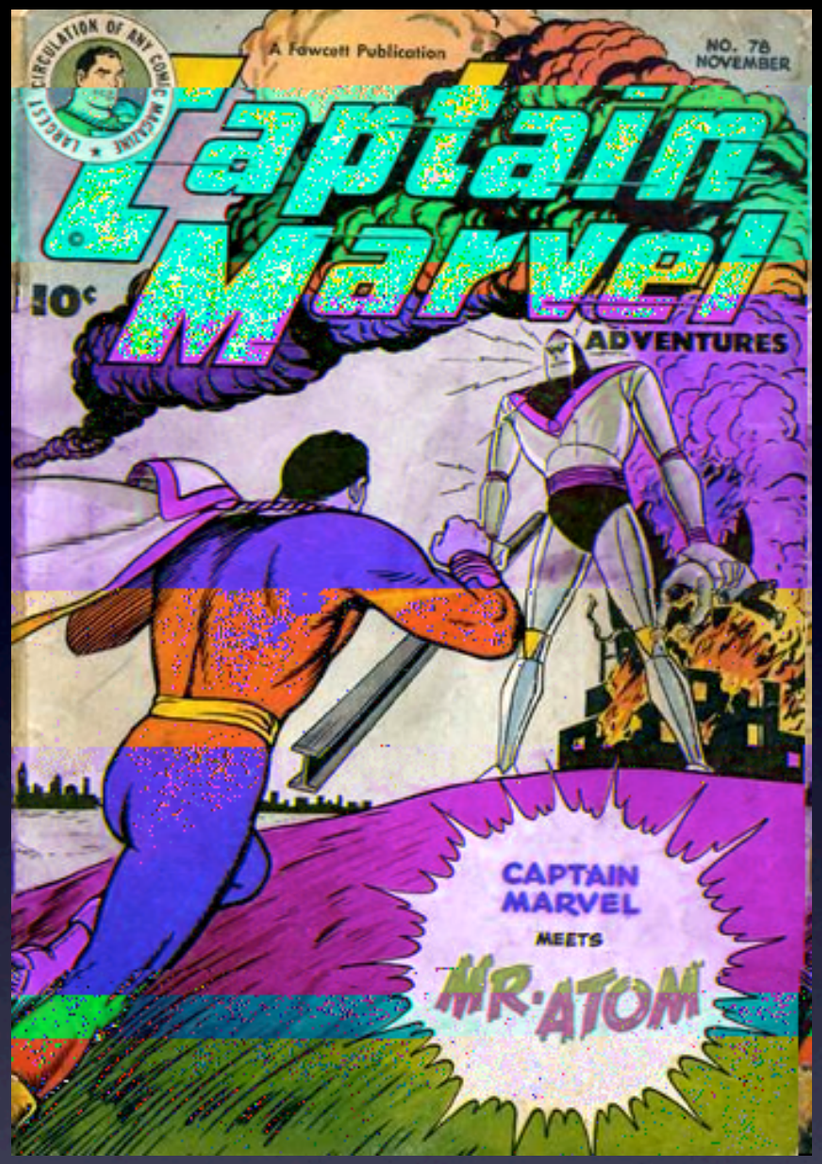


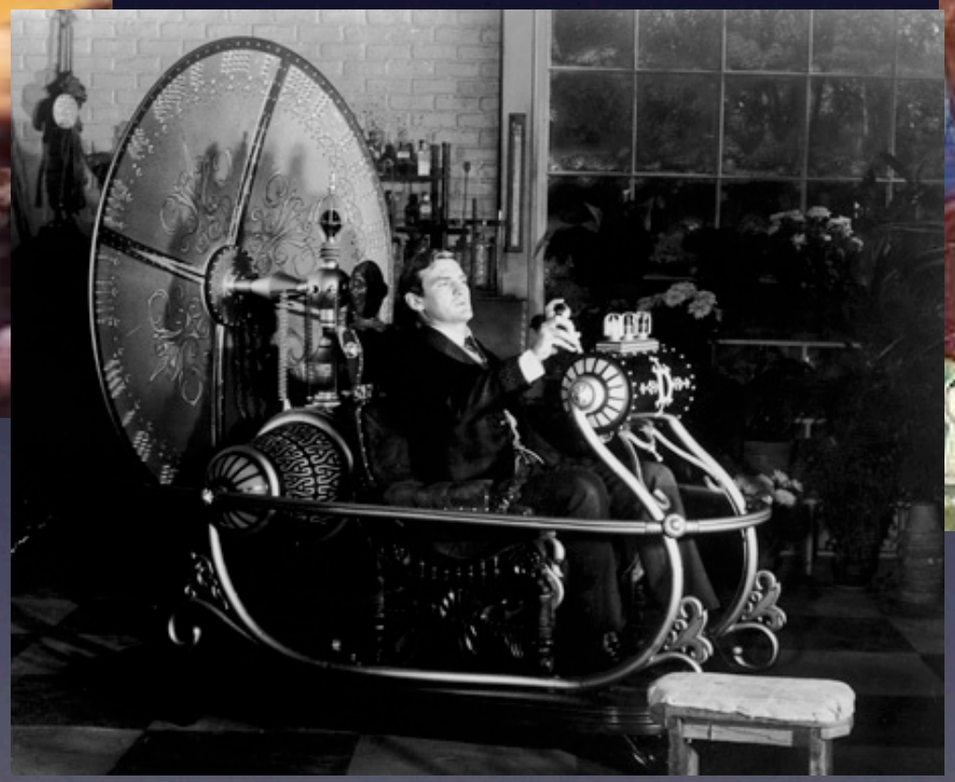
Captain Marvel and the Wonderful World of DNA

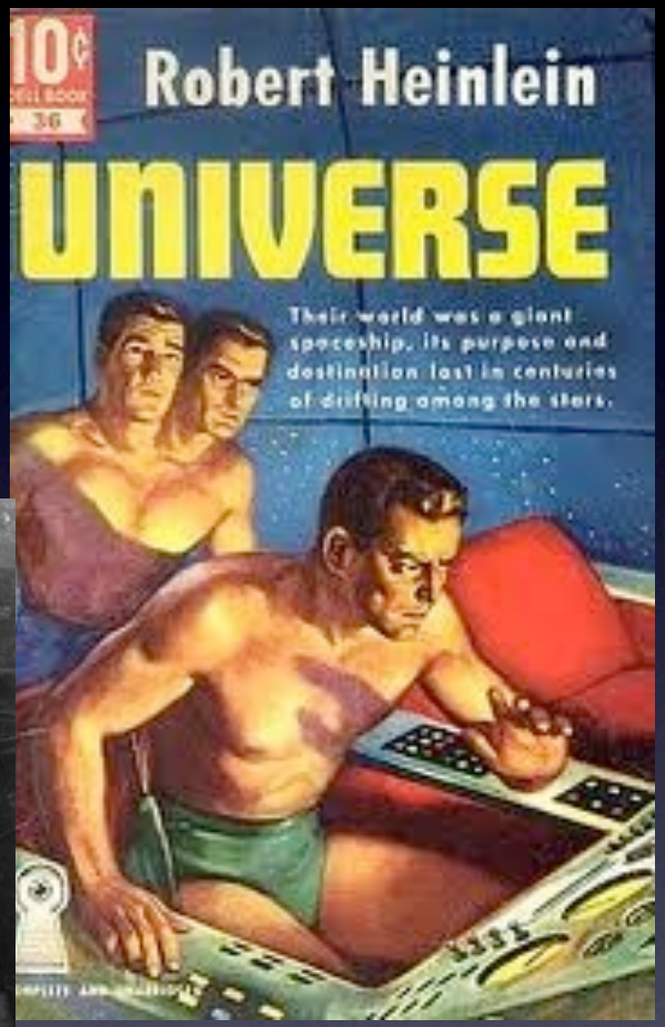
NIH
April 4, 2013

David Rejeski
Science and Technology Innovation Program
Woodrow Wilson International Center for Scholars
Washington, DC

