally accepted



# WHAT IS SCIENCE?

- We are justified in guessing whatever seems probable with our current data
  - We must be willing to revise our guess in the light of new evidence
  - Certainty is not possible
  - Peer review to validate research
  - Replication study to confirm results, critique conclusions
    - Often place single study in larger body of knowledge
- Communication with the community



# CONTRASTING SCIENCE AND PSEUDOSCIENCE



Past data predicts  
future state of affairs  
**Data used to try to  
disprove guess**



Past data to predict the  
present  
**Data used to confirm  
guess**



# INTENTIONALLY FABRICATED SCIENCE

Graphics that manipulate you

- Editors initially focus on the graphs, charts, and images. Failure to understand what you're doing visually manifests in these graphics, so it's an early tell.



# YES, THIS CHART WAS SHOWN IN THE US SENATE

2,007,371 in 2006

327,000 in 2013

*Cakes*

289,750 in 2006

935,733 in 2013

*Something  
Controversial*

2006

2007

2008

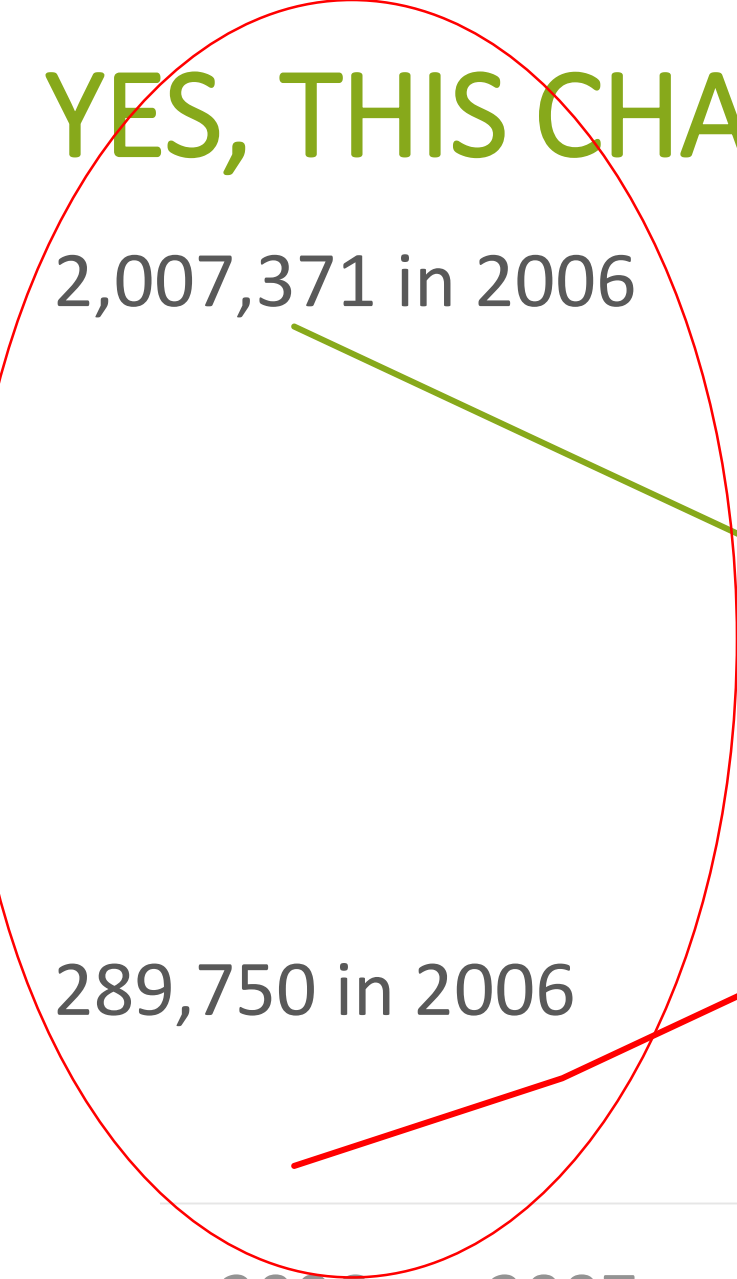
2009

2010

2011

2012

2013



# YES, THIS CHART WAS SHOWN IN THE US SENATE

2,007,371 in 2006

