How Science is Different from Other Jobs: Responsibility to Public

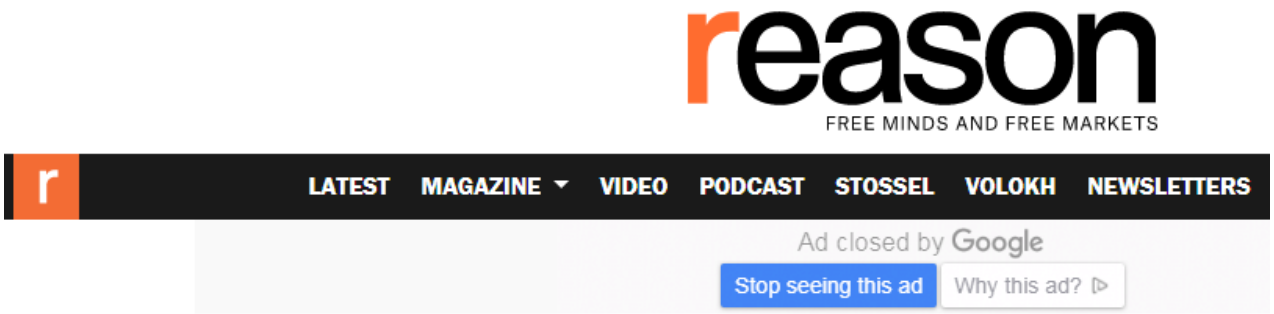
Natasha Kirienko

BioSciences, Rice University

08/08/23

How Bad are Americans at Science?

How Bad are Americans at Science?



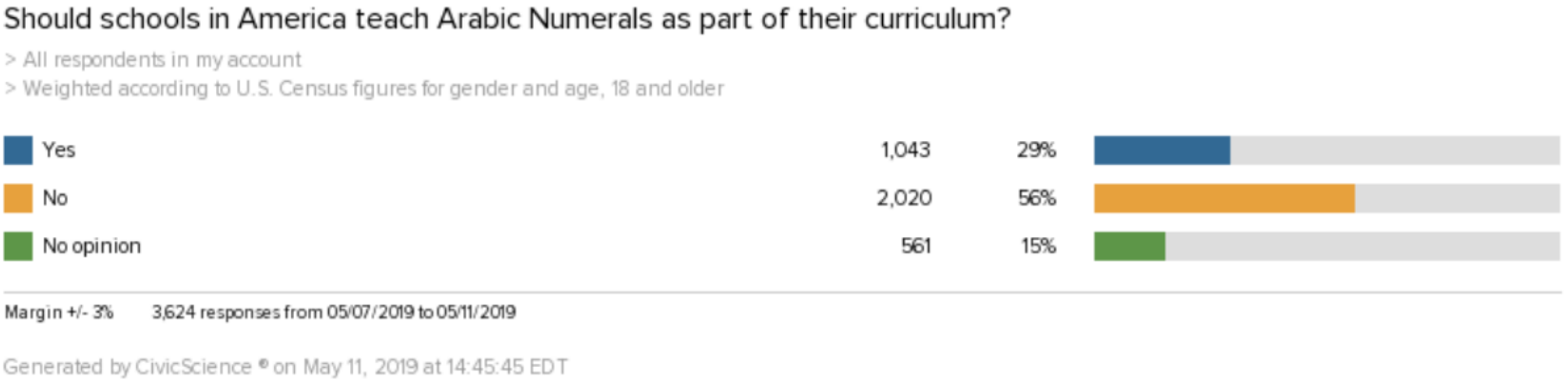
GMO FOOD

80 Percent of Americans Want to Label Food That Contains DNA

Sigh.

KATHERINE MANGU-WARD | 5.24.2016 3:25 PM

How Bad are Americans at Science?



How Bad are Americans at Science?

Sections

The Washington Post
Democracy Dies in Darkness

Sign I

Climate and Environment

Americans are still scientifically illiterate — and scientists still need a PR team

By **Chris Mooney**
January 29, 2015

How Bad are Americans at Science?

Sections

Climate and Environment

Americans are ... scientifically illiterate — and scientists still need a PR team

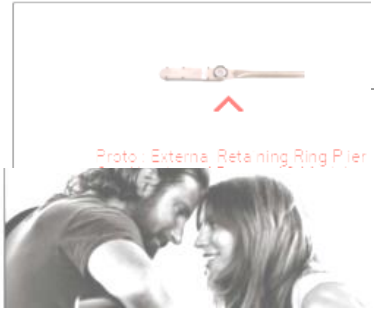
By Chris Mooney
January 29, 2015

... That Contains DNA

Sigh.

KATHERINE MANGU-WARD | 5.24.2016 3:25 PM

Are We Doomed???



Not as bad as you think…

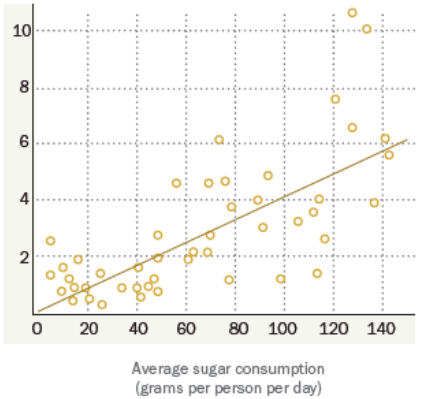
SEPTEMBER 14, 2015

THE ART AND SCIENCE OF THE SCATTERPLOT

63% of American Adults Can Correctly Read This Chart

63% of American Adults Can Correctly Read This Chart

Which of the following statements best describes the data in the graph below?



A. In recent years, the rate of cavities has increased in many countries

B. In some countries, people brush their teeth more frequently than in other countries

C. The more sugar people eat, the more likely they are to get cavities (CORRECT)

D. In recent years, the consumption of sugar has increased in many countries

Source: American Trends Panel (wave 6). Survey of U.S. adults conducted Aug. 11-Sept. 3, 2014.

PEW RESEARCH CENTER

Science & Health

Americans Are Smart About S

What Americans know and don't know about science

% of U.S. adults who answer each question correctly

Life science

Antibiotic resistance is a major concern of antibiotics overuse — 79

Identify the definition of an incubation period — 76

Inserting a gene into a plant is an example of genetic engineering — 56

Earth and other physical science

Oil, natural gas and coal are fossil fuels — 68

Tilt of Earth's axis in relation to sun determines seasons — 63

Deforestation on land leads to increased erosion — 60

The main components of antacids are bases — 39

Numeracy and chart reading

Chicago, Ilinois, has the greatest annual range of temperatures (with charts) — 59

A car traveling 40 mph travels 30 miles in 45 minutes — 57

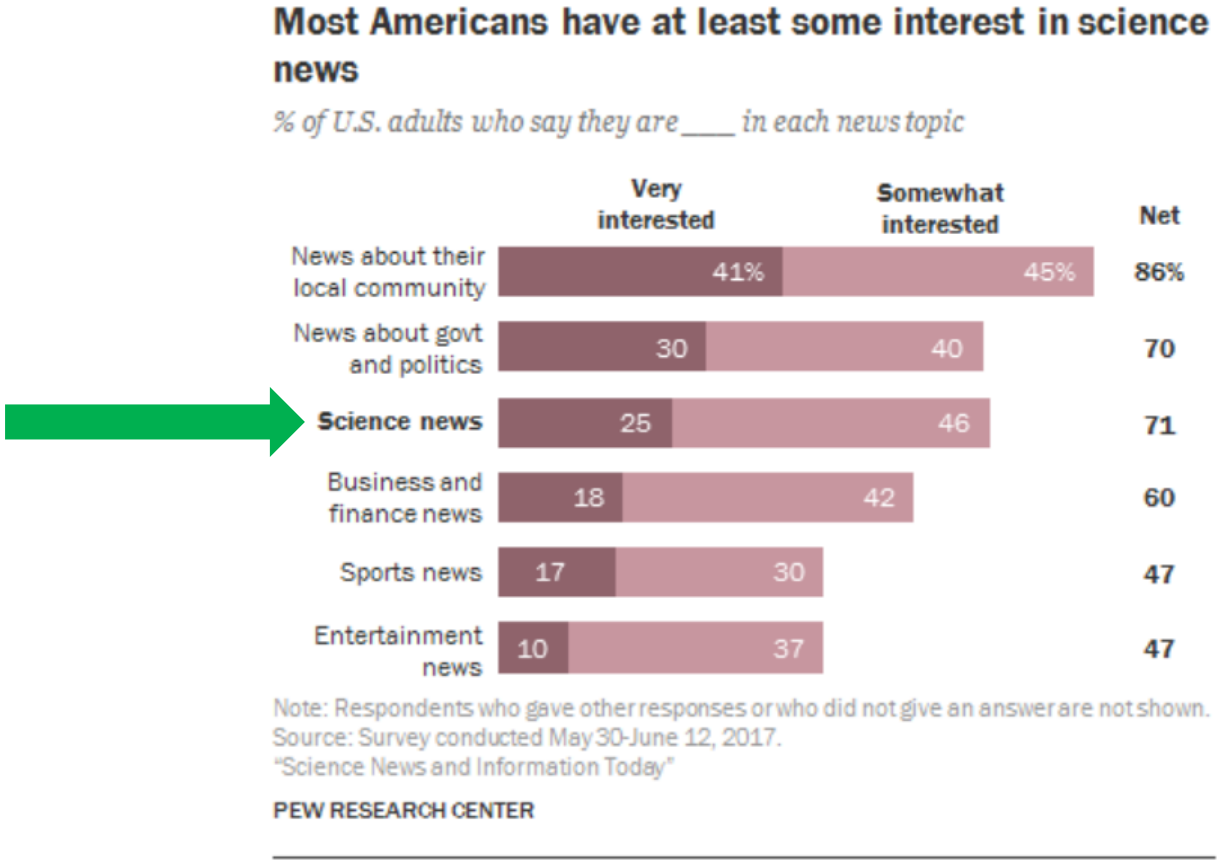
Scientific processes

Identify the need for a control group to determine effectiveness of a new drug — 60

Identify a hypothesis about a computer slowing down — 52

Notes: All questions are multiple choice; for full question wording, see topline.
Source: Survey conducted Jan. 7-21, 2019.