Synthetic BIOLOGY PROJECT

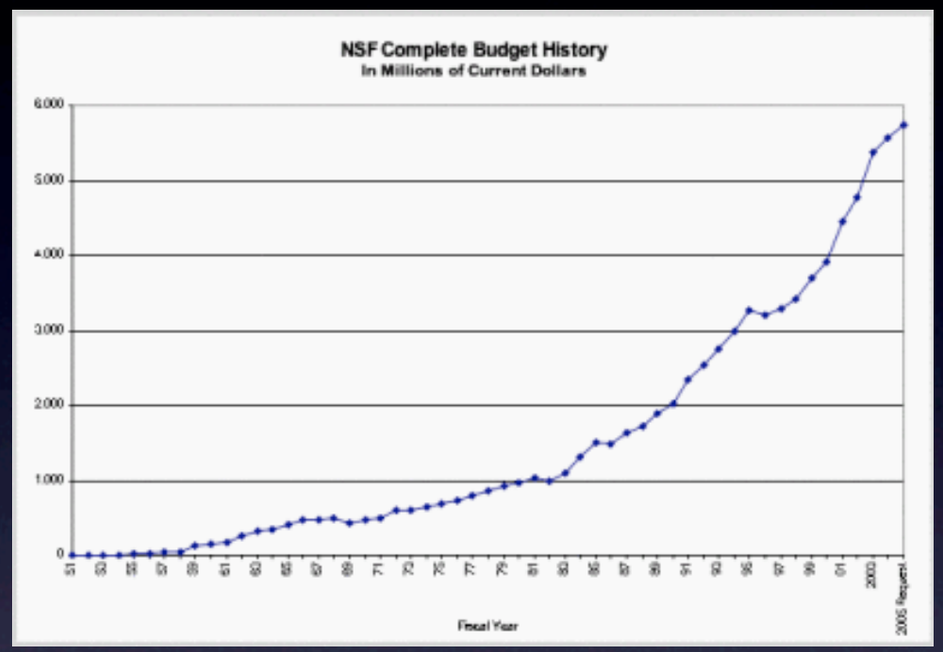
Science and Fiction Past

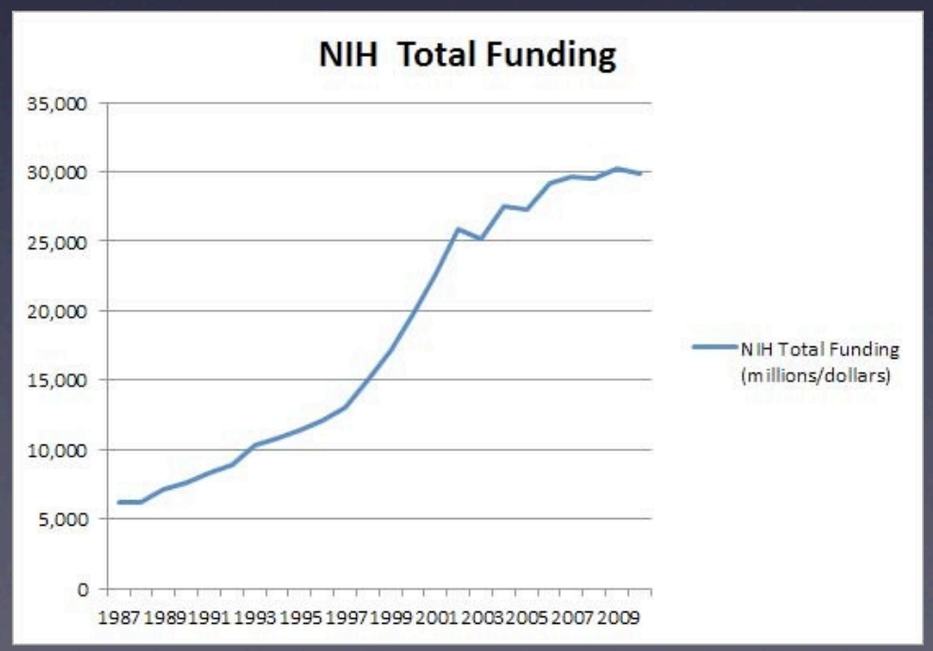




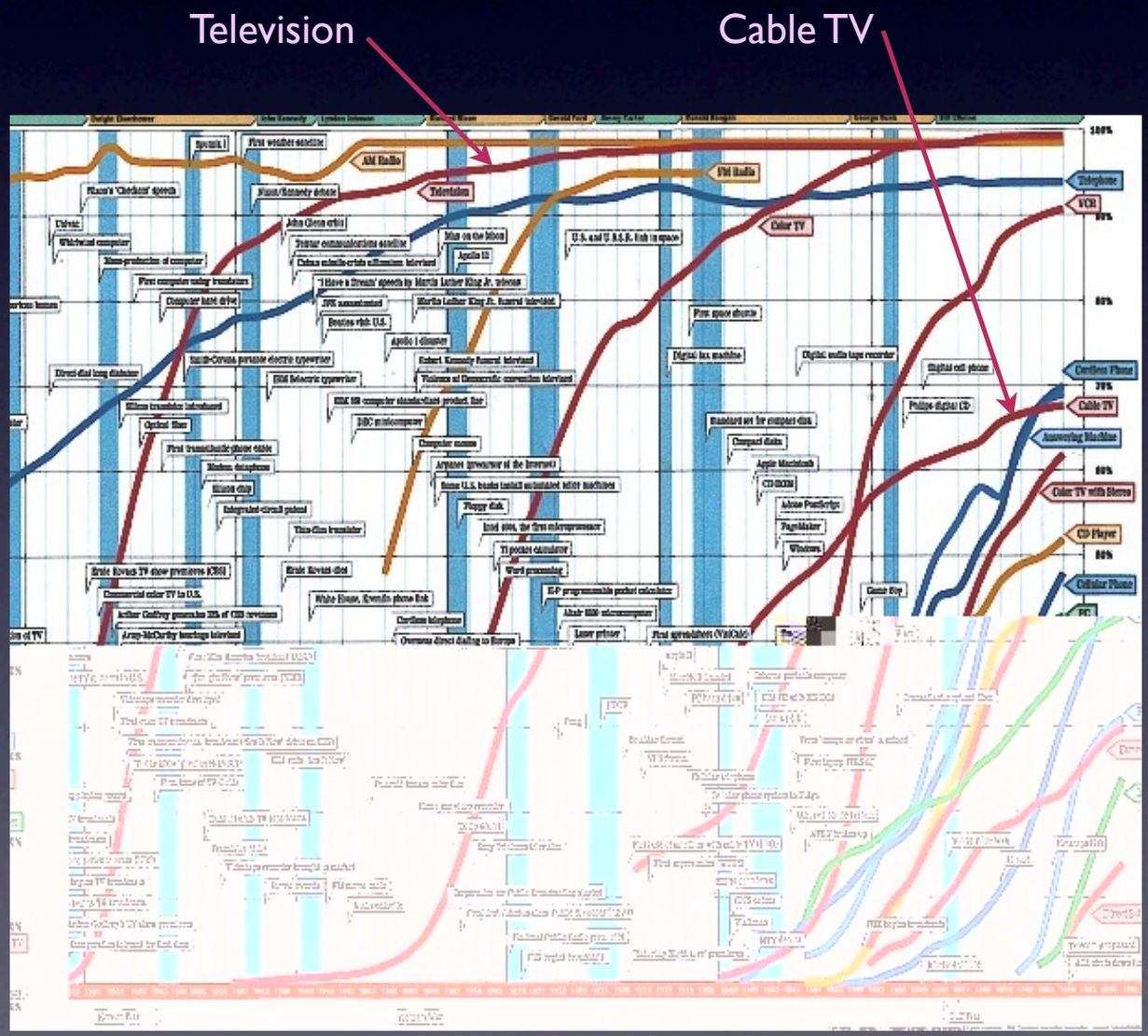
Post WWII: Big Science and Big Media Collide

NSF and NIH Budgets





Media and Technology Penetration



Science and Comics

1940

1962

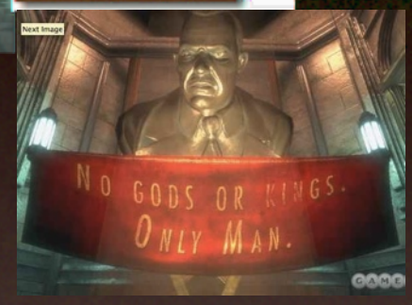
1963

1987

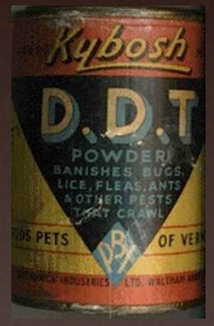
Cultural Narratives Shape Public Perceptions

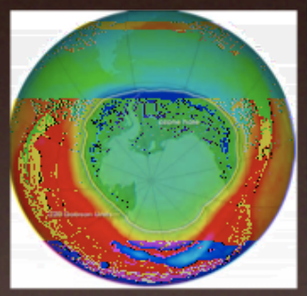
A sphere of public interest around technology tends to emerge in response to threat more than promise.

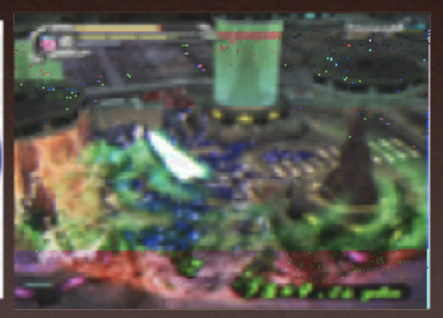
1. Dr. Strangelove: The corruption or manipulation of science for evil purposes.



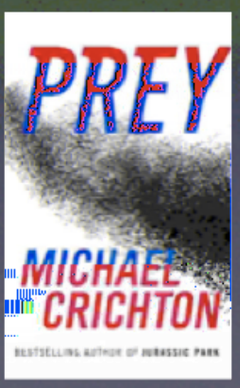
2. Trojan Horse: We accept innovations into our lives and learn later that we made a mistake.

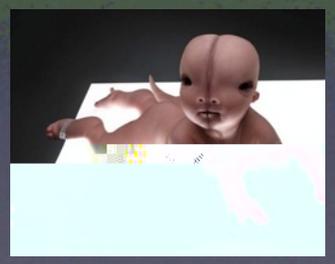




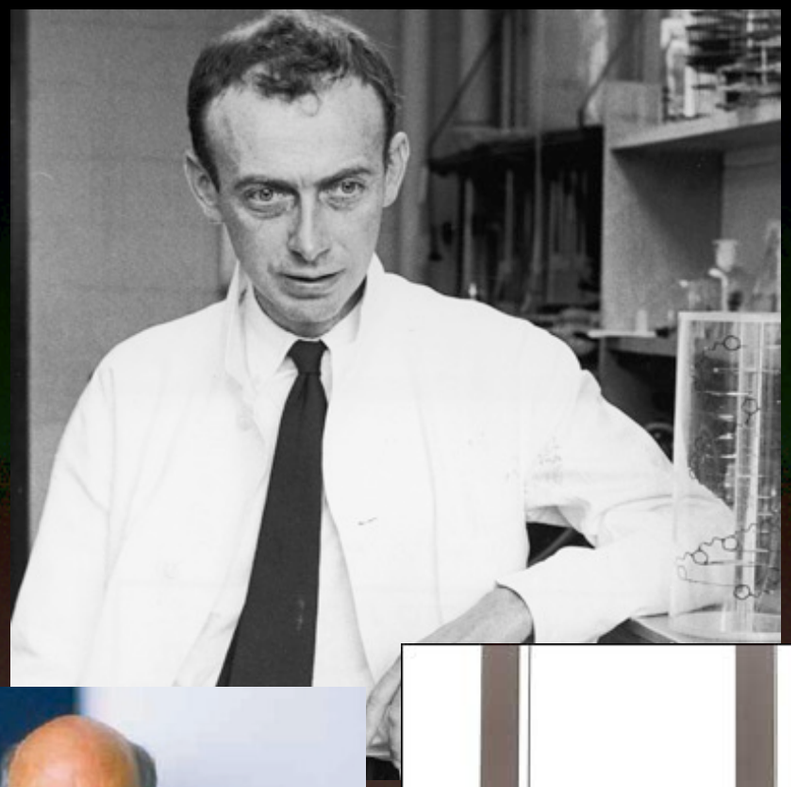


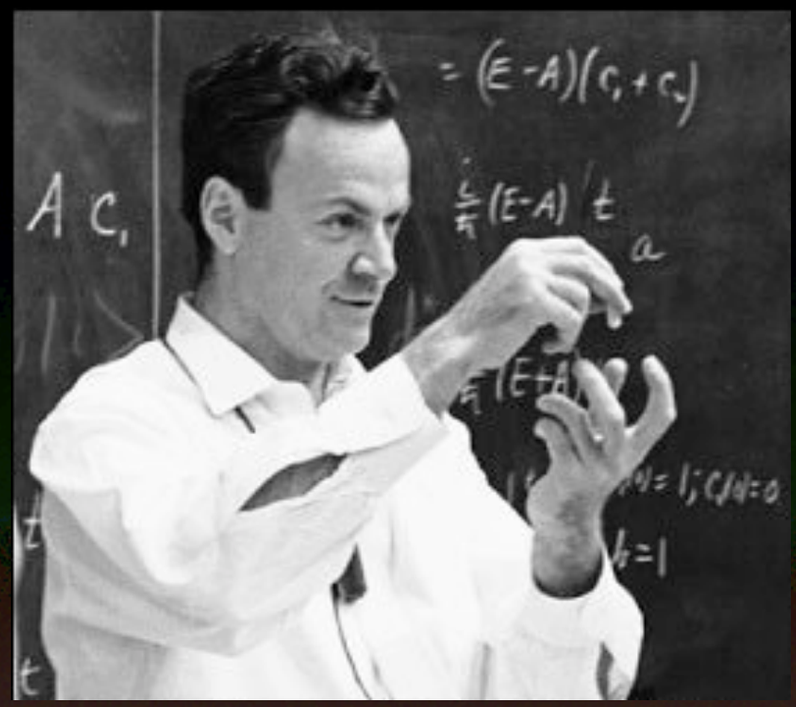
3. Oops!: The accidental release of harmful substances or organisms, often due to technological and/or human error.

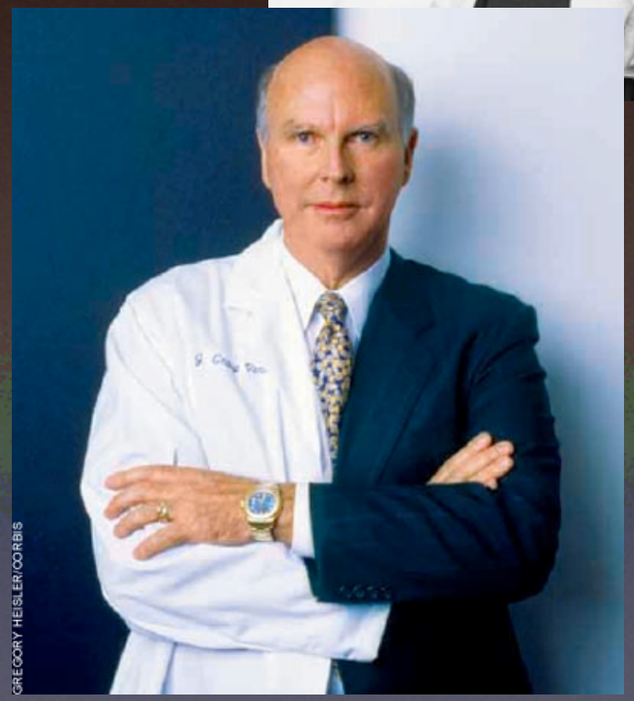


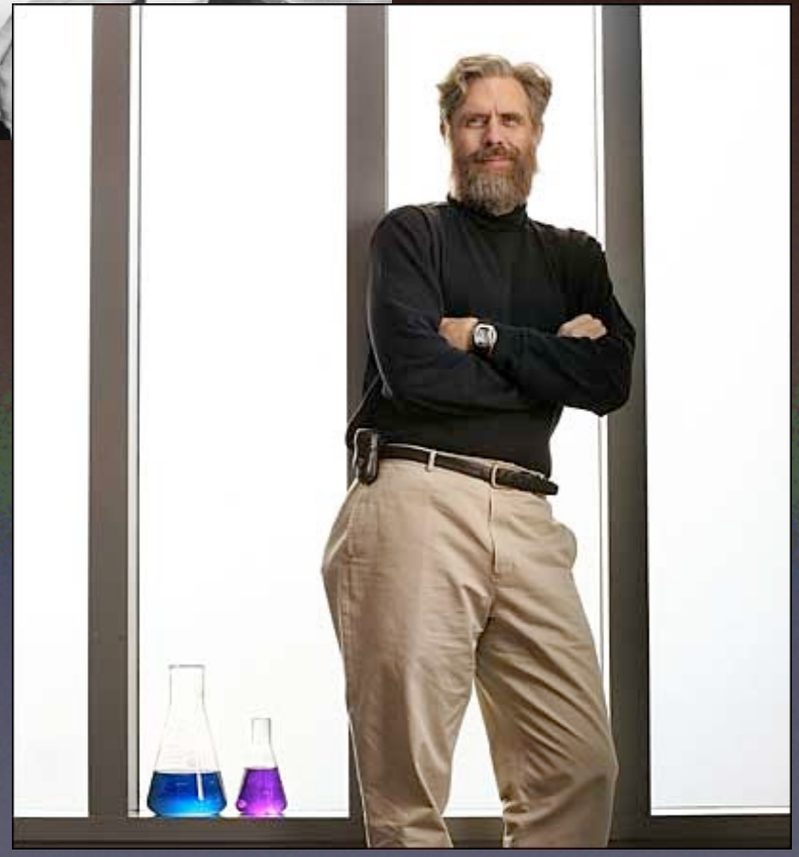


Rise of the Entrepreneurial Scientists

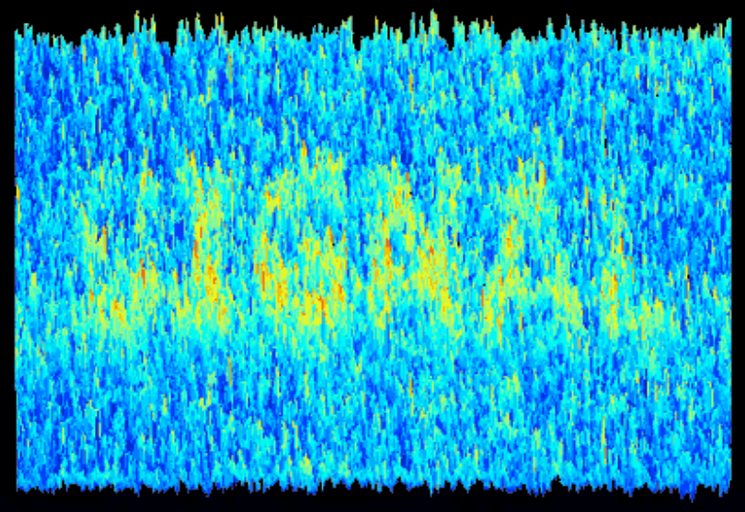








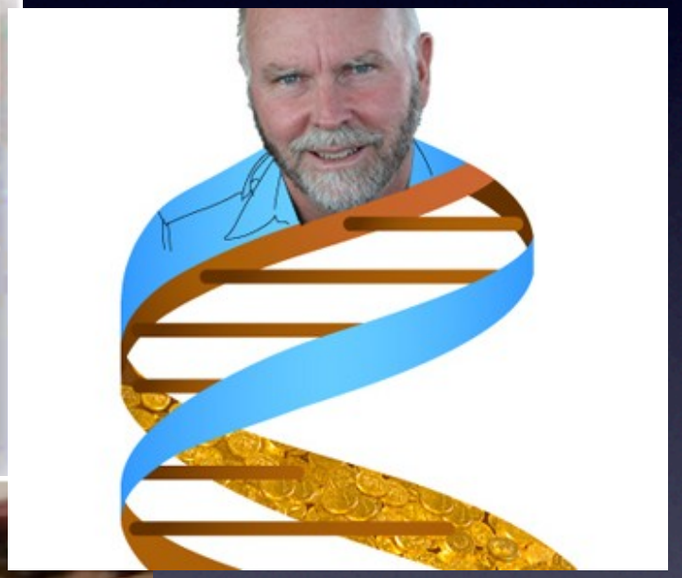
Science on the Colbert Report



The public often understands complex scientific issues "less through direct experience or past education than through the filter of journalistic language and imagery."