327,000 in 2013

*Cakes*

289,750 in 2006

935,733 in 2013

*Something  
Controversial*

2006

2007

2008

2009

2010

2011

2012

2013



# YES, THIS CHART WAS SHOWN IN THE US SENATE

2,007,371 in 2006

327,000 in 2013

*Cakes*

289,750 in 2006

935,733 in 2013

*Something  
Controversial*

2006

2007

2008

2009

2010

2011

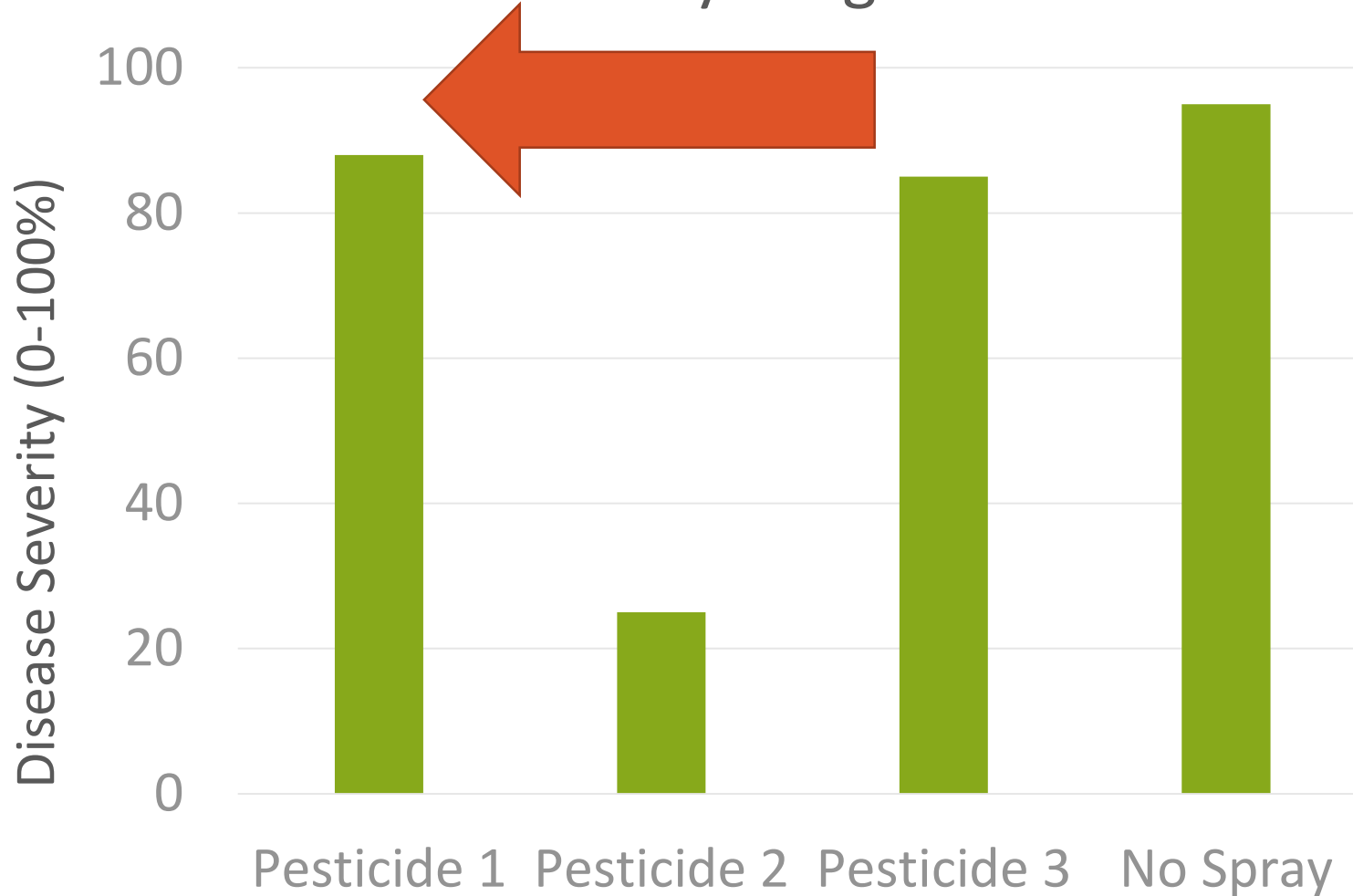
2012

2013



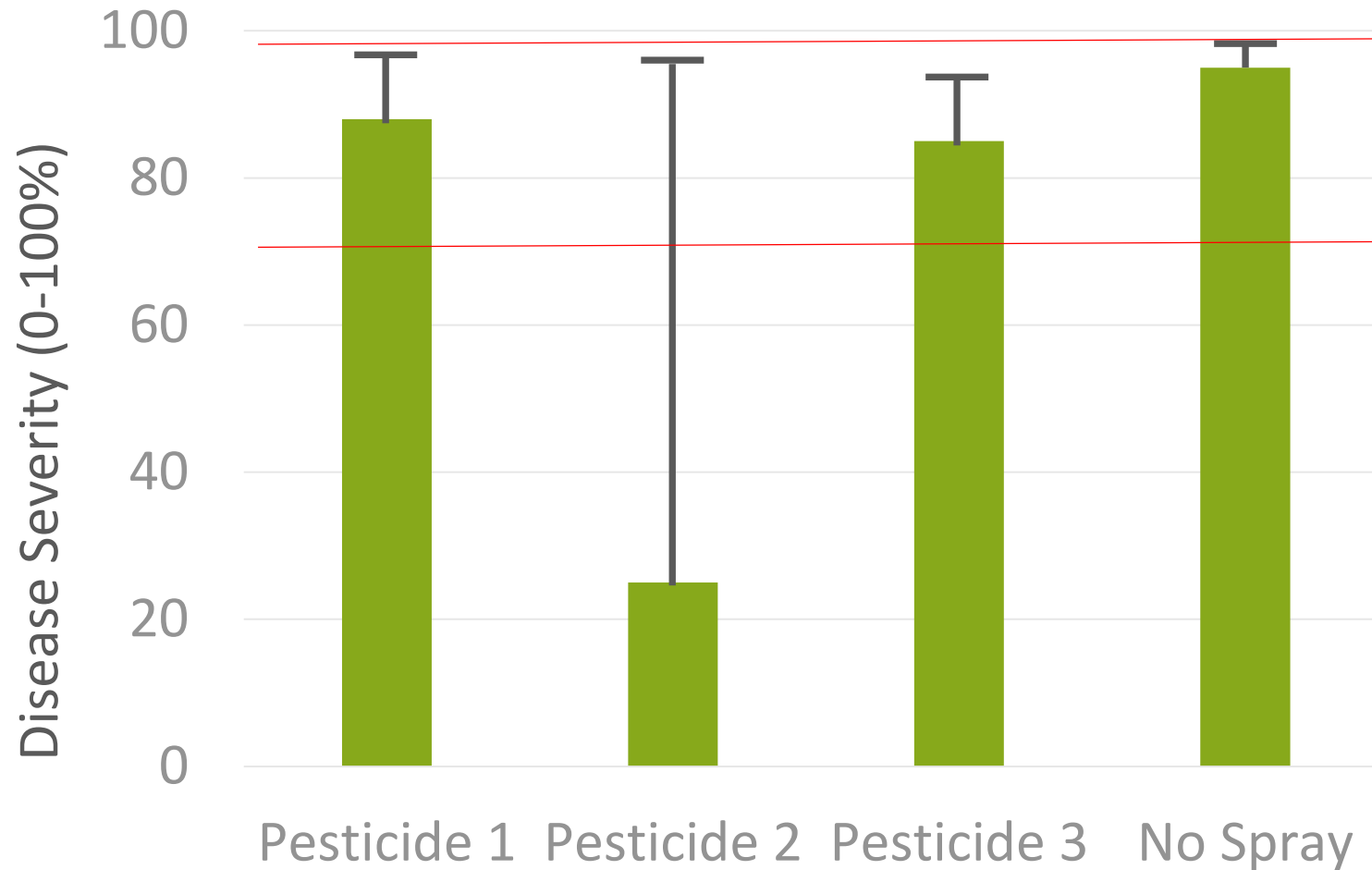
# IMPROPER INTERPRETATION - GRAPHICS

- Meaningless graphics - graph with means and no test, talking about which is greater and less doesn't show anything