And Americans are *Interested* In Science

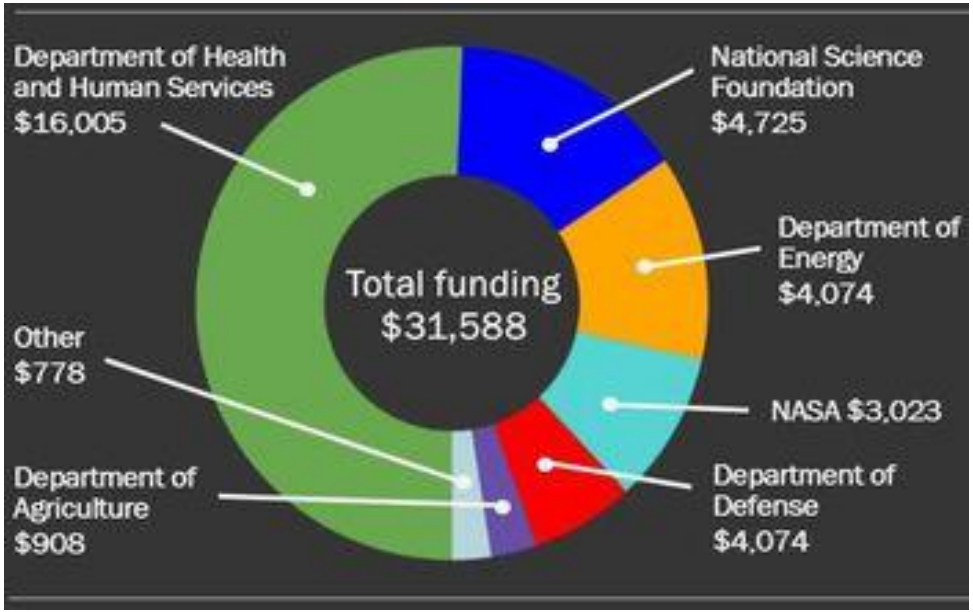


But…

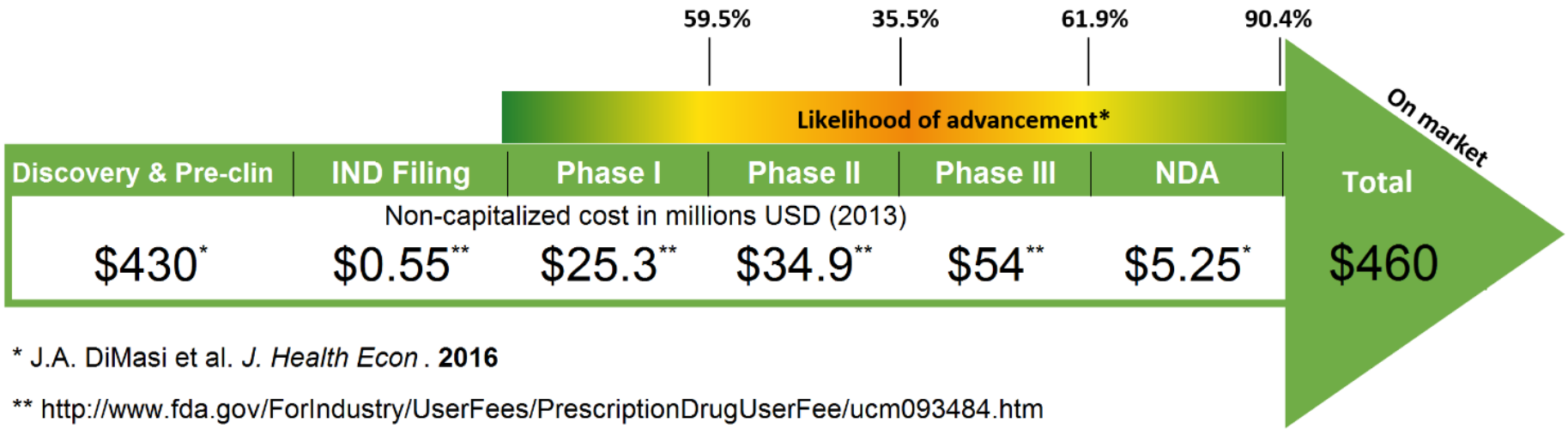
- In 2006, 41% of survey respondents expressed confidence in academia; by 2014, that number was 14%
- From 2009-2015, public belief that science makes life more difficult increased by 50%
- From 2013-2017, the proportion of respondents who, “do not trust scientists at all” has increased by 50%

Why is confidence in science receding?