Nelkin, D. 1987. *Selling Science: How the Press Covers Science and Technology*, NY: Freeman.

Images



From: US, UK, Germany, France

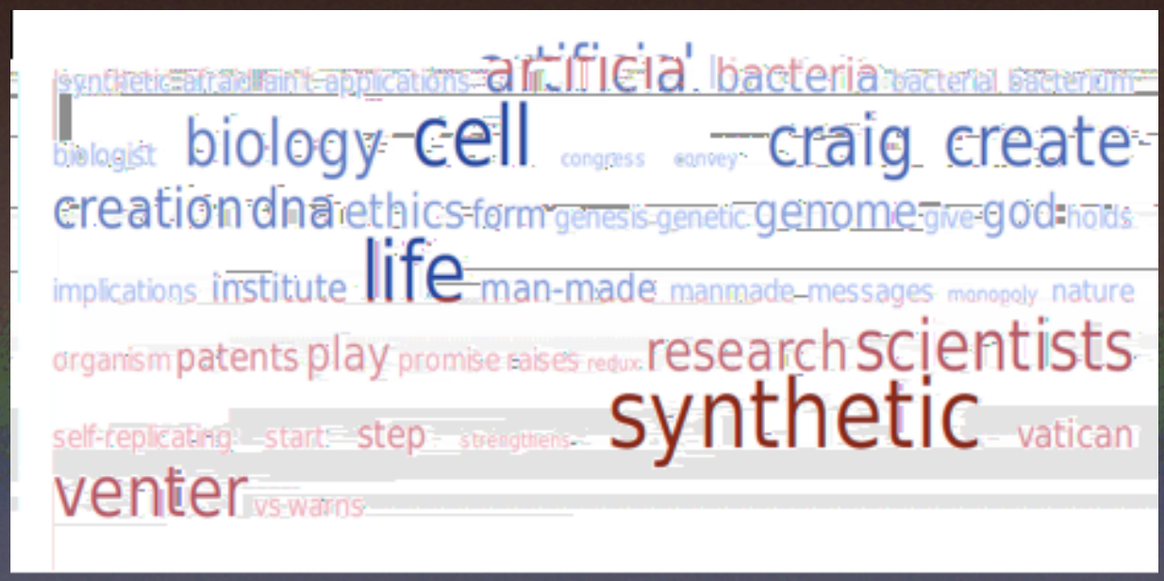
Just Read the Headlines!!!

Cartoon Adapted from Far Side

Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome

Daniel G. Gibson,[1] John I. Glass,[1] Carole Lartigue,[1] Vladimir N. Noskov,[1] Ray-Yuan Chuang,[1] Mikkel A. Algire,[1] Gwynedd A. Benders,[2] Michael G. Montague,[1] Li Ma,[1] Monzia M. Moodie,[1] Chuck Merryman,[1] Sanjay Vashee,[1] Radha Krishnakumar,[1] Nacyra Assad-Garcia,[1] Cynthia Andrews-Pfannkoch,[1] Evgeniya A. Denisova,[1] Lei Young,[1] Zhi-Qing Qi,[1] Thomas H. Segall-Shapiro,[1] Christopher H. Calvey,[1] Prashanth P. Parmar,[1] Clyde A. Hutchison, III,[2] Hamilton O. Smith,[2] J. Craig Venter[1,2,*]

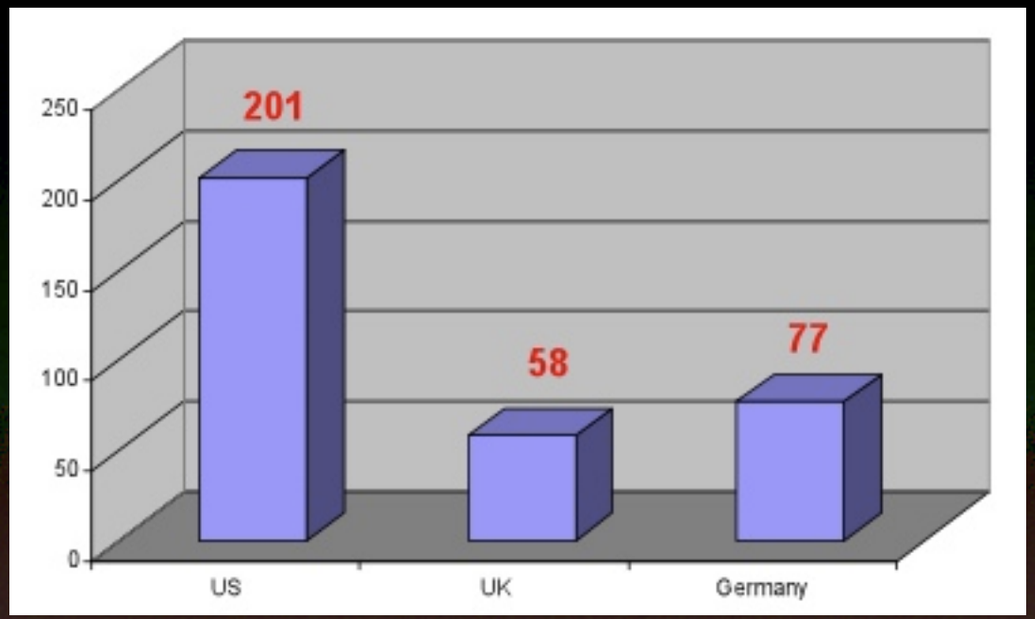
Published Online May 20, 2010
Science DOI: 10.1126/science.1190719



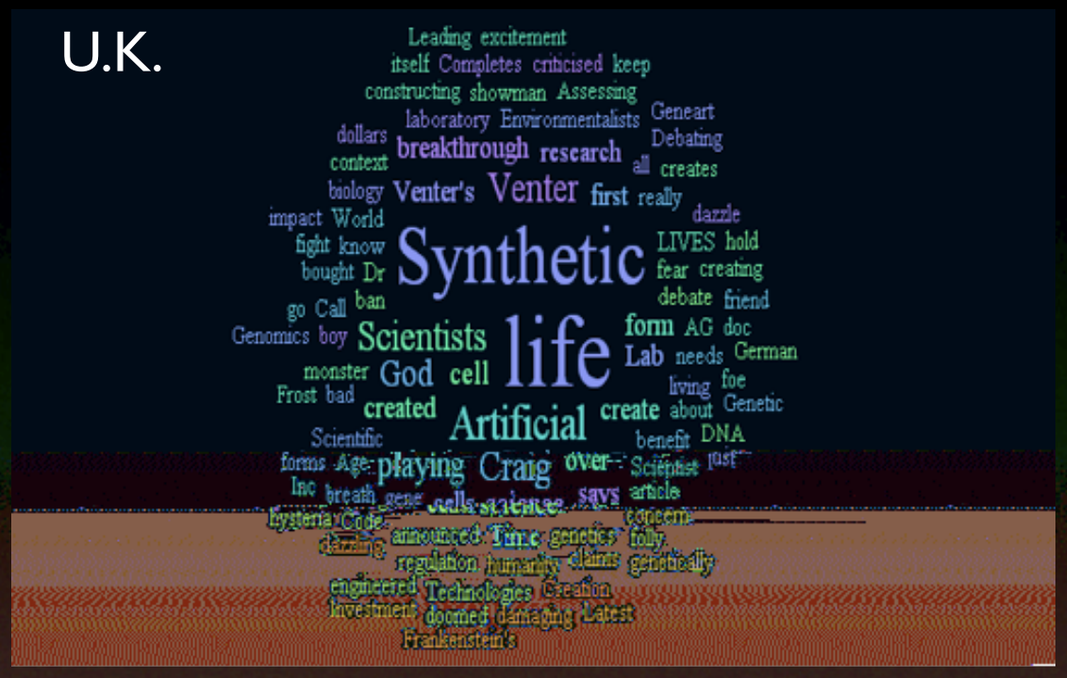
U.S. Press Headlines
May 20-25, 2010
Type size indicates relative frequency of word use

Media Headlines

Number of Press Articles Covering Venter Research (May 20 - June 13, 2010)



U.K.



U.S.

Germany

Wanted: 'Adventurous woman' to give birth to Neanderthal man - Harvard professor seeks mother for cloned cave baby

- **Professor George Church of Harvard Medical School believes he can reconstruct Neanderthal DNA**
- **His ambitious plan requires a human volunteer willing to allow the DNA to be put into stem cells, then a human embryo**

By ALLAN HALL and FIONA MACRAE

PUBLISHED: 10:36 EST, 20 January 2013 | **UPDATED:** 04:16 EST, 21 January 2013

Amateurs Are New Fear in Creating Mutant Virus

Background on Our Work

30+ hours of U.S.-based focus groups
on nanotechnology and synthetic biology

Annual national surveys (with Hart Research)

- 4 on nanotechnology
- 1 on nanotech and synthetic biology
- 2 on synthetic biology

Research on perceptions of emerging technologies
(done with the Cultural Cognition Project at Yale)

Research on media coverage and framing of synthetic biology, in the U.S. and Europe

Funded by the Sloan Foundation and Pew Charitable Trusts

Trends in AMERICAN + EUROPEAN Press Coverage of Synthetic Biology

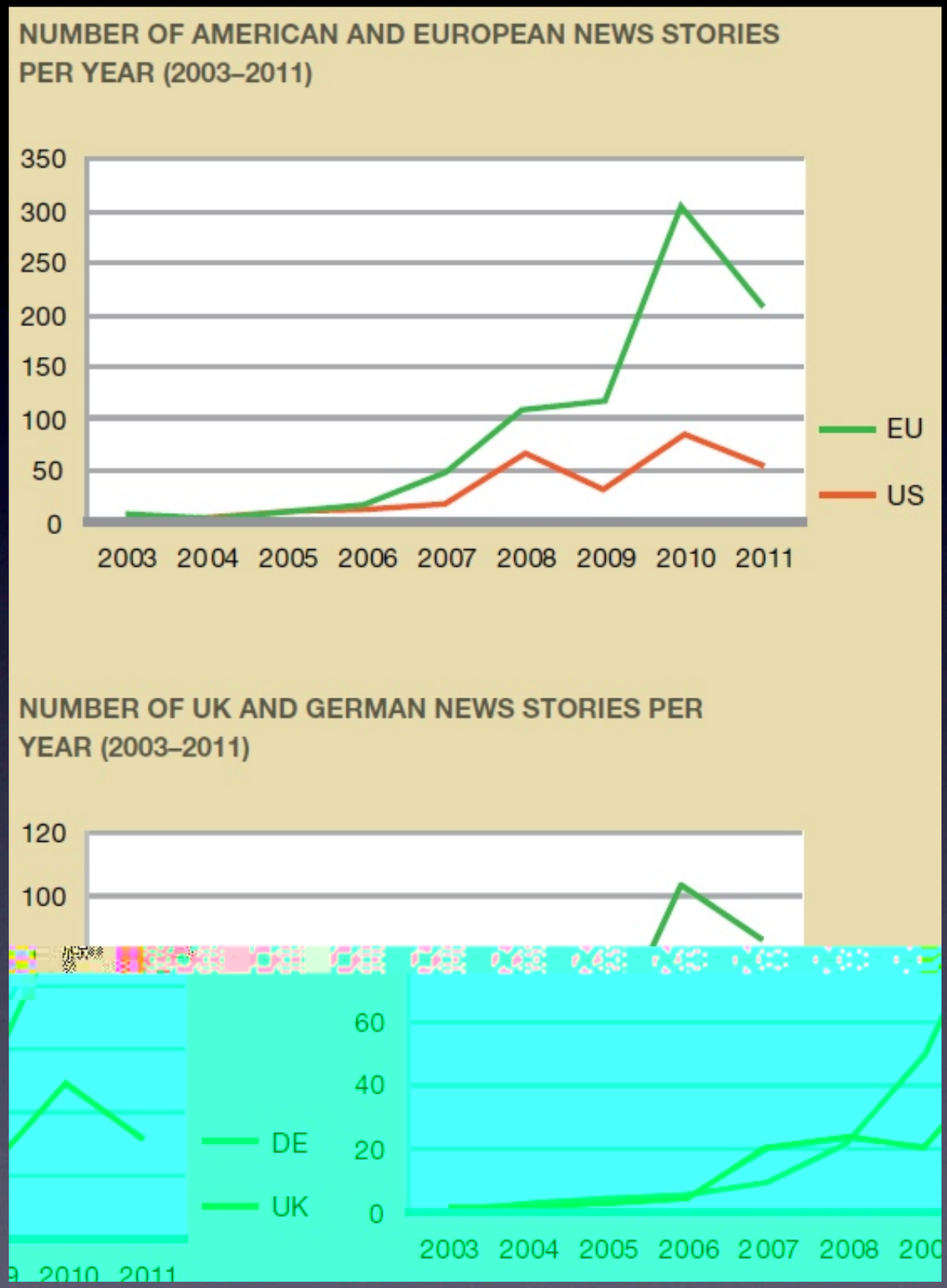
TRACKING THE YEARS 2008–2011

http://www.synbioproject.org/process/assets/files/6636/synbio_press_final.pdf?