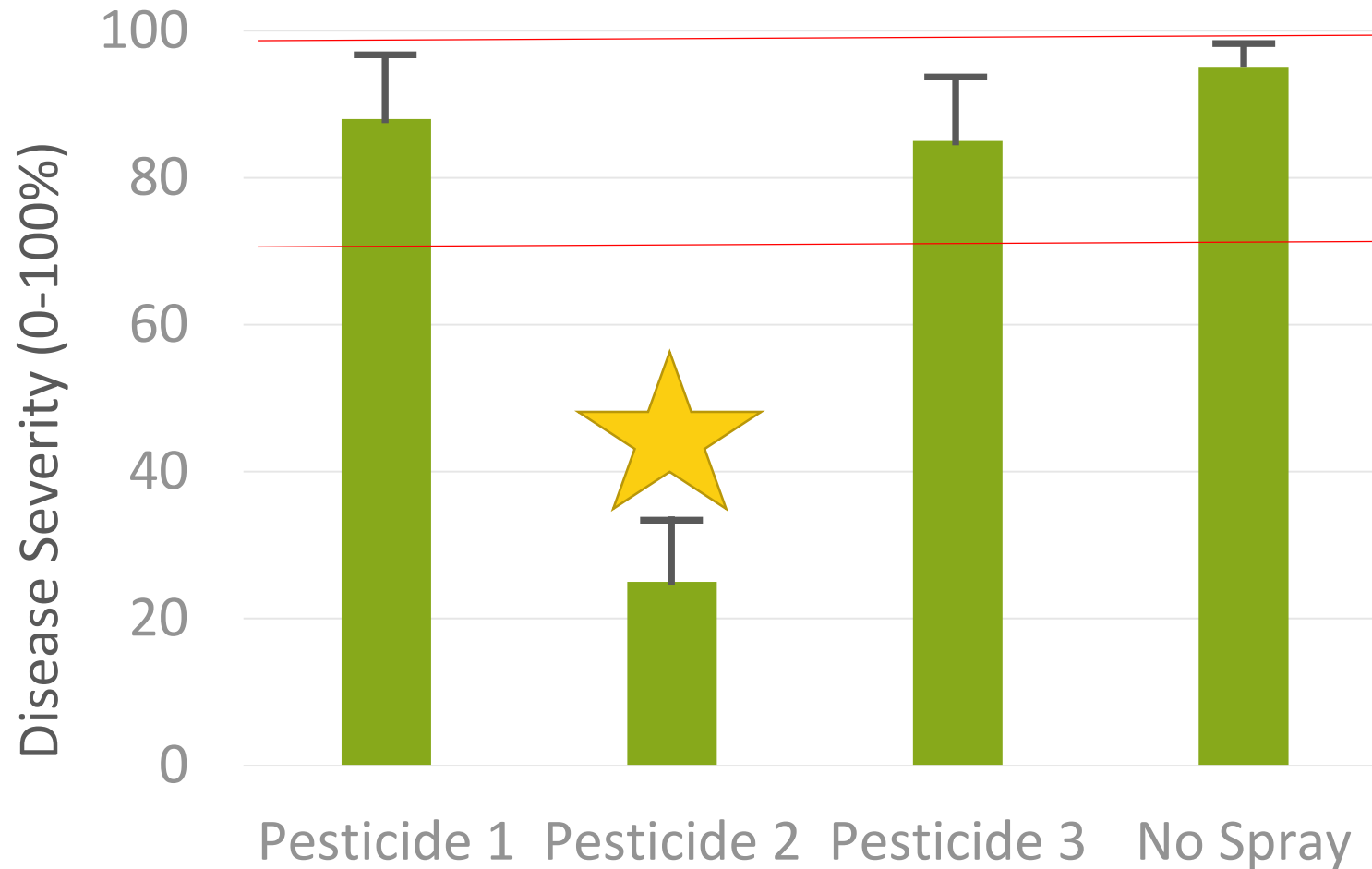
# IMPROPER INTERPRETATION - GRAPHICS

- Graph with means and measure of dispersion – you can evaluate results



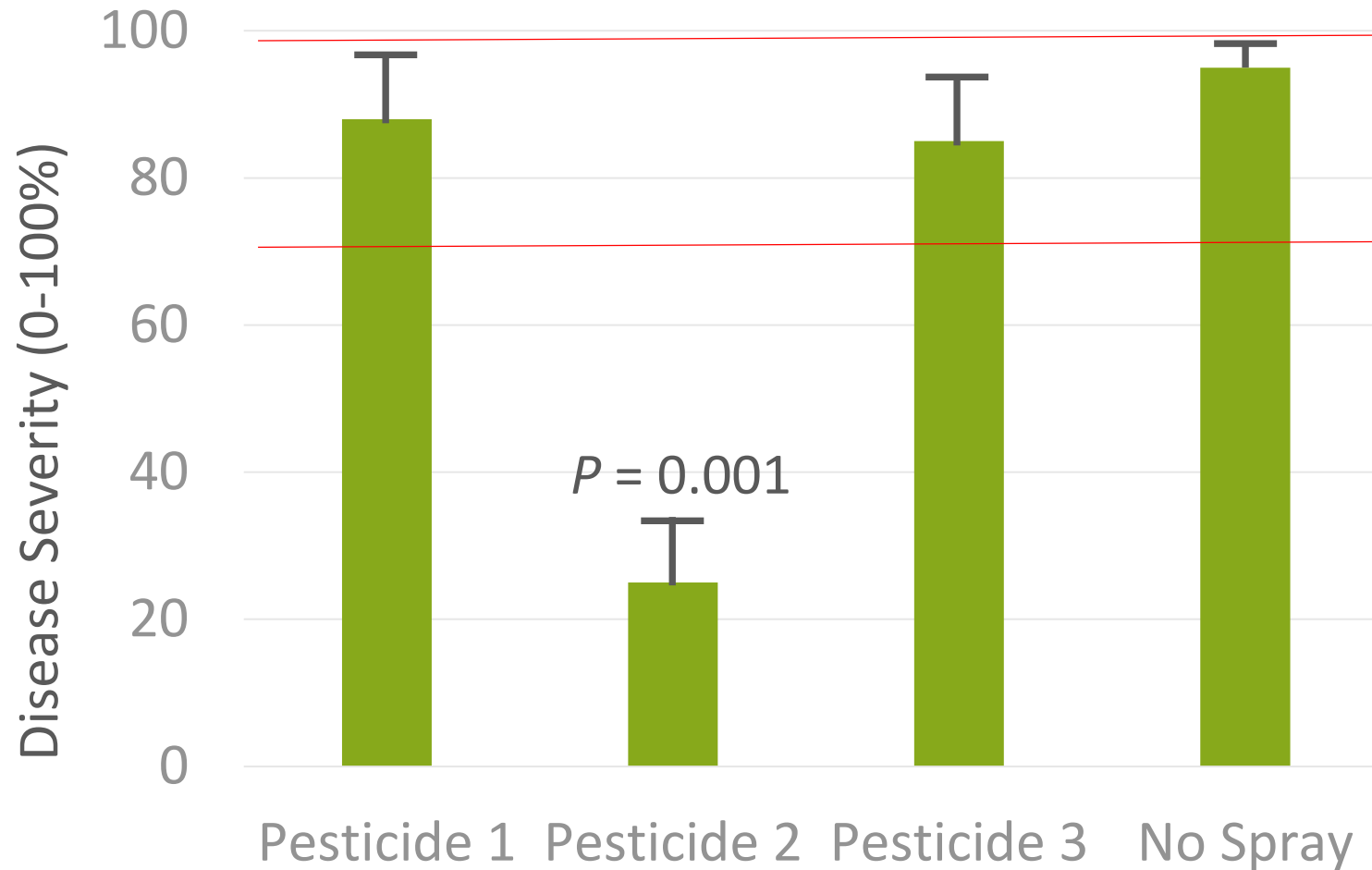
# IMPROPER INTERPRETATION - GRAPHICS

- Graph with means and measure of dispersion and statistical test indicated – best view of results



# IMPROPER INTERPRETATION - GRAPHICS

- Graph with means and measure of dispersion and statistical test indicated – best view of results





# IMPROPER INTERPRETATION - TERMS

Broad, undefined terms

- Use: either intentional or unintentional
- Natural, modern, etc. These are commonly used words that don't have a strong scientific definition
  - Terms like “modern” change what they refer to over time



# IMPROPER INTERPRETATION - TERMS

Broad, undefined terms

- Use: either intentional or unintentional
- Natural, modern, etc. These are commonly used words that don't have a strong scientific definition
  - Terms like “modern” change with time
  - Terms like “natural” as a positive health term
    - Uranium, radon, lead are also natural

# IMPROPER INTERPRETATION - TERMS

Use of the word “proven”

1. Guess how something works
2. Compute the consequences of the guess
3. Compare to experiment
  - a) If guess disagrees with experiment - wrong
  - b) If guess agrees with experiment – failed to disprove

If someone says the science proves something, then they don't really understand the science.