Although There Is a Lot of Funding for Science…



Science is Expensive

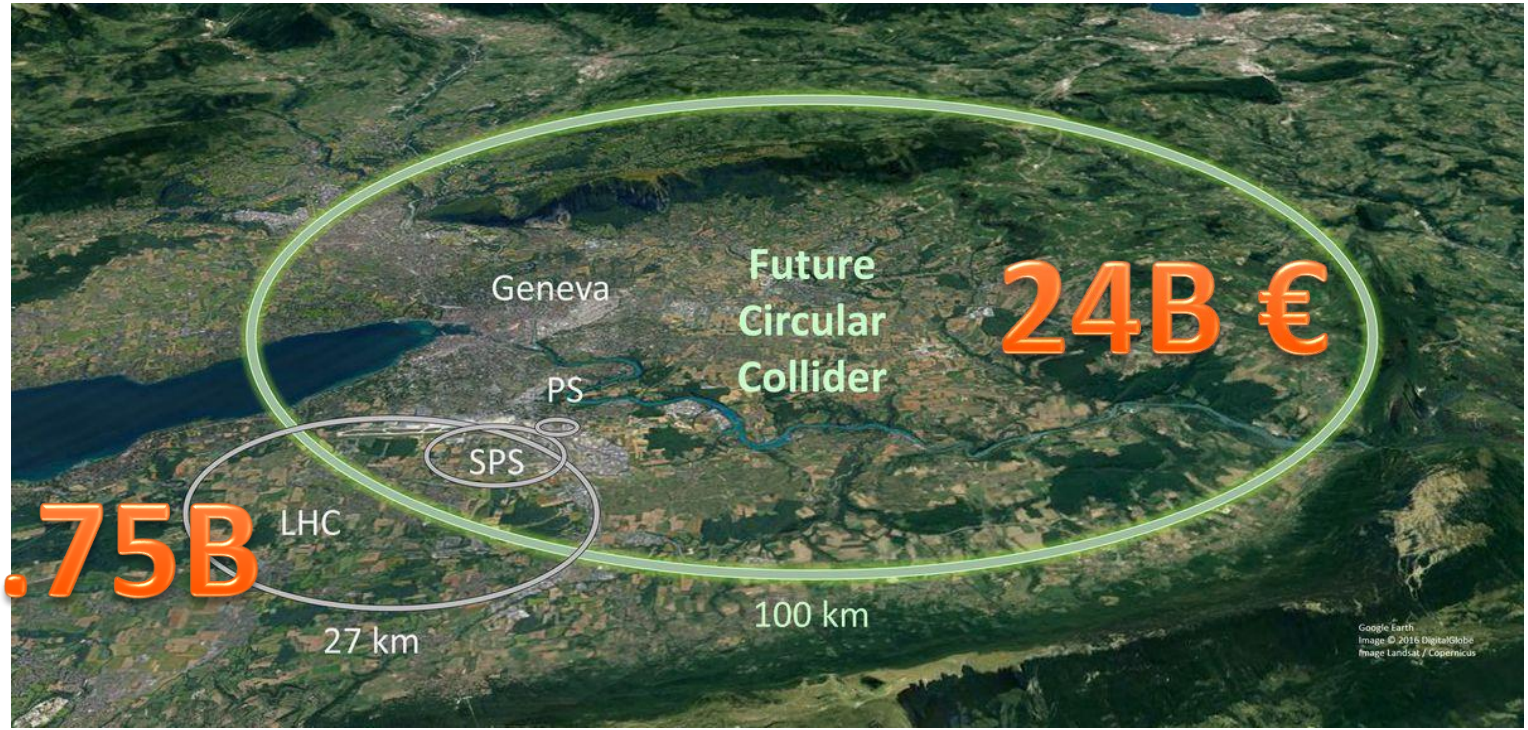


* J.A. DiMasi et al. *J. Health Econ* . **2016**

** http://www.fda.gov/ForIndustry/UserFees/PrescriptionDrugUserFee/ucm093484.htm

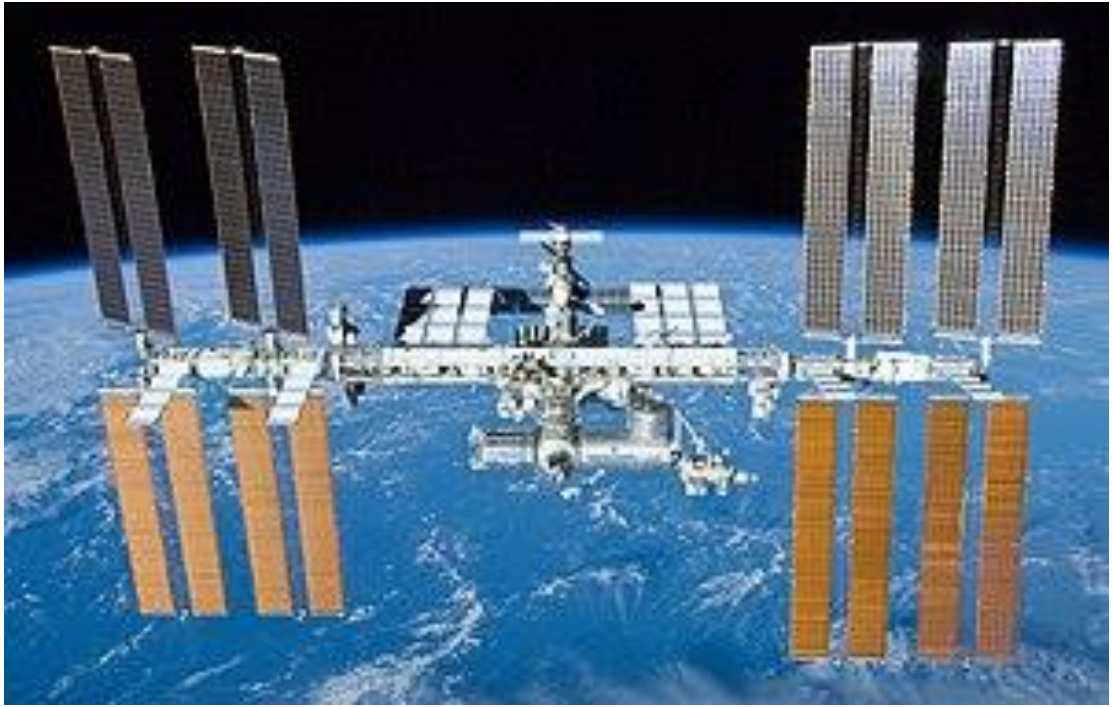
New drug? $500M-$2B

Science is Expensive



$4.75B

Science is Expensive



International Space Station?

$150B

But why is confidence in science receding?

The Flat Earth Society is…incredible

- Modern Flat Earth beliefs originated in the 1890s.
- Brief moment of popularity, but quickly disappeared.
- Reimagined in mid-1950s, but same pattern formed.
- In 2004, something strange happened:
  - A small group of Flat Earthers started a website and a blog.
  - Like minds have gathered and developed a YouTube channel, a Facebook, etc.
  - They are now doing experiments that sometimes involve shooting themselves several thousand feet into the sky to “prove that the world is flat”.
- Popularity has been surging for the last 15 years.
- They manage to believe this in the face of incredible proof.

And It Isn't Just Them!
Popular Products in the "Marketplace of Ideas"

- CIA created HIV
- Fluoridated water allows mind control
- NASA faked landing on the Moon
- Antivaxxers (including those who had this position prior to 2020)

- It goes on and on…

It’s the Internet

- The Internet contains more information than any of us could ever hope to learn.
- Probably the greatest learning tool we’ve ever had, other than writing itself

It’s the Internet

“These are dangerous times. Never have so many people had access to so much knowledge, and yet been so resistant to learning anything.”

-- Tom Nichols, *The Death of Expertise*

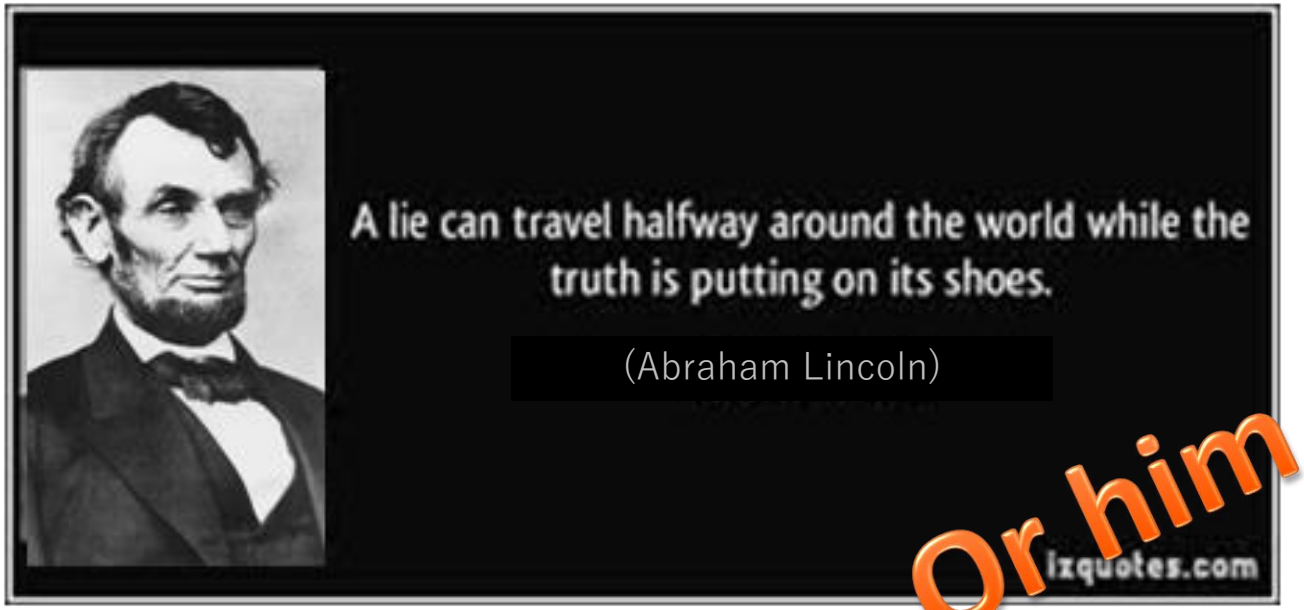
It’s the Internet

- The Internet contains more information than any of us could ever hope to learn.
- Probably the greatest learning tool we’ve ever had, other than writing itself
- Too often, people don’t use the Internet to learn.
- Instead…

People are *Terrible*
At Telling Truths from Falsehoods

It wasn't him.

People are *Terrible*
At Telling Truths from Falsehoods



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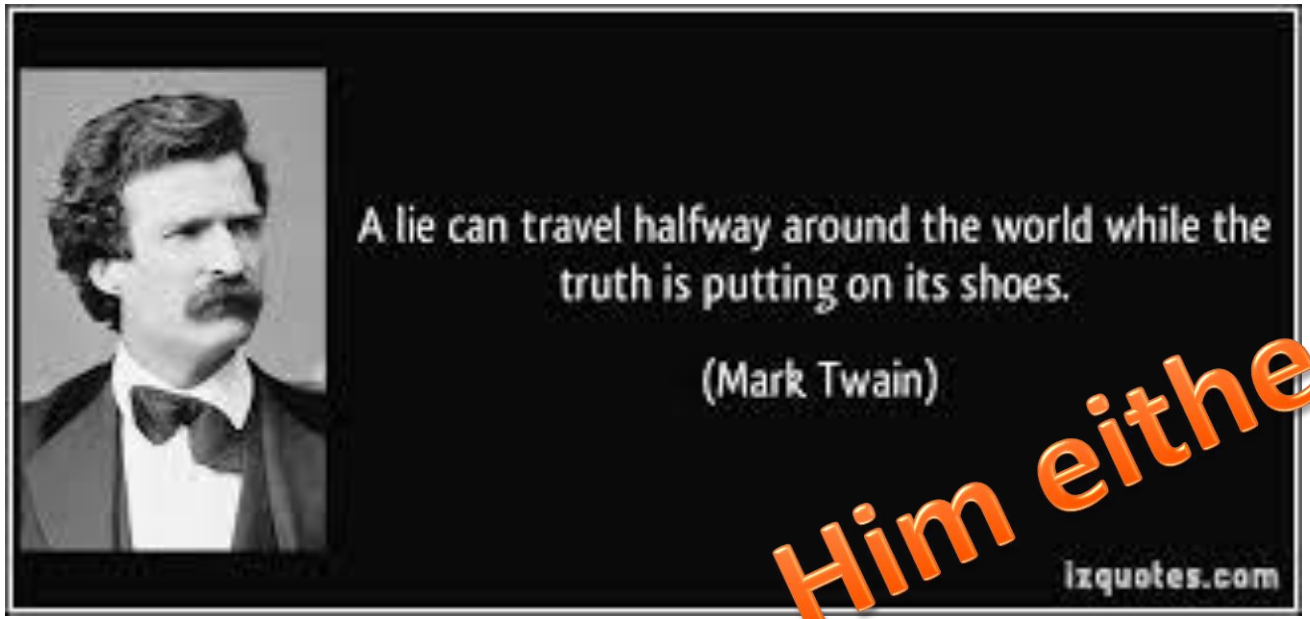