Increased Coverage

- Press coverage of synthetic biology has tripled in the United States in 2008-2011 over 2003-2008

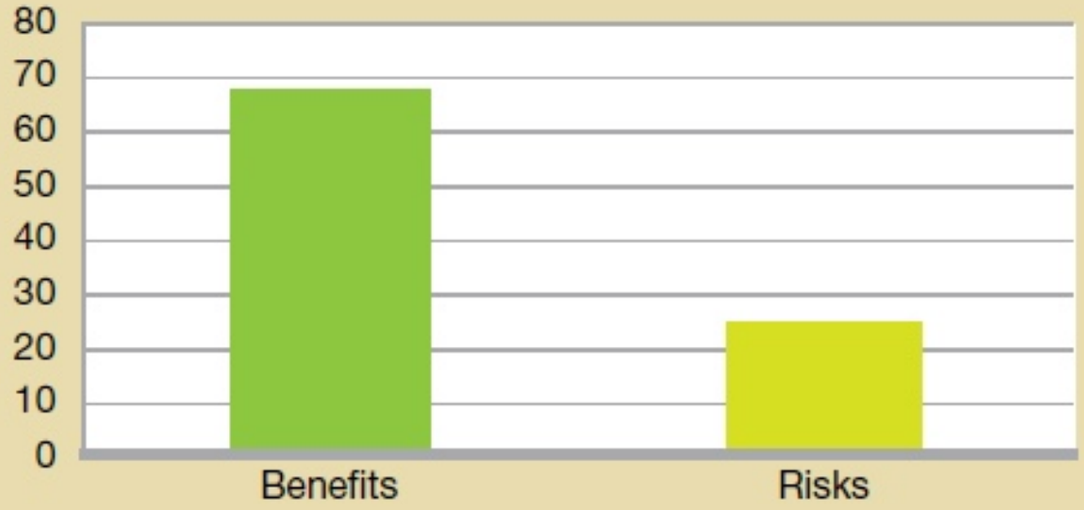
- Coverage has increased steadily in Europe



Risk versus Benefits

PERCENTAGE OF AMERICAN NEWS STORIES MENTIONING POTENTIAL RISKS, POTENTIAL BENEFITS, OR BOTH (JAN. 2008–DEC. 2011)

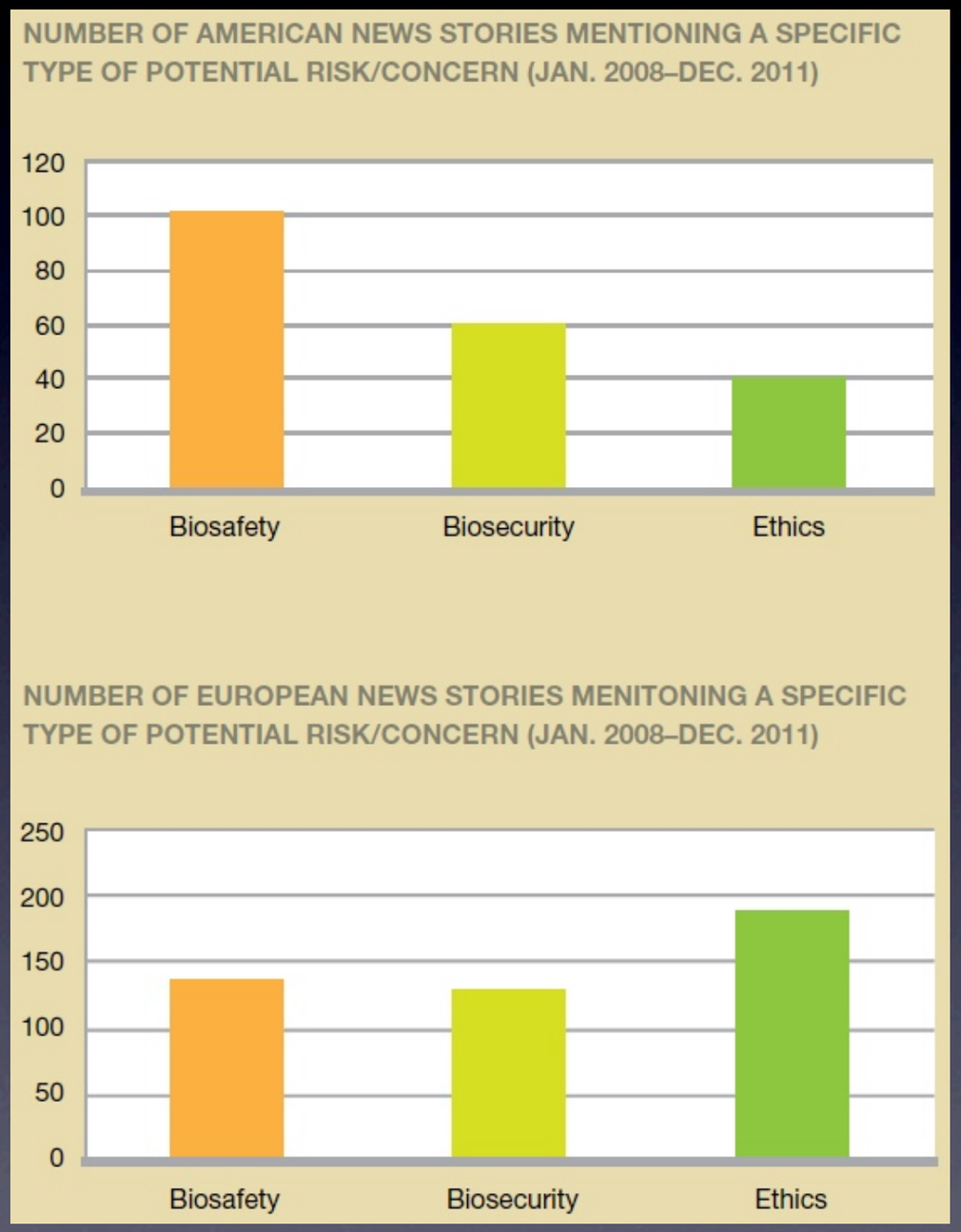
NUMBER OF AMERICAN NEWS STORIES MENTIONING POTENTIAL RISKS OR BENEFITS (JAN. 2008–DEC. 2011)



PERCENTAGE OF NEWS STORIES IN EUROPEAN PRESS THAT MENTION POTENTIAL RISKS, POTENTIAL BENEFITS, OR BOTH (JAN. 2008–DEC. 2011)

NUMBER OF EUROPEAN NEWS STORIES MENTIONING POTENTIAL RISKS OR BENEFITS (JAN. 2008–DEC. 2011)

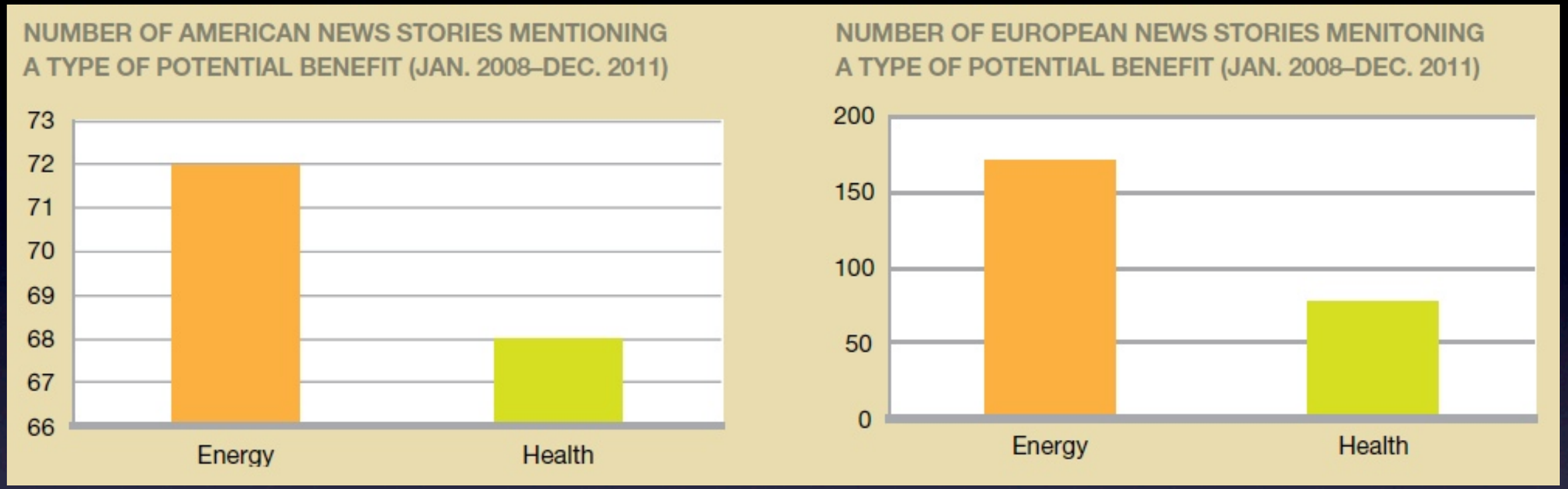
How Risk is Covered



In the United States, focus on biosafety, followed by biosecurity and ethics

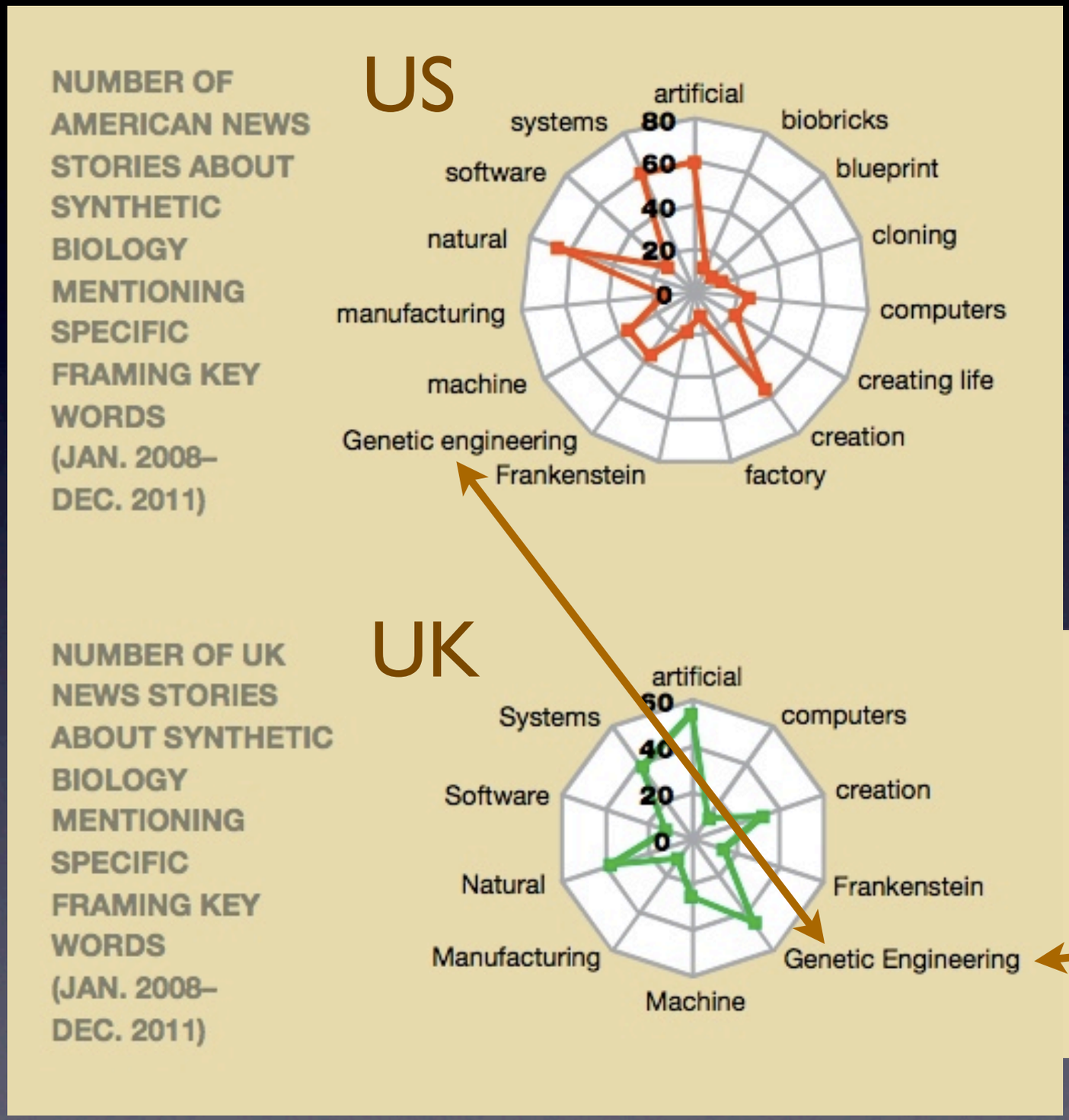
- In Europe, ethics is covered most extensively, followed by biosafety and biosecurity
- In our 2008 report, biosecurity was the most-covered risk in the United States and biosafety was the most-covered risk in Europe
- Ethics coverage fueled by international reports and meetings?