# IMPROPER INTERPRETATION – SIDE BY SIDE

- Side by side experiments

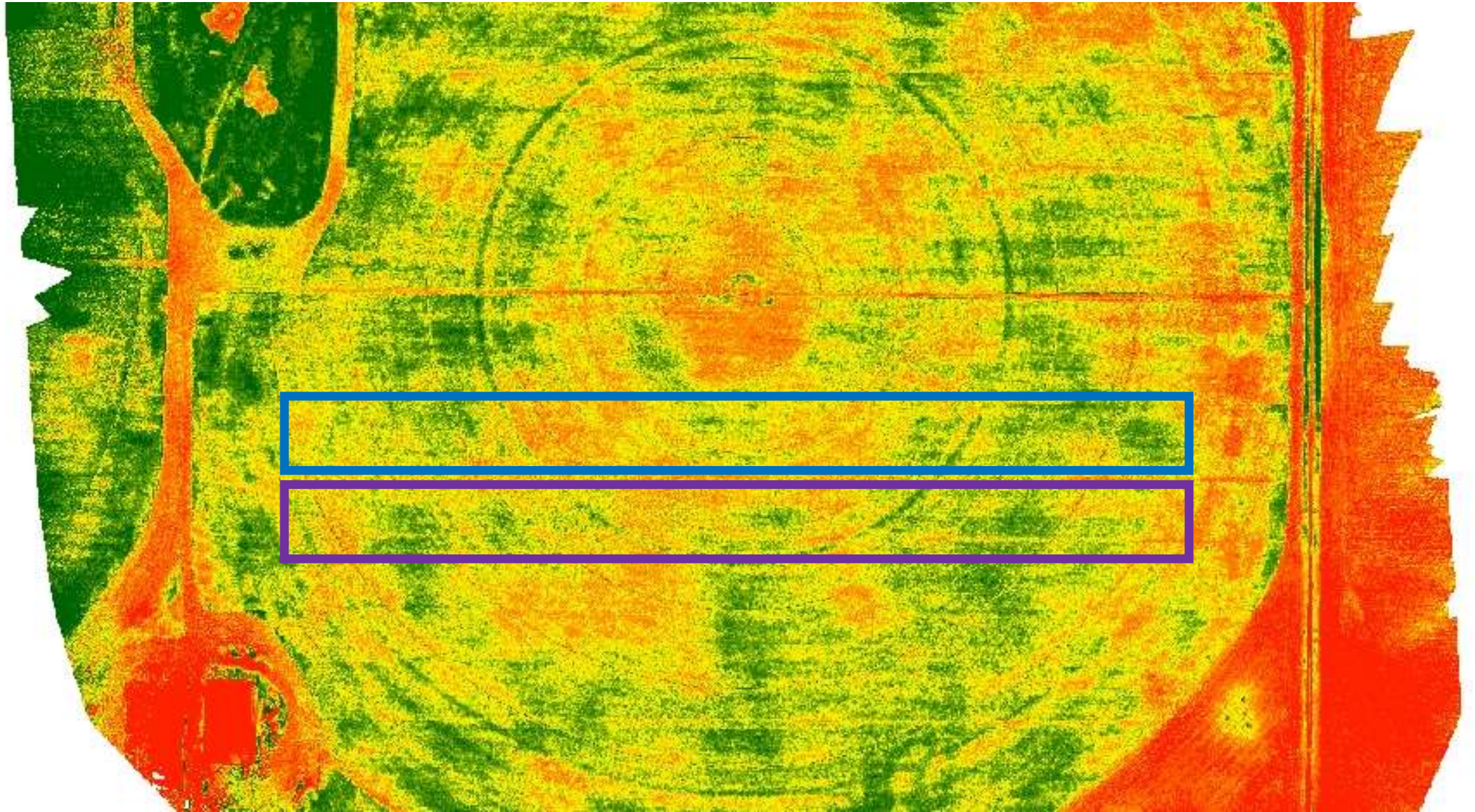
- Pros

- Less time
- Less space
- Cheaper
- Quicker
- Private
- Anyone can do it
- No scientist
- You know your crop best
- May reinforce what you're hearing