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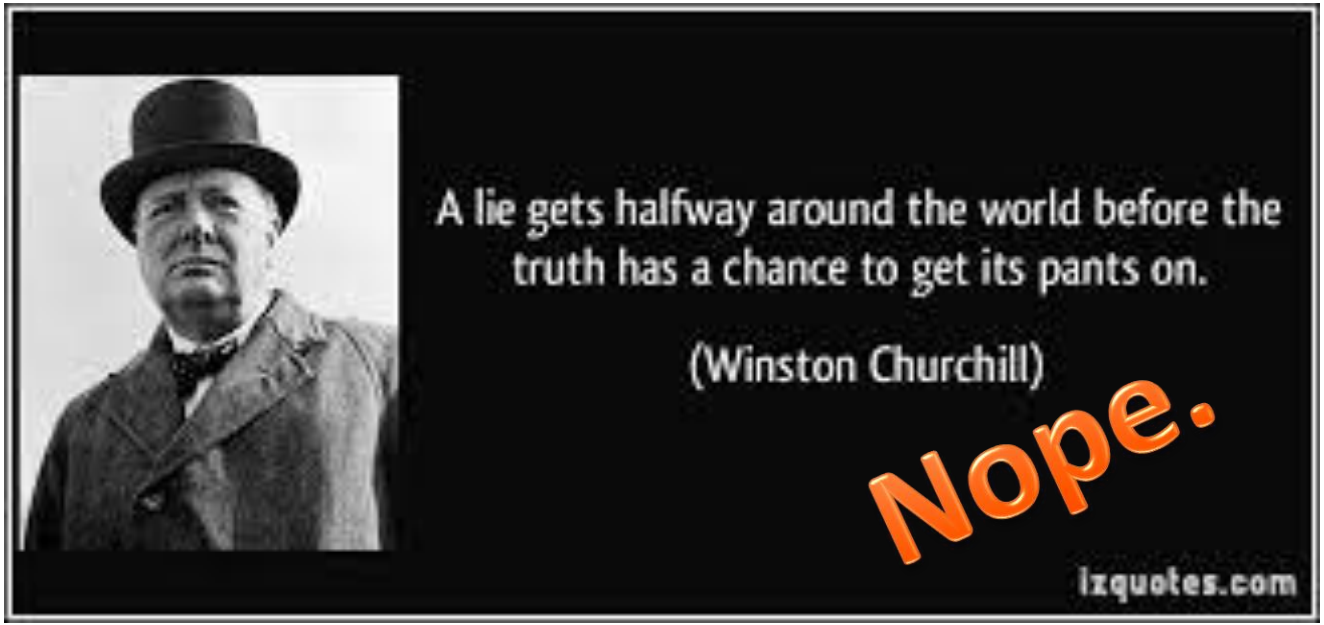
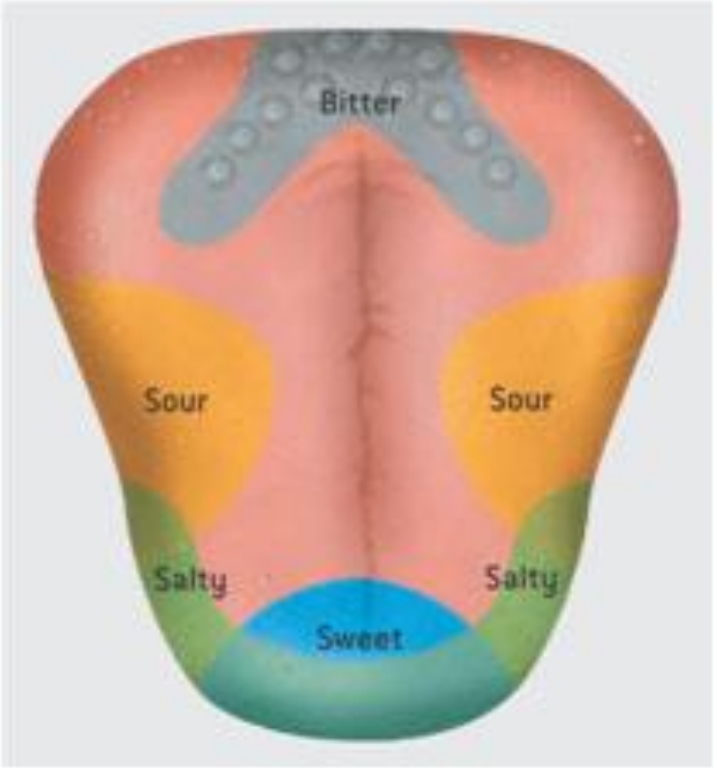


Repetition Builds Confidence

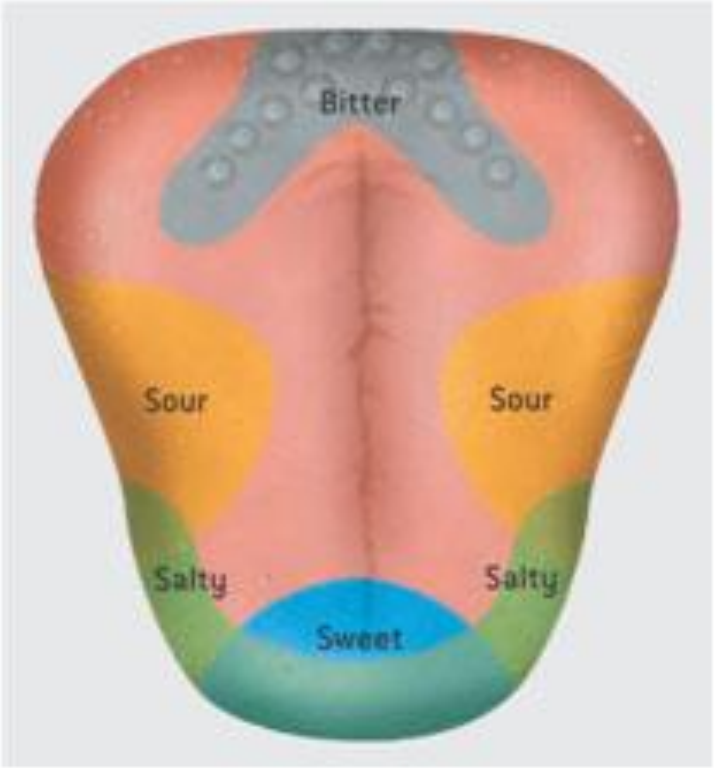
- Who's seen this image?



Repetition Builds Confidence

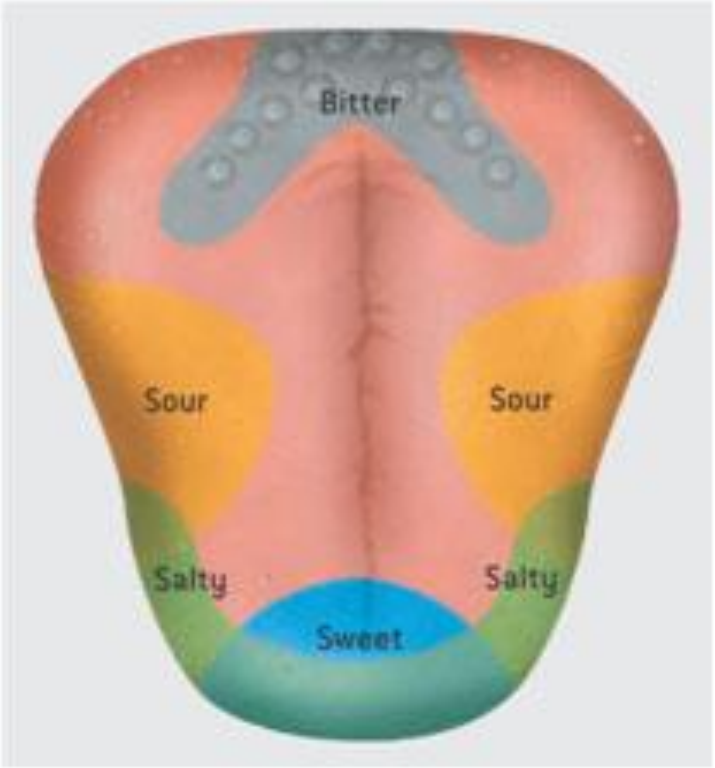
- Who's seen this image?