How Benefits are Covered



- Press coverage in both the United States and Europe focused on the benefits from synthetic biology in the energy sector
- This could stem from an interest in biofuels
- Coverage also focused on potential health benefits

Common Framing Terms



Data analysis using QDA Miner

Some Headlines

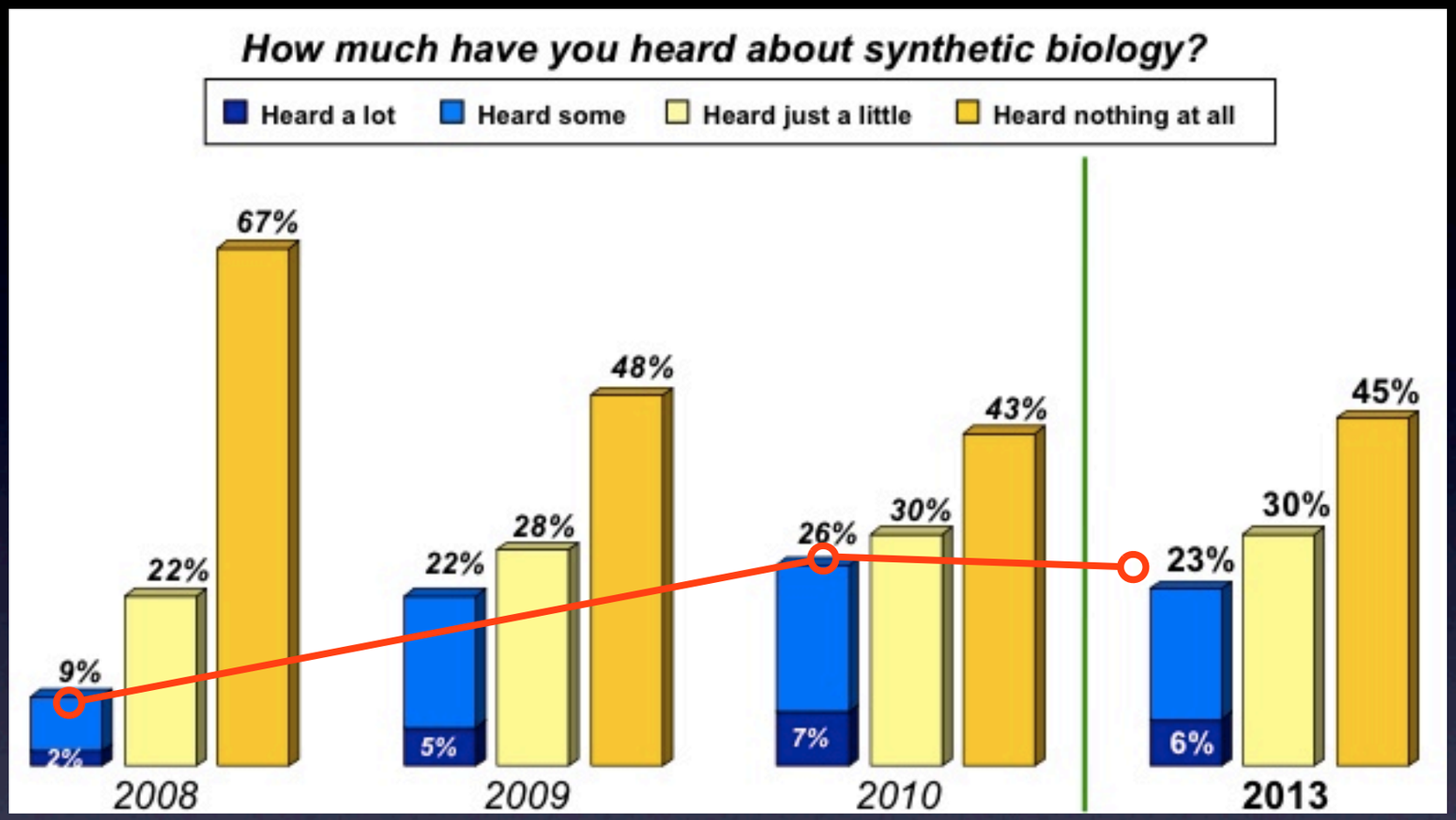
"Le Retour de Frankenstein" – "Frankenstein is back" La Croix, June 29, 2010

Is this man playing God by trying to create artificial life? The Herald (Glasgow), May 22, 2010

Is Craig Venter going to save the planet? Or, is this more hype from one of America's most controversial scientists? The Washington Post, Aug. 11, 2011

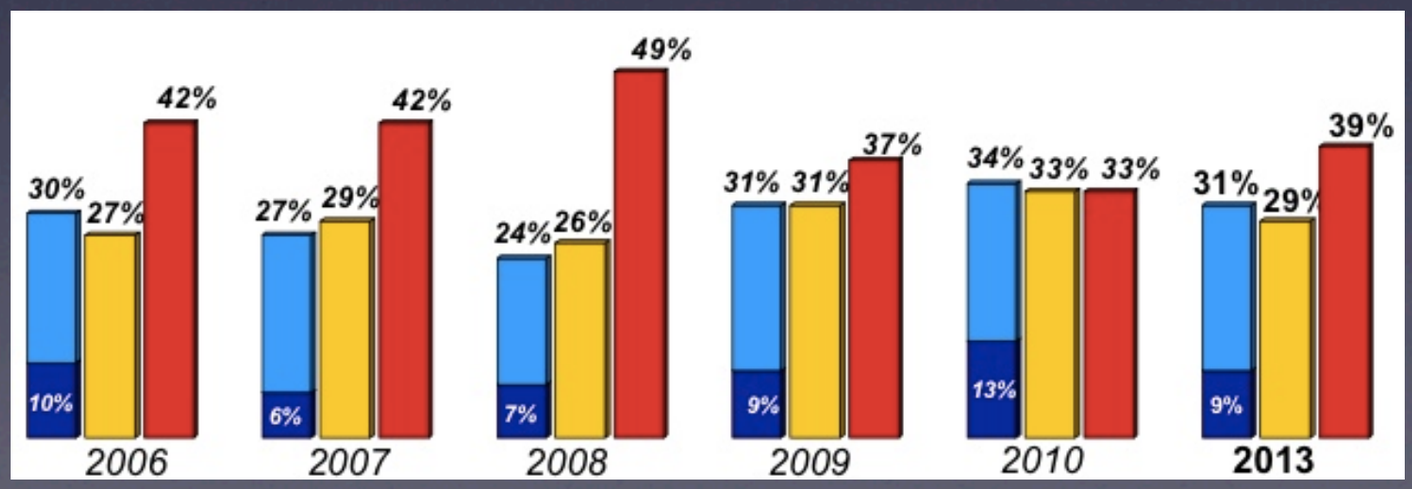
"'Eine fremde Intelligenz'; Der Genetiker George Church träumt von geklonten Mammuts und der Wiederauferstehung des Neandertalers" – "'A foreign intelligence'; The geneticist George Church dreams of cloned mammoths and the resurrection of the Neanderthals" Die ZEIT, March 25, 2010

Has the Public Heard of Synthetic Biology (US)?