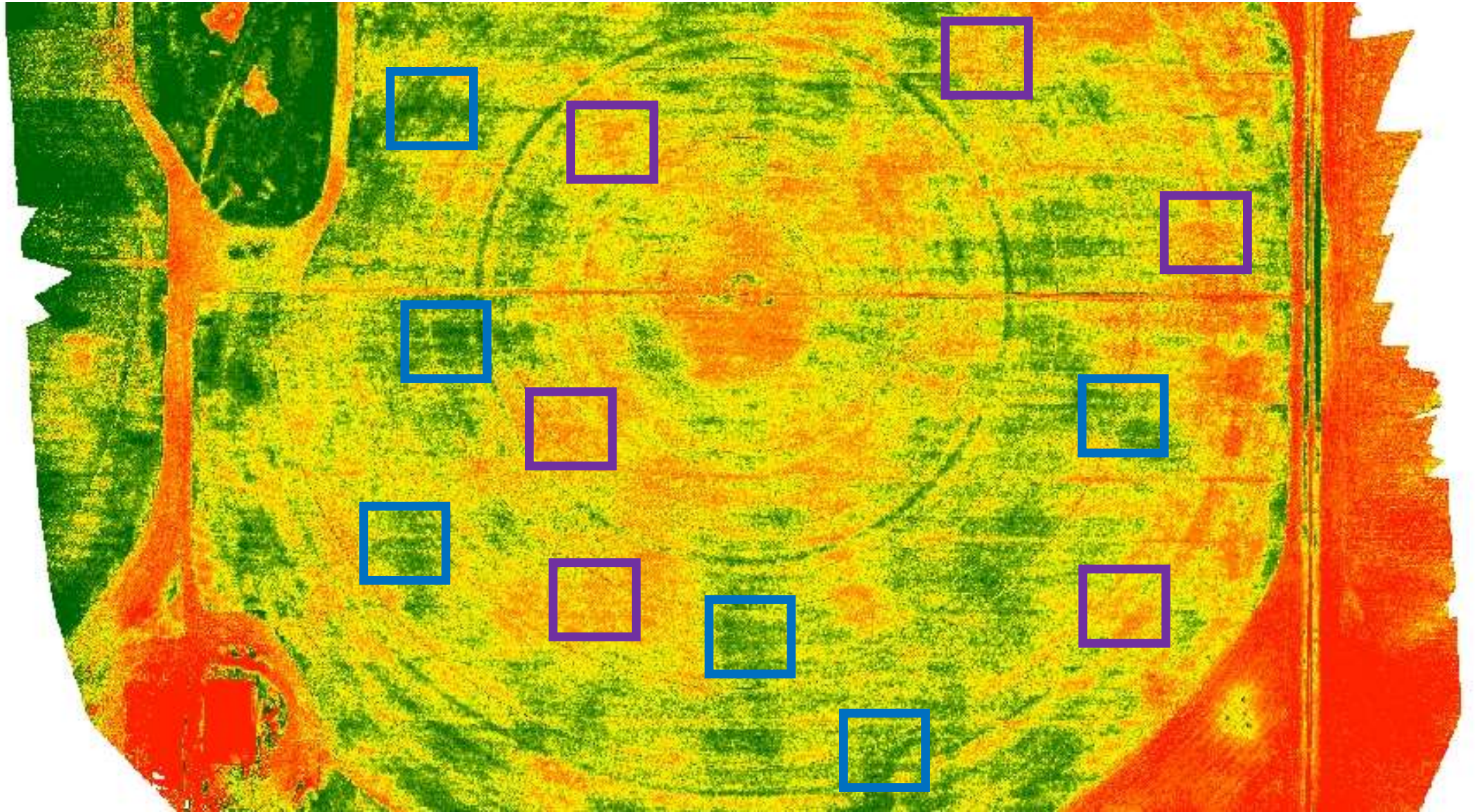
- Cons

- Lacks random assignment
- Lacks replication
- Lacks statistical analysis
- Impact of human error larger
- Impact variability larger
- Quality results?

# IMPROPER INTERPRETATION – SIDE BY SIDE



# IMPROPER INTERPRETATION – SIDE BY SIDE



# HOW YOU CAN SPOT PSEUDOSCIENCE

- Always ask for a detailed explanation of the science. Whoever is presenting it should be able to explain it on a level you can understand
  - You should always be able to weigh the results against the interpretation
  - Don't assume interpretation is always correct, regardless of who made the interpretation
- Always look for dispersion around means in graphs and tables
  - Lots of dispersion is a bad thing, inconclusive
- **Data used to try to disprove or confirm guess?**



# RESOURCES

- Flyer at CMCDC table
  - Available online at [mbpotatoresearch.ca](http://mbpotatoresearch.ca)
- Contact me at [mhpec@outlook.com](mailto:mhpec@outlook.com)
- Talk to your friendly neighborhood scientist



## SPECIAL THANKS

MHPEC Partners

KPPA

Simplot

McCain

Manitoba Potato  
Research Committee

Funded through  
Manitoba Agriculture  
CAP Program

# SOURCES AND CITATIONS

ESSENCE OF SCIENCE DERIVED FROM RICHARD FEYNMAN'S 1964 LECTURE AS VIEWED ON  
[HTTPS://WWW.NPR.ORG/SECTIONS/KRULWICH/2012/05/17/152913171/THE-ESSENCE-OF-SCIENCE-EXPLAINED-IN-63-SECONDS](https://www.npr.org/sections/krulwich/2012/05/17/152913171/the-essence-of-science-explained-in-63-seconds)

FEYMAN'S VIEWS WERE COMBINED WITH WILLIAM GARVEY'S *COMMUNICATION: THE ESSENCE OF SCIENCE*  
FROM [HTTPS://WWW.ELSEVIER.COM/BOOKS/COMMUNICATION-THE-ESSENCE-OF-SCIENCE/GARVEY/978-0-08-023344-4](https://www.elsevier.com/books/communication-the-essence-of-science/garvey/978-0-08-023344-4)

ESSENCE AND PHILOSOPHY OF SCIENCE ALSO DERIVED FROM KARL POPPER'S *LOGIC OF SCIENTIFIC DISCOVERY*  
AND REJECTION OF THE INDUCTIVE METHOD OF EMPIRICAL SCIENCES