- Ever licked a lollipop?



Repetition Builds Confidence

- Who's seen this image?
- Ever licked a lollipop?
- After you did that test, did you believe it anyway?



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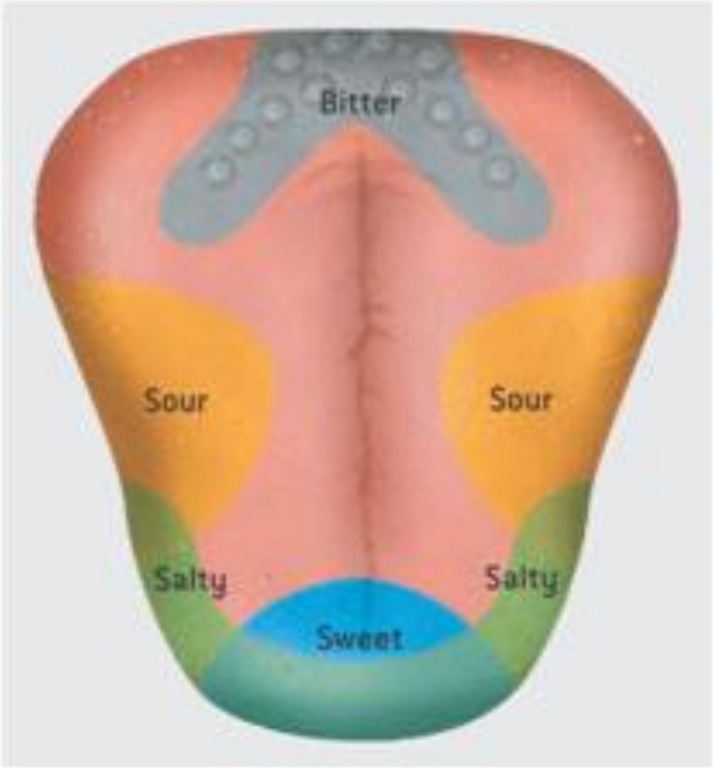


So why did anyone believe it?

- Because you saw it in a textbook in elementary school
- Originally came from a mistranslation (by Edwin G. Boring) from a German medical text
- The ascribed regions have a *slight* difference in sensitivity, but

Repetition Builds Confidence

Do Carrots Improve Eye-Sight? –

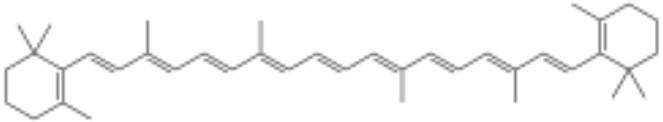
Food Theory: But Really... Do Carrots HELP Your Eyes?

https://www.youtube.com/watch?v=tPHmDZq9YRE&t=226s

Food Theory: But Really...Do Carrots HELP Your Eyes?

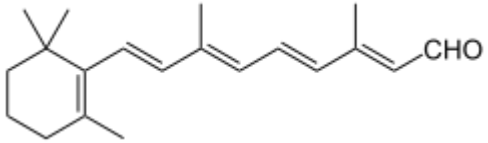
Indeed, Cunningham became the leading RAF night fighter pilot of World War II, chalking up 20 kills, and numerous decorations, in an often hair-raising series of sorties. A modest man, John Cunningham was fêted like a film star. Nicknamed Cats' Eyes - a sobriquet he never liked - his exceptional skill on the nocturnal battlefield was put down to **eating carrots** to improve his night vision.

This romantic, if rather naïve, explanation for his success, masked the reality. British scientists had secretly developed a sophisticated and formidable airborne radar system which allowed its pilots to home in on Luftwaffe bomber streams, often with devastating consequences.



provitamin A foods
(beta-carotene)

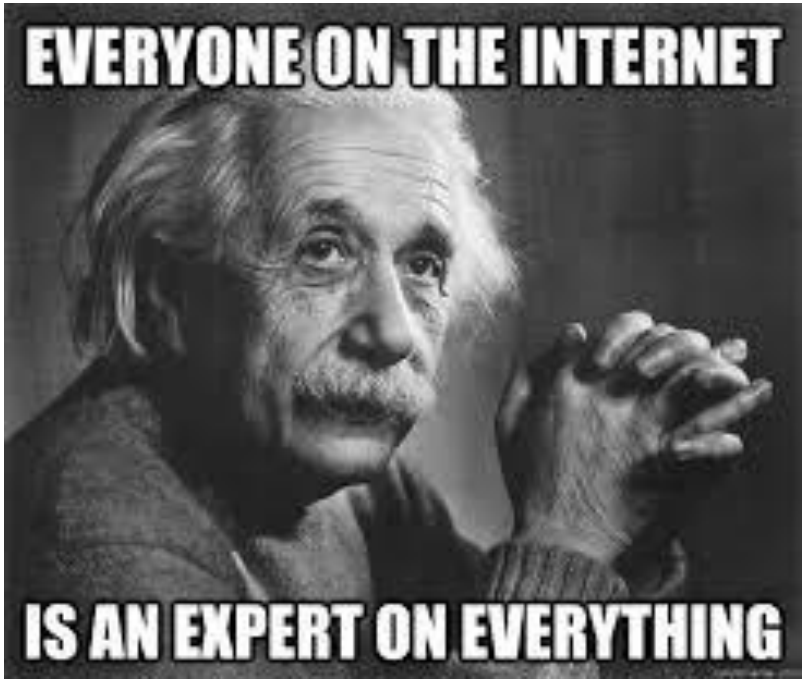
vs



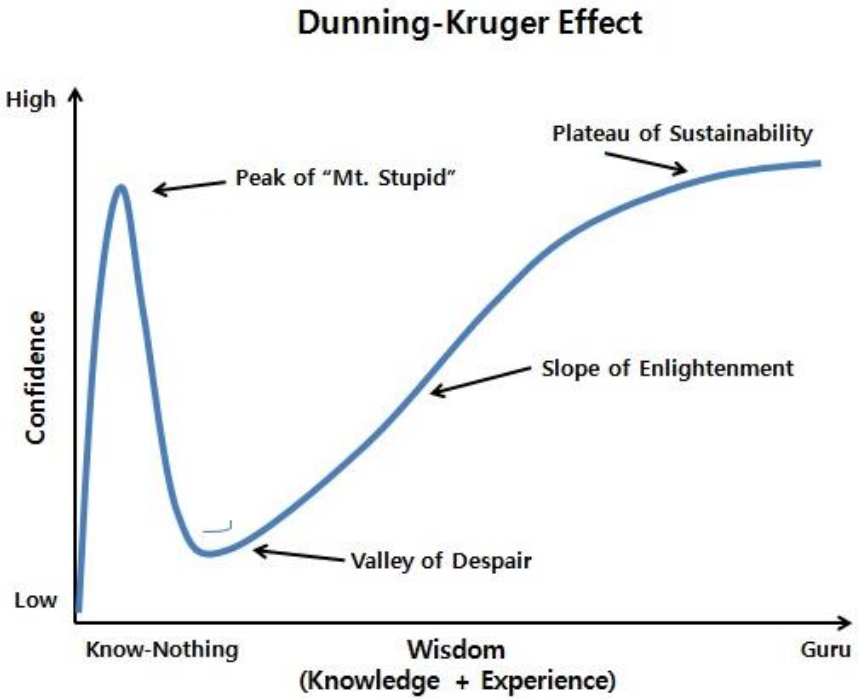
vitamin A foods
(retinol)

The Internet is Good
At Spreading Bad Information

- People learn *just a little bit.*
- Summit “Mt. Stupid”