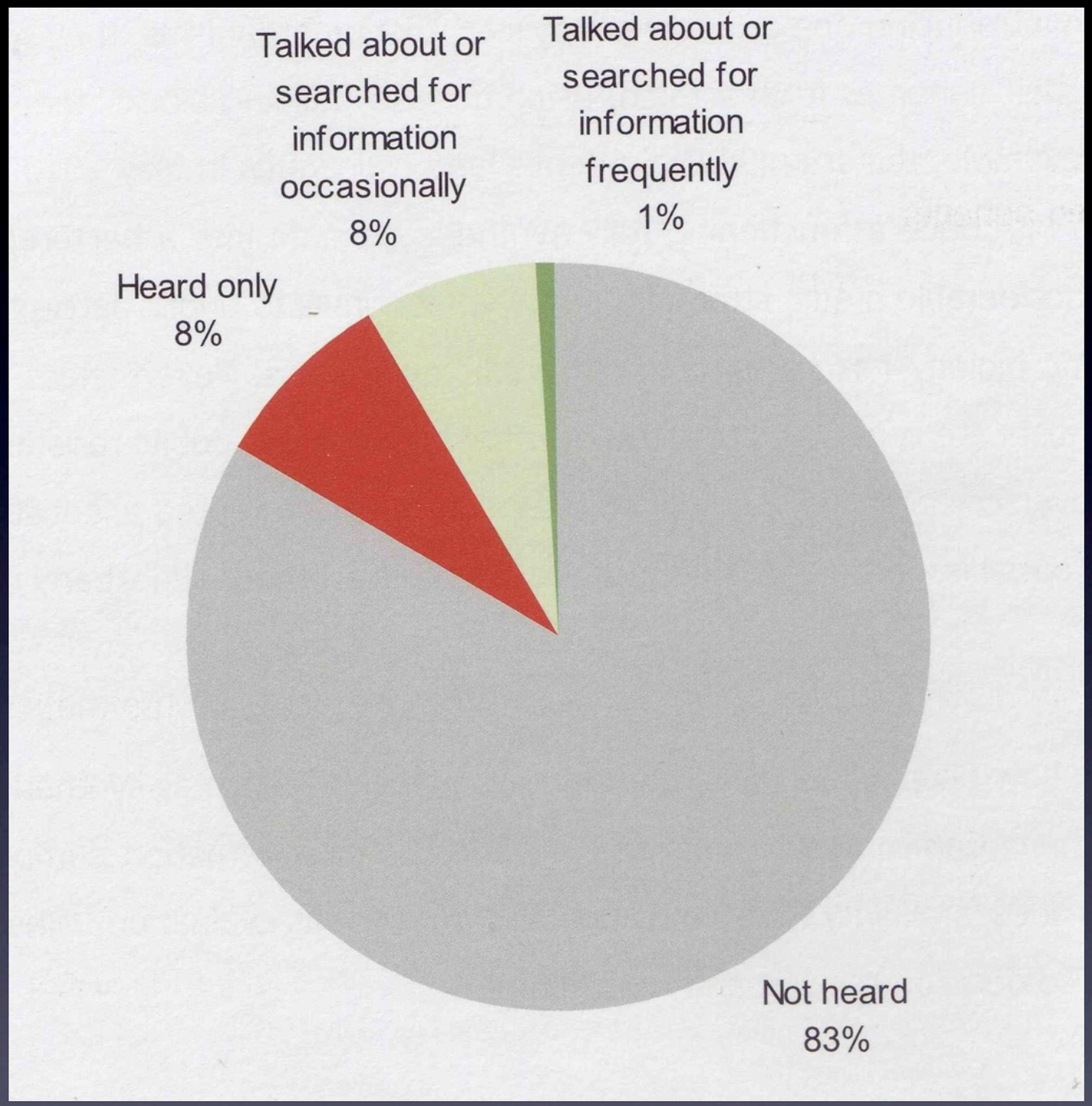


Who knows the most:
White
Male (18-49)
College educated
Income > $70K

Nanotech Awareness

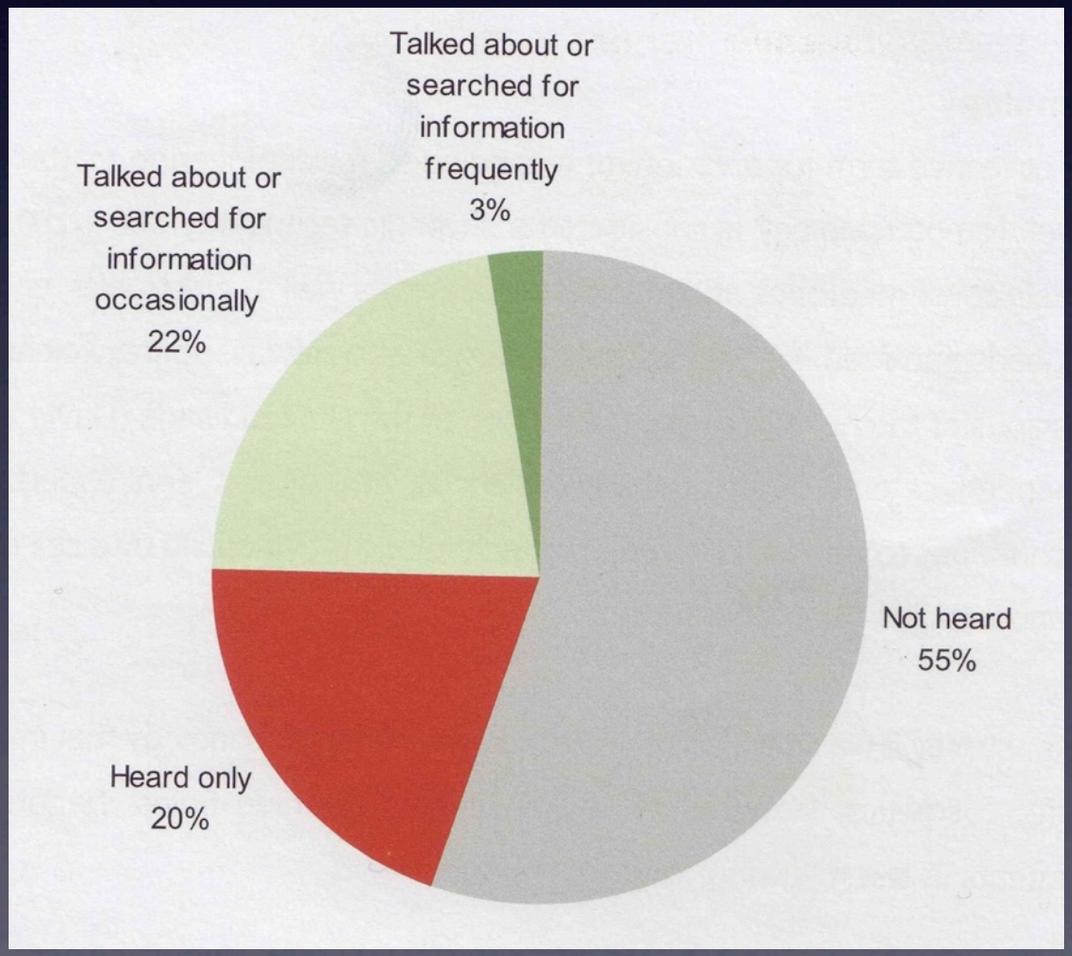


Has the Public Heard of Synthetic Biology (EU)?



Nanotechnology

Synthetic Biology



Source: Europeans and Biotechnology in 2010: Winds of Change?

What Is Synthetic Biology?

"Having the word 'synthetic' next to the word 'biology' does provoke a reaction in people that can be negative." Professor Paul Freemont UK Centre for Synthetic Biology

What do you think synthetic biology is?
(Volunteered Comments)

Unnatural, man-made, something that isn't real, artificial	32%
Reproducing/recreating life, cloning, genetic/ DNA manipulation	15%
Prosthetics, artificial limbs/organs/tissues	10%
Synthetic oils/composites/materials	9%
Development of medicines/treatments for diseases	6%
Agricultural applications, weather-resistant plants/crops	6%
Based in science/scientific experimentation/ research	5%
Don't know; no response	24%

Synthetic Biology → Artificial life → Cloning, Stem Cells, GMOs

Initial Reactions

I am excited but freaked out.

It is weird, but creative.

It Depends

I am neutral, but for me it is case specific.

In the medical field, it is appropriate. But for a cosmetic reason or for food, then I don't agree with it.

I am positive, look at this in terms of knee replacement.

If synthetic biology could make food grow in places it doesn't grow, I am all for it.

It changed my mind when I understood a little bit more about where we are going with it.

The only ultimate thing I have a problem with is the computer-generated parent.

Concerns

What stops that plastic-eating organism from not mutating?

I am worried about self replication.

They say they can put in these stop buttons...but I'd like to see more guarantees (more research) because, ...you can't control nature.

I would be concerned about who was running this, and how far they go to re-engineer a certain species.

How do you regulate that?

I think the ramifications are not going to be short term.

I am adamantly against any sort of genetic modification. I think it is a very fine line to play God.

Synthetic Biology: The 3 Voting Blocks

I Hate It

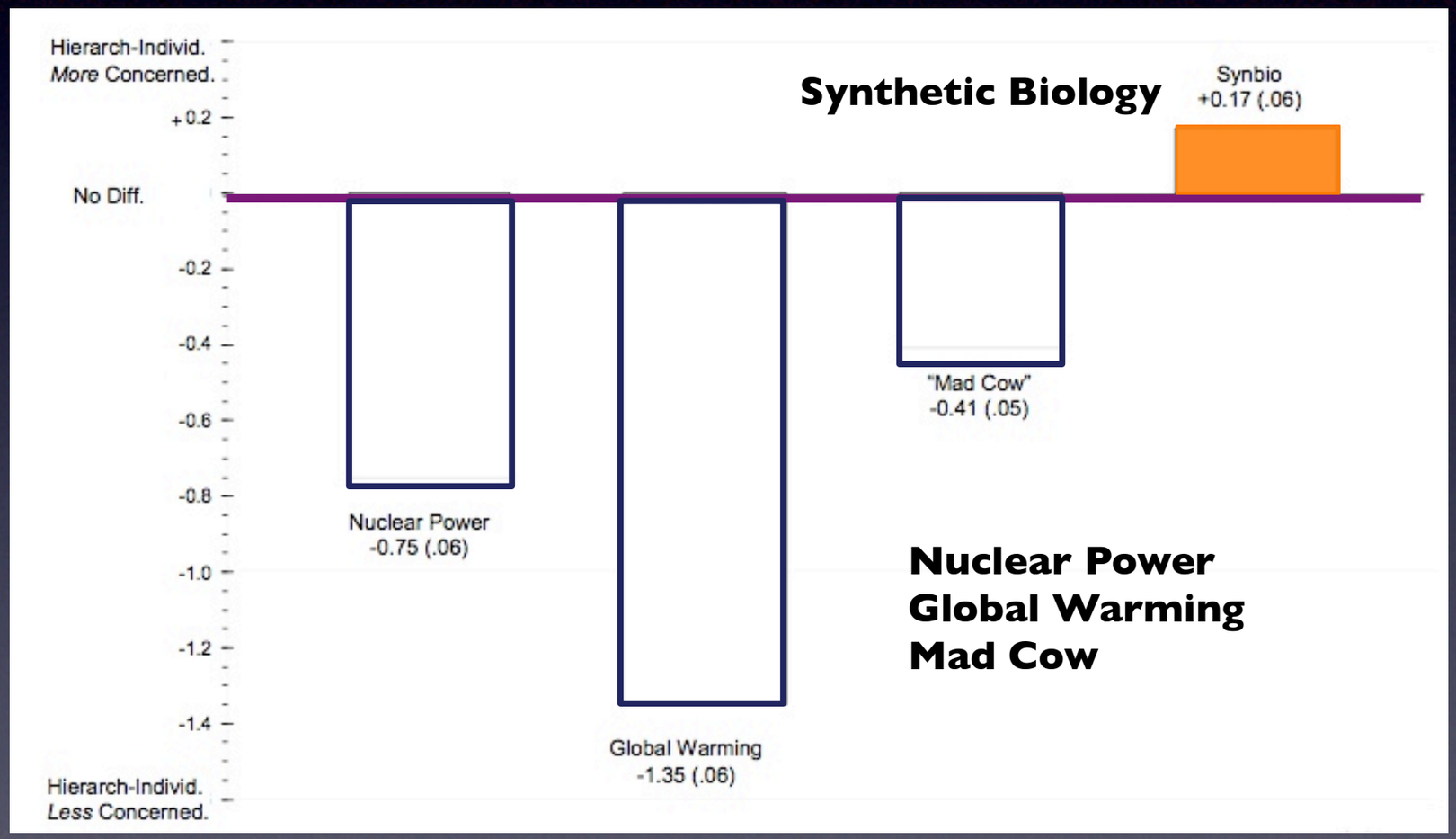
Convince Me

I Love It

New Opponents?

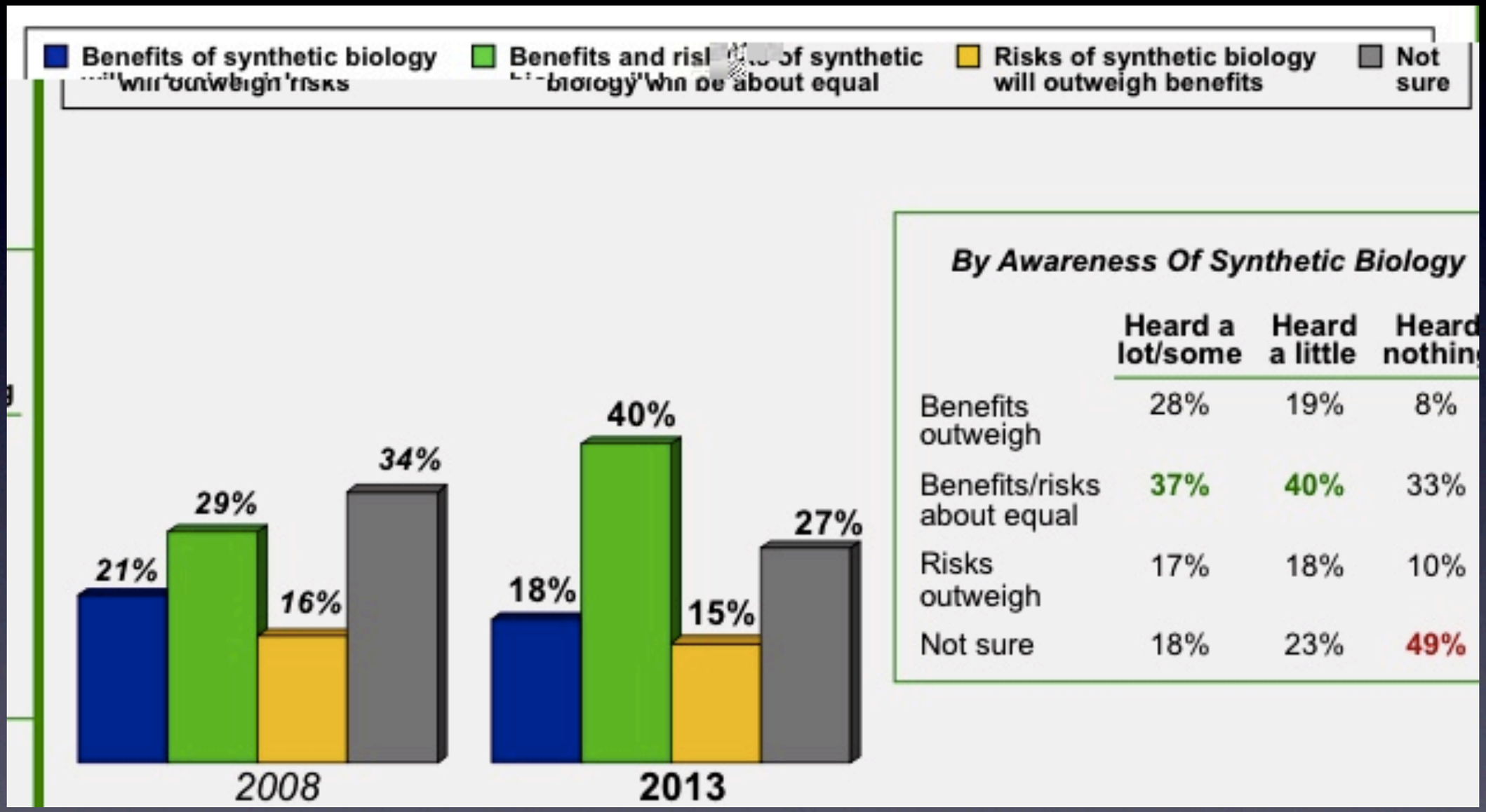
Inversion of the Leiserowitz effect (found by Kahan et al)[1]

Anthony Leiserowitz labeled as "environmental risk naysayers" a segment of U.S. society whose members are disproportionately white and male, politically conservative, and highly religious.[2]



1. Kahan, D. et al "Risk and Culture: Is Synthetic Biology Different?" Cultural Cognition Working Paper #29.
2. Leiserowitz, A.A. American risk perceptions: Is climate change dangerous? *Risk Anal.* ***25, 1433-1442 (2005)***

Risk versus Benefits: Pre-Information



	Heard a lot/some	Heard a little	Heard nothing
Benefits outweigh	28%	19%	8%
Benefits/risks about equal	37%	40%	33%
Risks outweigh	17%	18%	10%
Not sure	18%	23%	49%

Report at: http://www.synbioproject.org/news/project/synthetic_biology_remains_mystery/