SIDE BY SIDE ADDITIONAL REFERENCE:  
[HTTPS://CIRT.GCU.EDU/RESEARCH/DEVELOPMENTRESOURCES/RESEARCH\\_READY/QUASIEXPERIMENTAL/BENE  
FITS\\_LIMITS](https://cirt.gcu.edu/research/developmentresources/research_ready/quasiexperimental/benefits_limits)

STATISTICAL SUMMARIES FORWARDED BY LEONARD ROSSNAGEL FROM SPRAYERS 101  
[HTTPS://SPRAYERS101.COM/STATISTICS/?UTM\\_SOURCE=SUBSCRIPTIONS&UTM\\_CAMPAIGN=9E3C0219C9-  
RSS\\_EMAIL\\_CAMPAIGN&UTM\\_MEDIUM=EMAIL&UTM\\_TERM=0\\_56DF56683A-9E3C0219C9-99450233](https://sprayers101.com/statistics/?utm_source=subscriptions&utm_campaign=9E3C0219C9-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_56DF56683A-9E3C0219C9-99450233)

CRITICAL THINKING TUTORIAL FROM [HTTP://WWW.AUSTHINK.COM/CRITICAL/](http://www.austhink.com/critical/), PARTICULARLY OF THE  
LIBERTY OF THOUGHT AND DISCUSSION BY JOHN STUART MILL

PSEUDOSCIENCE MODERN DEFINITION DERIVED FROM STEPHEN LOWER'S THOUGHTS ON JUNK SCIENCE  
FROM [HTTP://WWW.CHEM1.COM/ACAD/SCI/PSEUDOSCI.HTML](http://www.chem1.com/acad/sci/pseudosci.html)

# IMAGE CREDITS

PERSEUS IMAGE TAKEN FROM [HTTPS://WWW.CONSTELLATION-GUIDE.COM/CONSTELLATION-LIST/PERSEUS-CONSTELLATION/](https://www.constellation-guide.com/constellation-list/perseus-constellation/)

PERSEUS IMAGE TAKEN FROM [HTTPS://WWW.CONSTELLATION-GUIDE.COM/CONSTELLATION-LIST/PERSEUS-CONSTELLATION/PERSEUS-CONSTELLATION-ILLUSTRATION/](https://www.constellation-guide.com/constellation-list/perseus-constellation/perseus-constellation-illustration/)

HOMUNCULUS TAKEN FROM  
[HTTPS://WWW.GOOGLE.COM/URL?SA=I&SOURCE=IMAGES&CD=&CAD=RJA&UACT=8&VED=2AHUKEWIR3PNF4ITGAHWHOYMKHZ7PAFCQJRX6BAGBEAU&URL=HTTPS%3A%2F%2FPEKLING.PW%2FPIN-BY-CARMEN-PETRY-ON-HOMNKULUS-T-HOMUNCULUS.HTML&PSIG=AOVVAW3CKIILB5MSDBLPRDKRLDB9&UST=1548362122695282](https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=2AHUKEWIR3PNF4ITGAHWHOYMKHZ7PAFCQJRX6BAGBEAU&url=https%3A%2F%2FPEKLING.PW%2FPIN-BY-CARMEN-PETRY-ON-HOMNKULUS-T-HOMUNCULUS.HTML&psig=AOVVAW3CKIILB5MSDBLPRDKRLDB9&ust=1548362122695282)

BANANA PIC COURTESY OF [HTTPS://WWW.WNYCSTUDIOS.ORG/STORY/HEADLINE-MIGHT-KILL-YOU](https://www.wnycstudios.org/story/headline-might-kill-you)

20<sup>TH</sup> CENTURY SCIENTISTS COURTESY OF NEW YORK STATE AGRICULTURAL EXPERIMENTAL STATION ARCHIVES AND DR. KERIK COX

MANITOBA POTATO HARVEST PICTURE COURTESY OF EARL BARON

THINKING EMOJI VECTOR CREATED FROM [HTTPS://IMGUR.COM/R/THINKING/MLFIQ](https://imgur.com/r/thinking/mlfiq)

SNAKE OIL PICTURE: [HTTPS://GIZMODO.COM/HOW-SNAKE-OIL-GOT-ITS-REPUTATION-5804378](https://gizmodo.com/how-snake-oil-got-its-reputation-5804378)

FUZZY CHARTS [HTTPS://BLOG.XLCUBED.COM/2008/08/THE-DASHBORD-SQUINT-TEST/](https://blog.xlcubed.com/2008/08/the-dashbord-squint-test/)