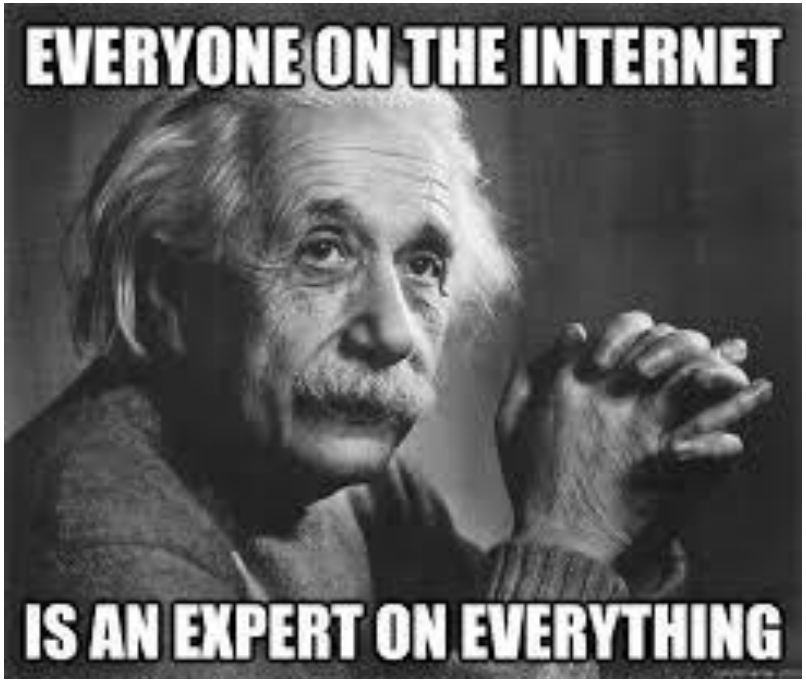


I Know Everything…About Everything: The Dunning-Kruger Effect



The Internet is Good At Spreading Bad Information

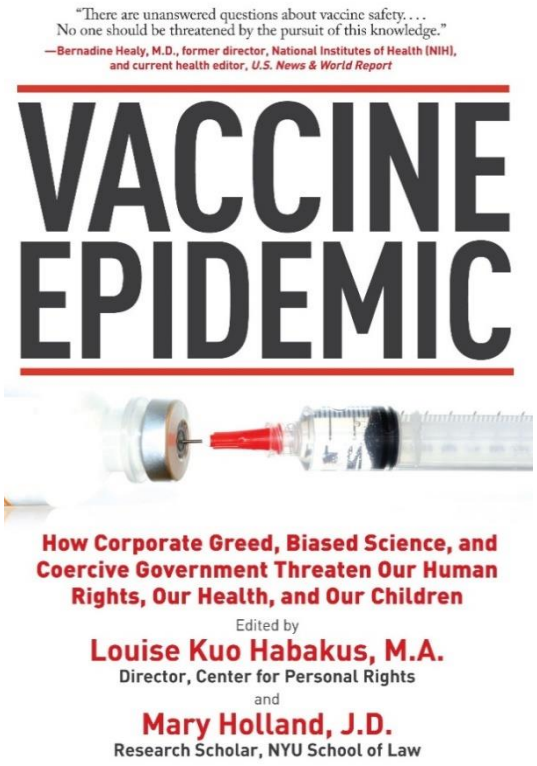
- People learn *just a little bit.*
- Summiting “Mt. Stupid”
- Echo chamber keeps them there
- Confidence remains high, knowledge remains low
- The Internet works in anecdote, rumor, and misinformation.

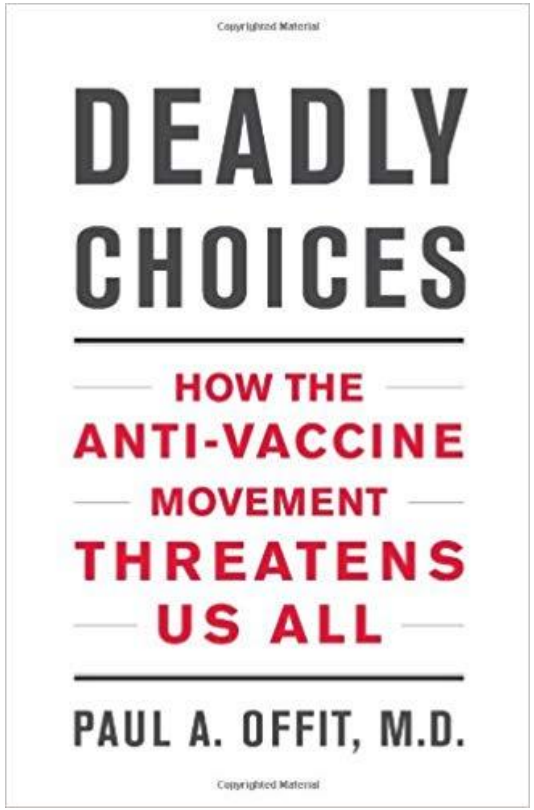


What's Causing Our Ignorance

- People are exposed to more information than any previous period in history
- They're also being exposed to loads of garbage
- Simultaneously, the value of expertise is being undermined by:
  - media (misguided attempts at fairness)
  - media
  - purveyors of bad ideas

What About Scientists?
Are WE Part of the Problem?





The Wakefield Scam

- Published in 1998, Wakefield linked MMR vaccine with autism.

- Later investigation revealed that Wakefield:
  - Obtained blood from patients without informed consent
  - Performed unauthorized medical treatments as part of the research protocol
  - Had a conflict of interest
    - Had his own vaccine that he wanted to market
  - Did NOT have a large unbiased cohort

EARLY REPORT

Early report

Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children

A J Wakefield, S H Murch, A Anthony, J Linnell, D M Casson, M Malik, M Berelowitz, A P Dhillon, M A Thomson, P Harvey, A Valentine, S E Davies, J A Walker-Smith

Summary

Background We investigated a consecutive series of children with chronic enterocolitis and regressive developmental disorder.

Methods 12 children (mean age 6 years [range 3–10], 11 boys) were referred to a paediatric gastroenterology unit with a history of normal development followed by loss of acquired skills, including language, together with diarrhoea and abdominal pain. Children underwent gastroenterological, neurological, and developmental assessment and review of developmental records. Ileocolonoscopy and biopsy sampling, magnetic-resonance imaging (MRI), electroencephalography (EEG), and lumbar puncture were done under sedation. Barium follow-through radiography was done where possible. Biochemical, haematological, and immunological profiles were examined.

Findings Onset of behavioural symptoms was associated, by the parents, with measles, mumps, and rubella vaccination in eight of the 12 children, with measles infection in one child, and otitis media in another. All children had intestinal abnormalities, ranging from lymphoid nodular hyperplasia to aphthoid ulceration. Histology showed non-specific inflammation in the colon in 11 children, reactive ileal lymphoid hyperplasia in seven, but no granulomas. Behavioural disorders included autism (nine), disintegrative psychosis (one), and possible postviral or vaccinal encephalopathy (two). There were no focal neurological abnormalities and MRI and EEG tests were normal. Abnormal laboratory results were significantly raised urinary methylmalonic acid compared with age-matched controls (p=0·003), low haemoglobin in four children, and a low serum IgA in four children.

Interpretation We identified associated gastrointestinal disease and developmental regression in a group of previously normal children, which was generally associated in time with possible environmental triggers.

Lancet 1998; **351:** 637–41
See Commentary page 611

Inflammatory Bowel Disease Study Group, University Departments of Medicine and Histopathology (A J Wakefield FRCS, A Anthony MB, J Linnell PhD, A P Dhillon MRCPath, S E Davies MRCPath) **and the University Departments of Paediatric Gastroenterology** (S H Murch MB, D M Casson MRCP, M Malik MRCP, M A Thomson FRCP, J A Walker-Smith FRCP), **Child and Adolescent Psychiatry** (M Berelowitz FRCPsych), **Neurology** (P Harvey FRCP), **and Radiology** (A Valentine FRCR), **Royal Free Hospital and School of Medicine, London NW3 2QG, UK**

Correspondence to: Dr A J Wakefield

Introduction

We saw several children who, after a period of apparent normality, lost acquired skills, including communication. They all had gastrointestinal symptoms, including abdominal pain, diarrhoea, and bloating and, in some cases, food intolerance. We describe the clinical findings, and gastrointestinal features of these...

Patients and methods

12 children, consecutively referred to the department of paediatric gastroenterology with a history of a pervasive developmental disorder, acquired skills and intestinal symptoms (diarrhoea, abdominal pain, bloating and food intolerance), were investigated. Children were admitted to the ward for... and examined by their parents.

Clinical investigations

...including details of immunisations and ...us diseases, and assessed the children. In 11 ... history was obtained by the senior clinician (JW-S). ...ical and psychiatric assessments were done by ...tant staff (PH, MB) with HMS-4 criteria.[3] Developmental ...ries included a review of prospective developmental records from parents, health visitors, and general practitioners. Four children did not undergo psychiatric assessment in hospital; all had been assessed professionally elsewhere, so these assessments were used as the basis for their behavioural diagnosis.

After bowel preparation, ileocolonoscopy was performed by SHM or MAT under sedation with midazolam and pethidine. Paired frozen and formalin-fixed mucosal biopsy samples were taken from the terminal ileum; ascending, transverse, descending, and sigmoid colons, and from the rectum. The procedure was recorded by video or still images, and were compared with images of the previous seven consecutive paediatric colonoscopies (four normal colonoscopies and three on children with ulcerative colitis), in which the physician reported normal appearances in the terminal ileum. Barium follow-through radiography was possible in some cases.

Also under sedation, cerebral magnetic-resonance imaging (MRI), electroencephalography (EEG) including visual, brain stem auditory, and sensory evoked potentials (where compliance made these possible), and lumbar puncture were done.

Laboratory investigations

Thyroid function, serum long-chain fatty acids, and cerebrospinal-fluid lactate were measured to exclude known causes of childhood neurodegenerative disease. Urinary methylmalonic acid was measured in random urine samples from eight of the 12 children and 14 age-matched and sex-matched normal controls, by a modification of a technique described previously.[3] Chromatograms were scanned digitally on computer, to analyse the methylmalonic-acid zones from cases and controls. Urinary methylmalonic-acid concentrations in patients and controls were compared by a two-sample *t* test. Urinary creatinine was estimated by routine spectrophotometric assay.