Background

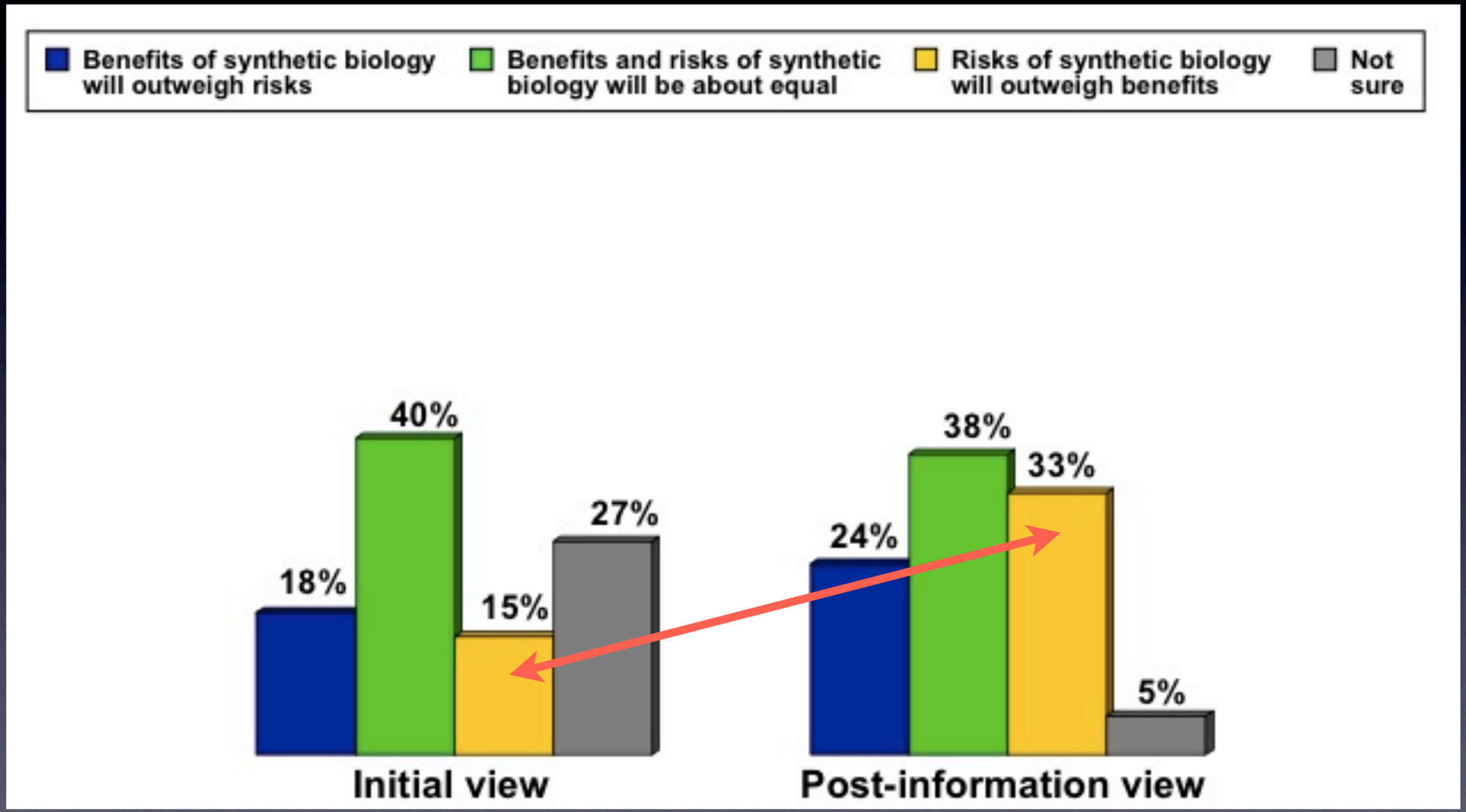
Description Of Synthetic Biology Given To Respondents

Synthetic biology is the use of advanced science and engineering to make or re-design living organisms, such as bacteria, so that they can carry out specific functions. Synthetic biology involves making new genetic code, also known as DNA, that does not already exist in nature.

The potential BENEFITS of synthetic biology include developing new micro-organisms to treat disease, including cancer, more effectively and to create new and less expensive medications. It also could be used to make new organisms that could provide cheaper and cleaner sources of energy than today's oil-based fuels, and to detect and break down environmental pollutants in the soil, air, and water.

While the potential RISKS of synthetic biology are not known, there are concerns that man-made organisms might behave in unexpected and possibly harmful ways and that they could cause harm to the environment. There also are concerns that, if these organisms fall into the wrong hands, they could be used as weapons. Additionally, the ability to create artificial life has raised moral and ethical questions about how life is defined.

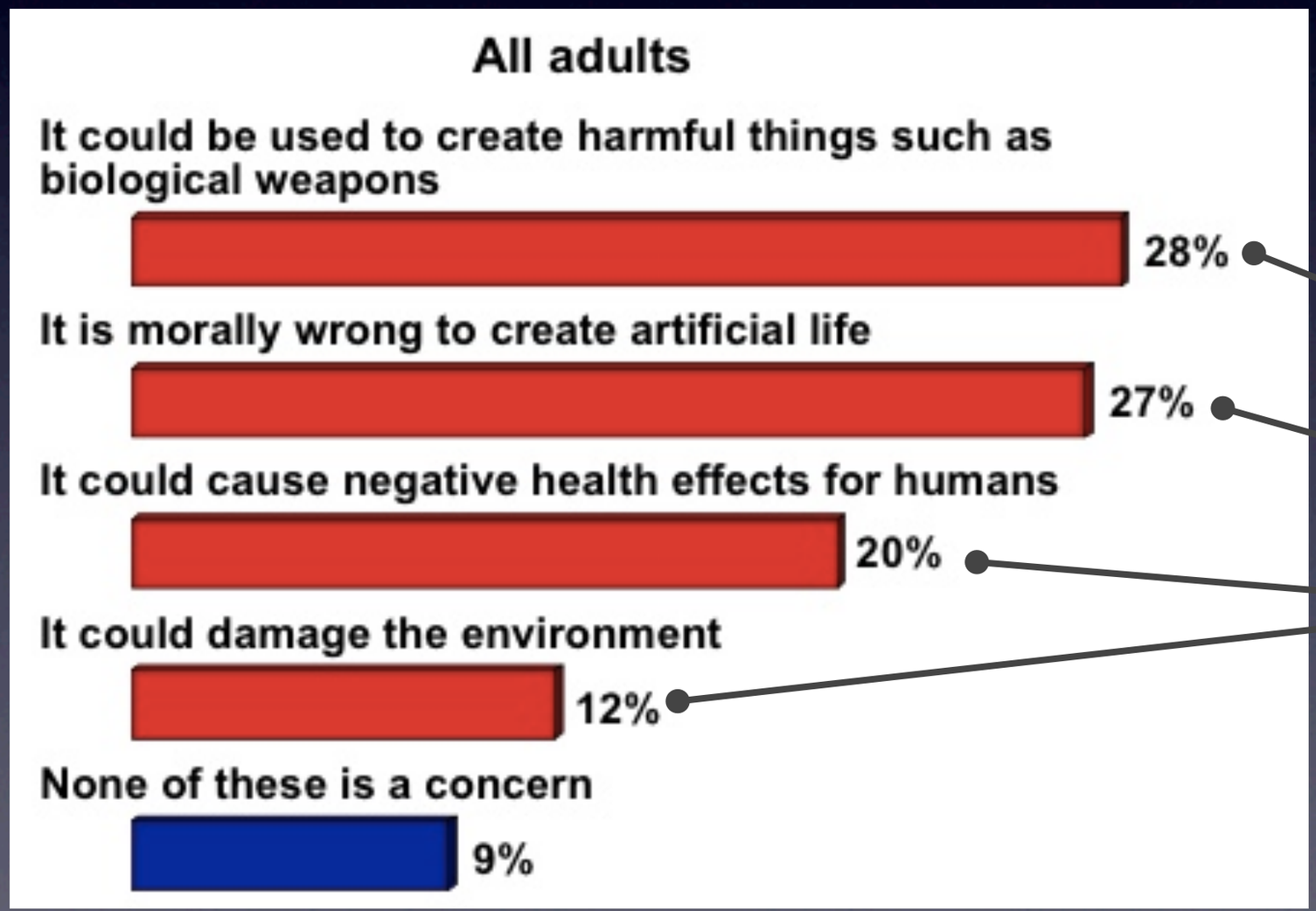
Risk versus Benefits: Post-Information



What Do People Worry About?

"*[But]*...once you start doing this, you open a Pandora 's box that you're not going to be able to close. And then we'll be doing it for things I no longer approve of."

"All the things that are positive that can be done with it are wonderful, absolutely wonderful. *[But]* My concern is that maybe by doing this we'll create something that we can't control,..."

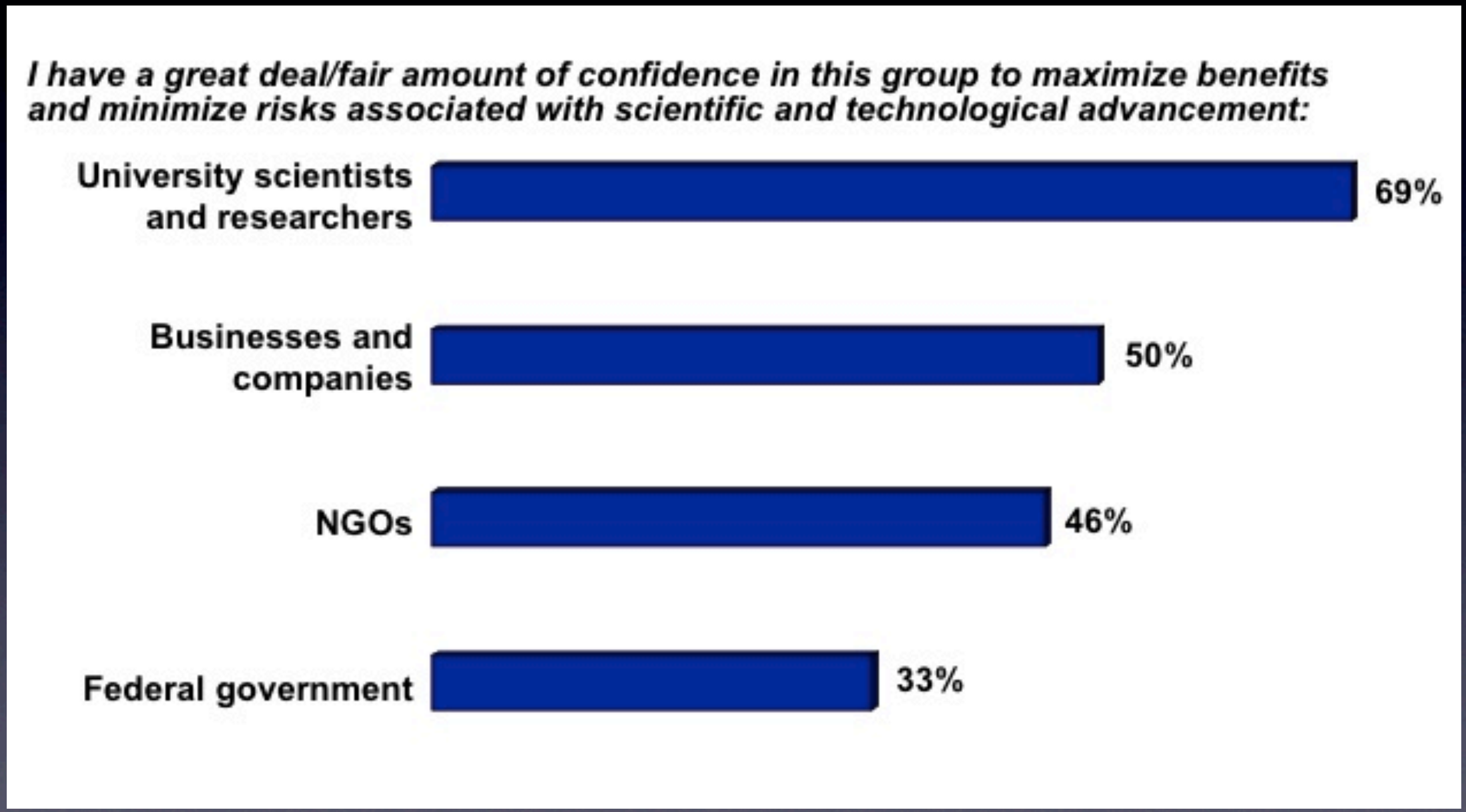


Biosecurity (28%)