Children were screened for antiendomyseal antibodies and boys were screened for fragile-X if this had not been done

Retracted

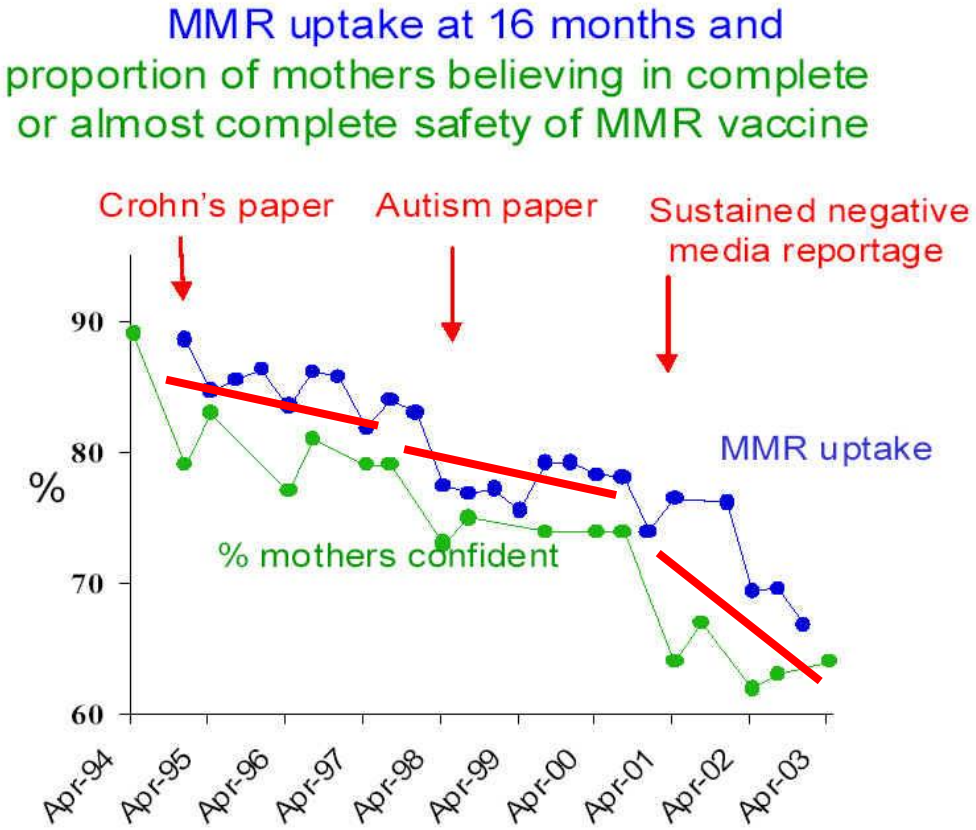
Summary

Onset of behavioural symptoms was associated, by the parents, with measles, mumps, and rubella vaccination in eight of the 12 children, with measles infection in one child, and otitis media in another. **All 12 children had intestinal abnormalities, ranging from lymphoid nodular hyperplasia to aphthoid ulceration**. Histology showed patchy chronic inflammation in the colon in 11 children and reactive ileal lymphoid hyperplasia in seven, but no granulomas. **Behavioural disorders included autism (nine), disintegrative psychosis (one), and possible postviral or vaccinal encephalitis (two)**.

Introduction

We saw several children who**, after a period of apparent normality, lost acquired skills, including communication**.

Even Then, Media (and the Internet) Played a Role



Side Note: RetractionWatch is great…

Top 10 most highly cited retracted papers

Ever curious which retracted papers have been most cited by other scientists? Below, we present the list of the 10 most highly cited retractions as of December 2020. Readers will see some familiar entries, such as the infamous *Lancet* paper by Andrew Wakefield that originally suggested a link between autism and childhood vaccines. You'll note that several papers — including the #2 most cited paper — received more citations after they were retracted, which research has shown is an ongoing problem.

Wakefield? #2

Article	Year of retraction	Citing Articles before retraction	Citing Articles after retraction	Total cites (journals indexed by Web of Science)
1. Primary Prevention of Cardiovascular Disease with a Mediterranean Diet. N ENGL J MED; APR 2013. *Estruch R, Ros E, Salas-Salvado J, Covas MI, Corella, D, Aros F, Gomez-Gracia E, Ruiz-Gutiérrez V, Fiol M, Lapetra J, Lamuela-Raventos RM, Serra-Majem L, Pinto X, Basora J, Munoz MA, Sorli JV, Martinez JA, Martinez-Gonzalez MA, et al., for the PREDIMED Study Investigators*	2018	1905	950	2855

Side Note: RetractionWatch is great…

Retraction Watch

Tracking retractions as a window into the scientific process

The Retraction Watch Leaderboard

Who has the most retractions? Here's our unofficial list (see notes on methodology), which we'll update as more information comes to light:

1. Yoshitaka Fujii (total retractions: 183) See also: Final report of investigating committee, our reporting, additional coverage
2. Joachim Boldt (163) See also: Editors-in-chief statement, our coverage
3. Hironobu Ueshima (121) See also: our coverage

A recent, high-profile example…

https://www.science.org/content/article/potential-fabrication-research-images-threatens-key-theory-alzheimers-disease

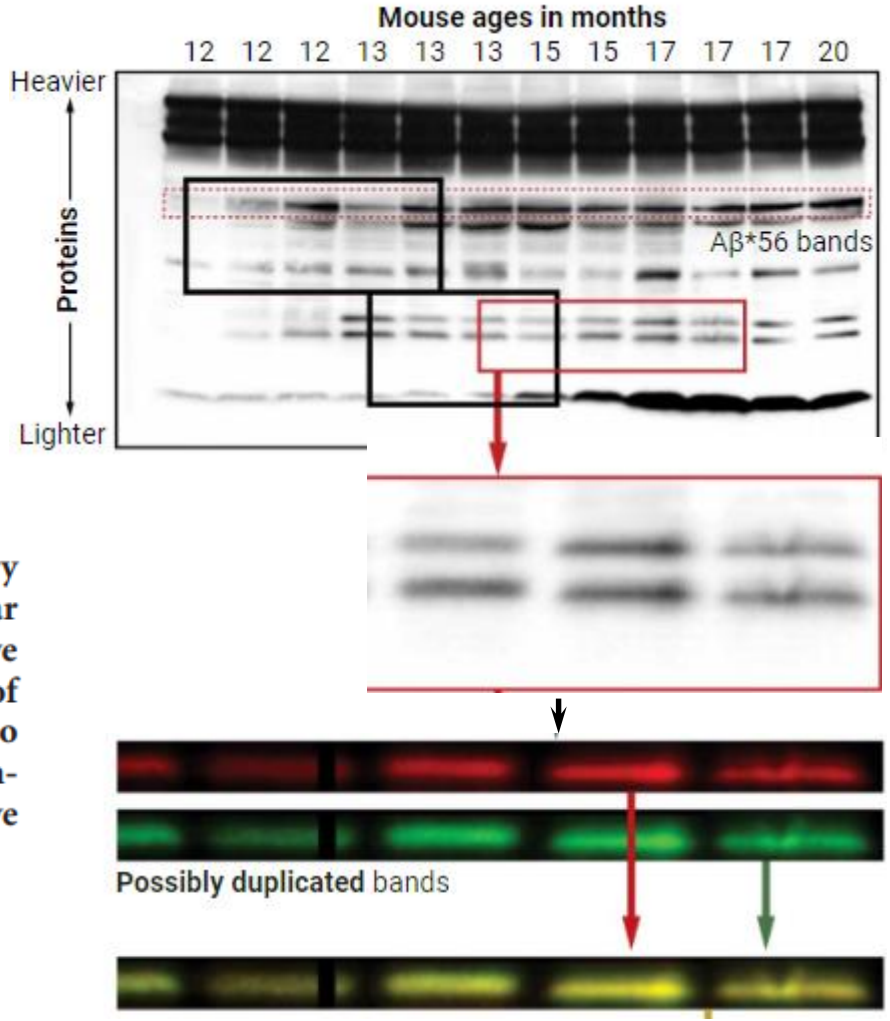
nature Vol 440|16 March 2006|doi:10.1038/nature04533

LETTERS

A specific amyloid-β protein assembly in the brain impairs memory

Sylvain Lesné[1], Ming Teng Koh[4], Linda Kotilinek[1], Rakez Kayed[6], Charles G. Glabe[6], Austin Yang[7], Michela Gallagher[4] & Karen H. Ashe[1,2,3,5]

We found that memory deficits in middle-aged *Tg2576* mice are caused by the extracellular accumulation of a 56-kDa soluble amyloid-β assembly, which we term Aβ*56 (Aβ star 56). Aβ*56 purified from the brains of impaired *Tg2576* mice disrupts memory when administered to young rats. We propose that Aβ*56 impairs memory independently of plaques or neuronal loss, and may contribute to cognitive deficits associated with Alzheimer's disease.



The Controversy

- NIH has invested > $10M in supporting research arguing that a *particular* version of Aβ peptide is responsible for Alzheimers. This led to the development of a drug that was seeking FDA approval.

- However, two prominent neuroscientists suspected that the data supporting this application were problematic, recruited a legal team and other experts to poke holes in this data and file a complaint with the FDA.

What Happened?

A 6-month investigation by *Science* provided strong support for Schrag's suspicions and raised questions about Lesné's research. A leading independent image analyst and several top Alzheimer's researchers—including George Perry of the University of Texas, San Antonio, and John Forsayeth of the University of California, San Francisco (UCSF)—reviewed most of Schrag's findings at *Science*'s request. They concurred with his overall conclusions, which cast doubt on hundreds of images, including more than 70 in Lesné's papers. Some look like "shockingly blatant" examples of image tampering, says Donna Wilcock, an Alzheimer's expert at the University of Kentucky.

Overall, 10 papers by Lesne are tagged on PubPeer for image manipulation.
(https://pubpeer.org/search?q=Sylvain+Lesne)

It’s More Complicated…

- The scientists originating the complaint with the FDA have shorted the stock of the company trying to market the drug. I.e., they stand to make a LOT of money if the drug fails.

- This is only *one version* of the Aβ peptide that is thought to cause Alzheimers’ Disease

The Resveratrol-Sirtuin Controversy

- “Supports antioxidant health”
- “Healthy aging support”
- “Support cardiovascular health”
- “Promotes healthy immune function”
- “May support healthy brain function”
- “Promotes healthy DNA”

The Resveratrol-Sirtuin Controversy

- Back in 2003, a Harvard study argued that resveratrol (an ingredient in grape skins) activated sirtuins.
  - This was suggested to slow aging, reduce heart disease and diabetes, etc.
  - The press eagerly reported it, red wine drinkers rejoiced.
- In 2005, two other groups published that the effect was an artifact and didn't happen *in vivo*
- In 2008, GlaxoSmithKline bought the intellectual property, developing resveratrol as an activator of sirtuins for almost $750M
- Since then, Pfizer and Amgen have also questioned the effects of resveratrol on sirtuins, some scientists argue that sirtuins aren't that involved in aging, etc.

What a Scientific Controversy Looks Like

- “Here we re-examined the reported effects of sirtuin overexpression on ageing and found that standardization of genetic background and the use of appropriate controls abolished the apparent effects in both *C. elegans* and *Drosophila*.

  These findings underscore the importance of controlling for genetic background and for the mutagenic effects of transgene insertions in studies of genetic effects on lifespan.”

Do Sirtuins Affect Lifespan?

- Probably. But not by as much as people originally thought

  Maybe 5-10%, instead of 50%

- Media is less likely to report these kinds of studies, which is why you don't hear as much about them.
- There are HUNDREDS of things that extend lifespan in controlled conditions, but most of them never make the news.
- Not even because the media is bad

  4% increase in lifespan is a boring news story.

What About Scientists?
Are WE Part of the Problem?

- Well…

Bad Ideas from Scientists

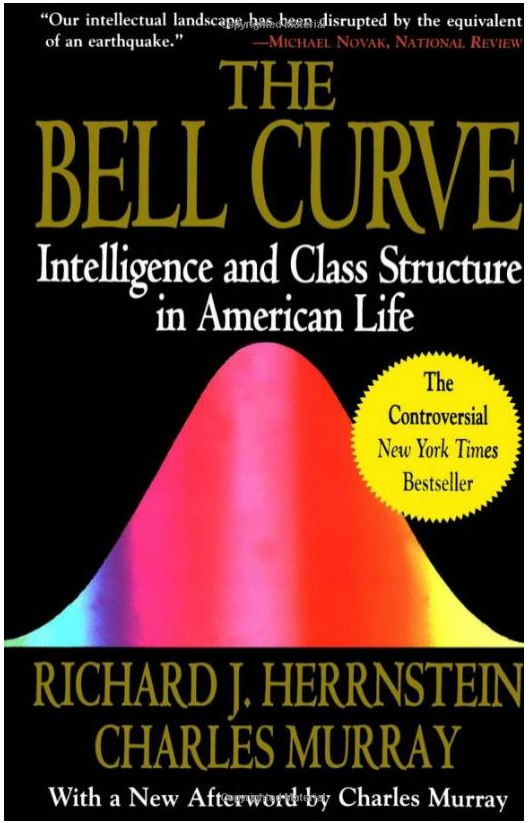
- Eugenics
- *The Bell Curve*
  - Purports that race predicts intelligence
  - "Skin color predicts IQ"

    Joe Somebody

    vs
  - "Skin color predicts IQ"

    James Watson (famous geneticist,

    co-discoverer of the structure of DNA)
- Hahneman and homeopathy
- *etc.*



What About Scientists? Are WE Part of the Problem?

- Well…*generally* no.

BUT,

- Science is hard
  - It must be done carefully to avoid mistakes
  - It must be repeated, in different labs and with different methods
- A scientific opinion =/= scientific consensus

What About Scientists? Are WE Part of the Problem?

- Well…*generally* no.

BUT,

- Science is dynamic
  - Mistakes must be acknowledged as part of science
  - The public needs to understand the limited importance of a single study

5G Technology and induction of coronavirus in skin cells

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EDITORIAL

5G Technology and induction of coronavirus in skin cells

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adverse systemic effects as well (11). In another study, it was argued that 5G technologies cause great harm to human health. Cancer is only one of the many problems. 5G causes 720 (factorial) different diseases in human beings, and can kill everything that lives except some forms of microorganisms

FIY, 10! = 3.63*10^6

40! = 8.32*10^81

720! = my Excel crashed…

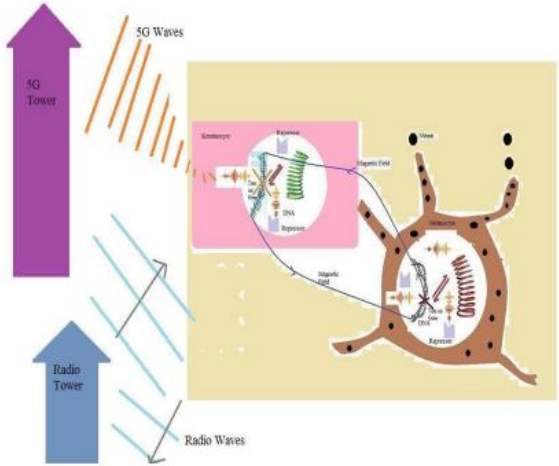

Fig. 2. Waves in 5G technology pass the cell membranes and contribute to gene expressions

On the other hand, skin cells could take waves of towers and transfer to other cells and neurons. Thus, dermatologic cells could act as an antenna (Fig. 1).

An antenna could take waves in which their wavelengths are equal to its size. Thus, millimeter waves in 5G technology could be taken more by dermatologic antennas. These waves could pass the cell membranes, enter the nucleus and interact with DNAs. Previously,

70% of Studies Cannot Be Replicated

- Obviously this is not ideal.
- But, there are a lot of explanations
  - Some data *are* fake
  - Studies don't always have sufficient material/details to replicate
    - But people try!
  - There are unaccounted for differences in experimental materials
  - The *p*-value problem
    - $p < 0.05$ means 5% are guaranteed to be wrong
  - Scientific experiments are getting a lot more complicated

Law of Information Dynamics

- 2nd Law of Thermodynamics: Disorder in a system will tend toward increase without the input of energy from outside.
  - Note: Adding energy *can* push either system toward its natural state more quickly.

- A system will tend toward disinformation unless energy directs it toward scientific consensus.

Prevalence of questionable research practices, research misconduct and their potential explanatory factors: A survey among academic researchers in The Netherlands

Gopalakrishna et al., . PLoS ONE 17(2): e0263023

QRP – questionable research practices **Scores: 1 to 7; 1 = never; 7 = always**

		Disciplinary field		
QRP	**Description (In the last three years.)**	**Life and medical sciences**	**Social and behavioural sciences**	**Natural and engineering sciences**
Any frequent QRP	Score 5, 6 or 7 on at least 1 of the 11 QRPs	55.3 (53.4, 57.1)	50.2 (48.0, 52.5)	49.4 (46.8, 52.0)
Any FF	Fabrication and/or Falsification	10.4 (7.1, 13.7)	5.7 (1.8, 9.5)	7.6 (3.1, 12.1)

Group Discussion #1

- You’re running a research lab. Your star student comes to you and tells you that their latest mouse study has found a way to double mouse lifespan. Later, another student privately approaches you to tell you that they have suspicions about the lifespan data. What do you do?

Group Discussion #2

- You're at your wits end. A competitor requested the mouse strain from your latest blockbuster paper that demonstrated a cure for a specific type of cancer. Naturally, you provided them the strain. Six months later, they publish the opposite results and put out a news release saying that your data are flawed. Worse, you had a licensing agreement with a pharmaceutical company to begin preparing the long journey to bringing your treatment to the clinic. What do you do about your competitor's results?