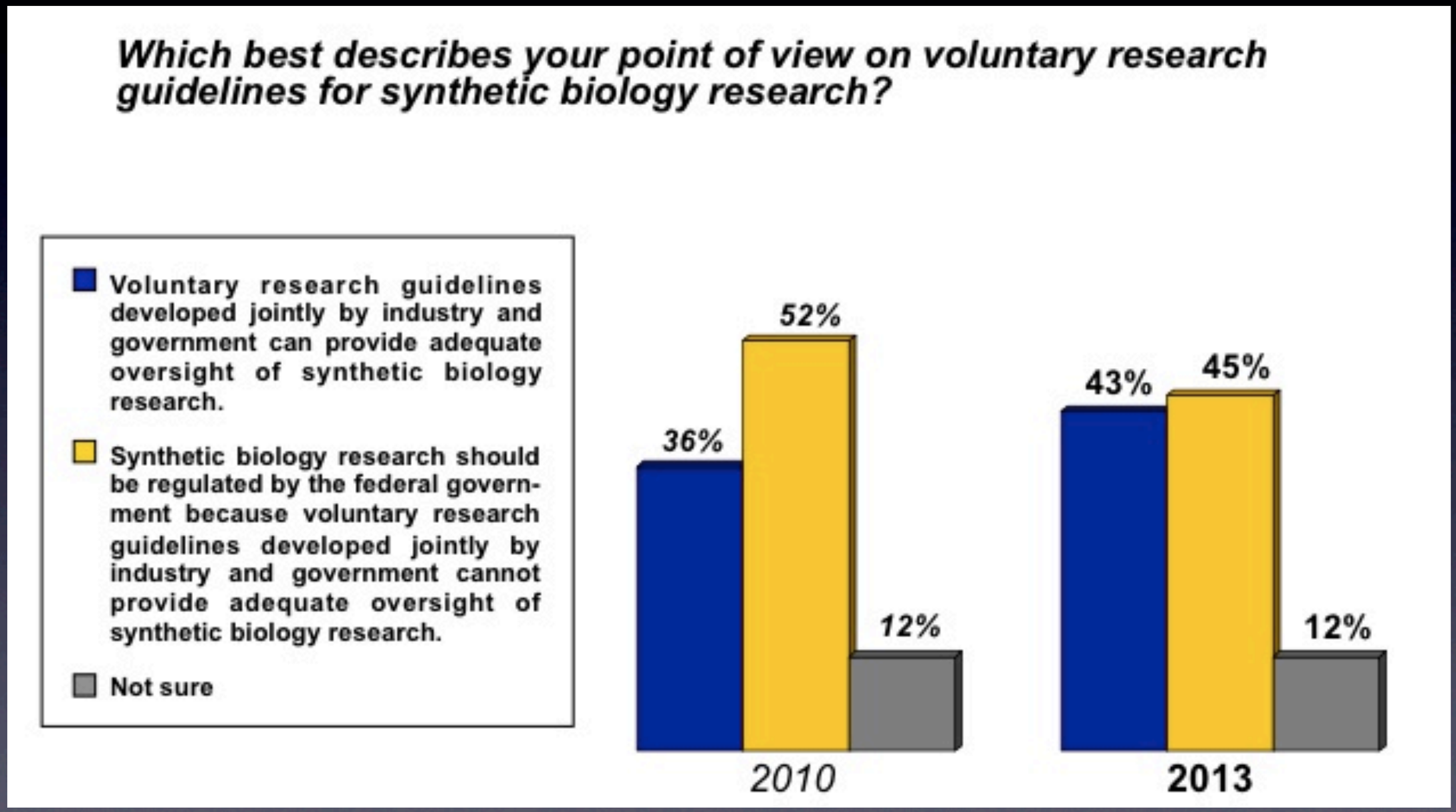
Ethics (27%)

Biosafety (22%)

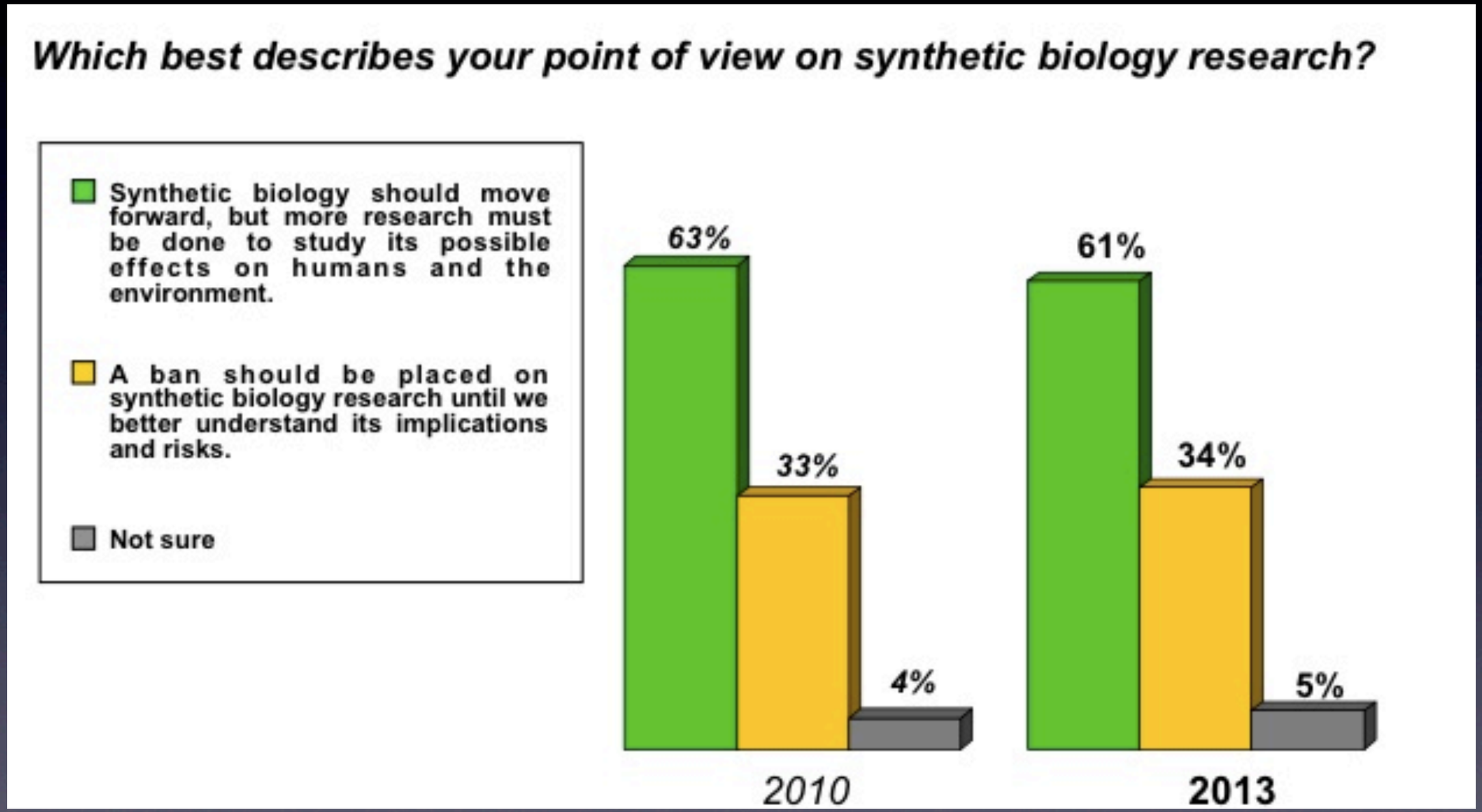
Who is Trusted?



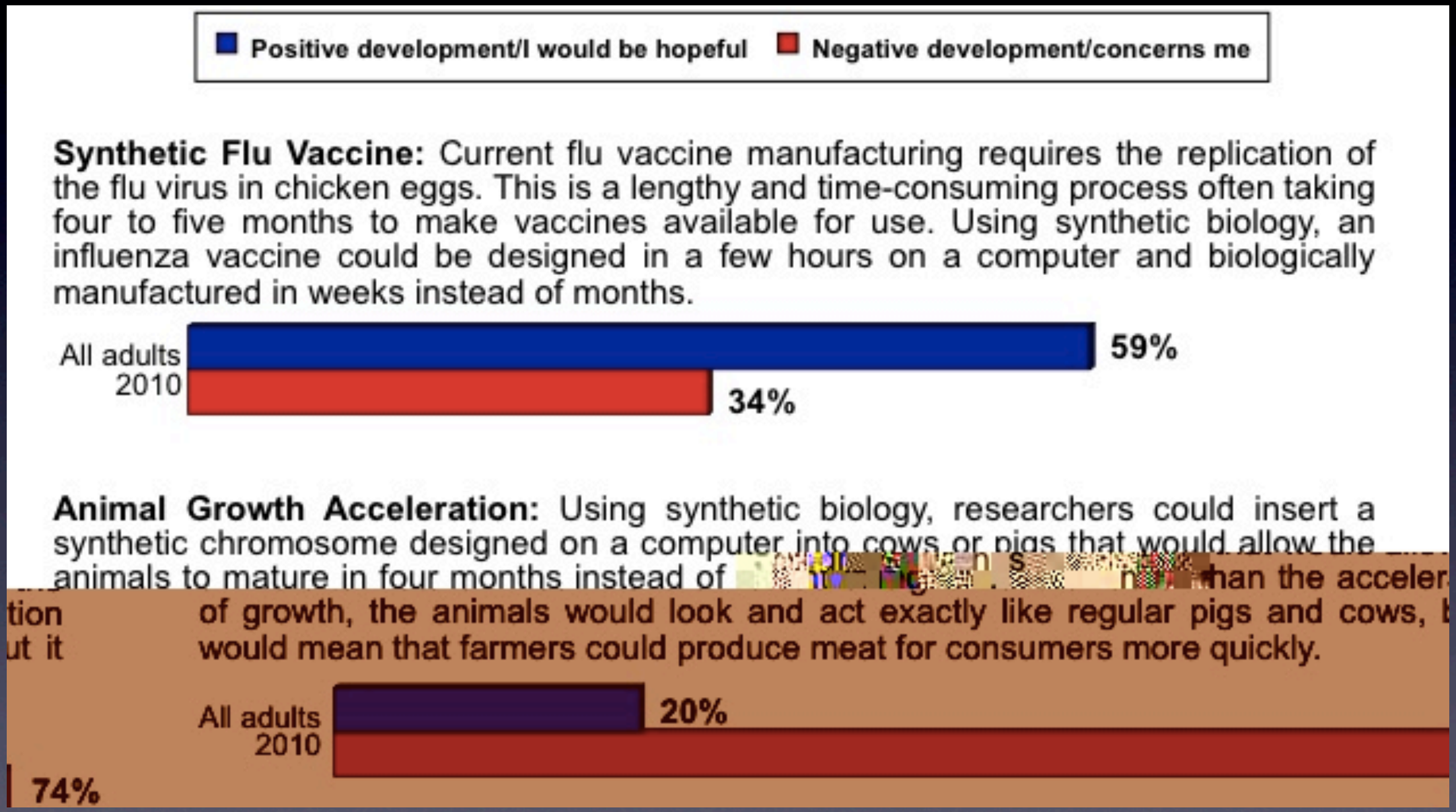
Voluntary or Mandatory Oversight?



Still Support for a Ban on Future Research

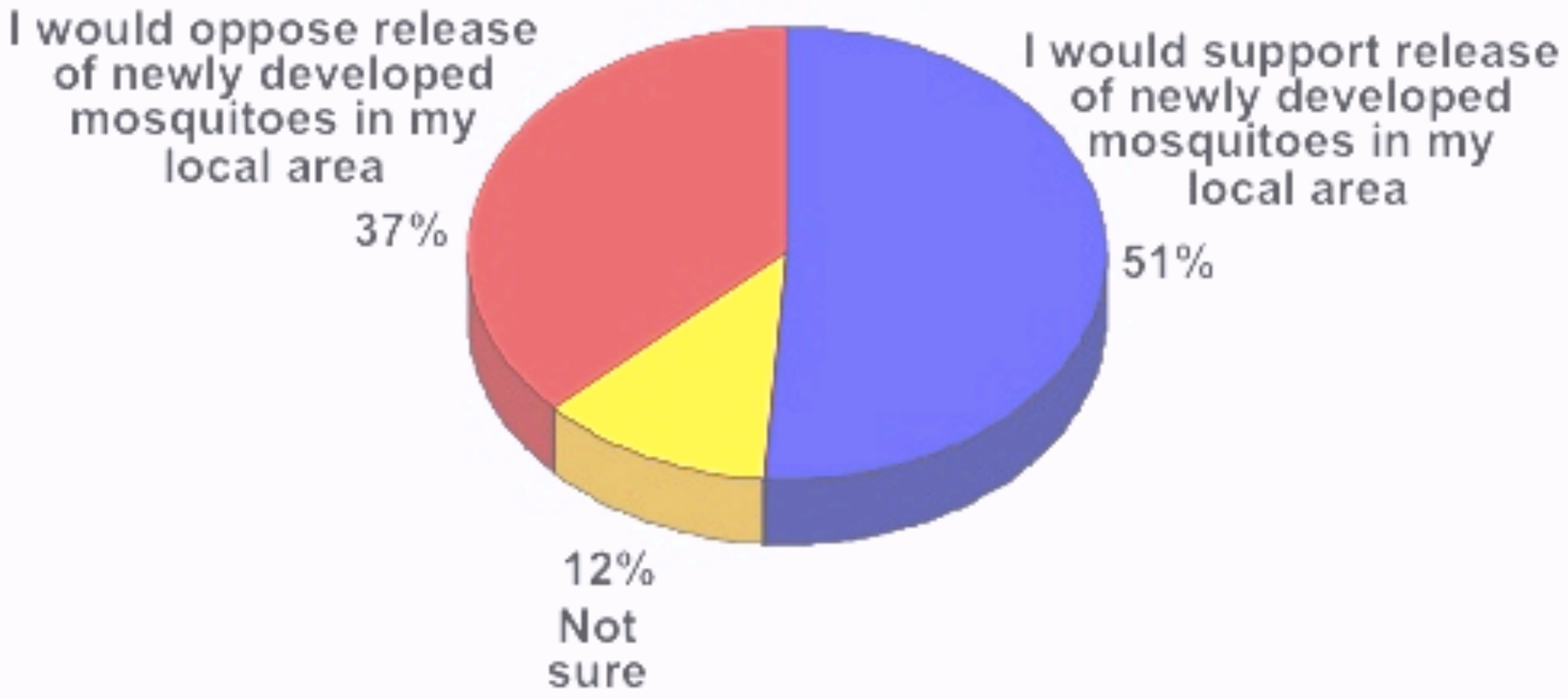


Applications Matter

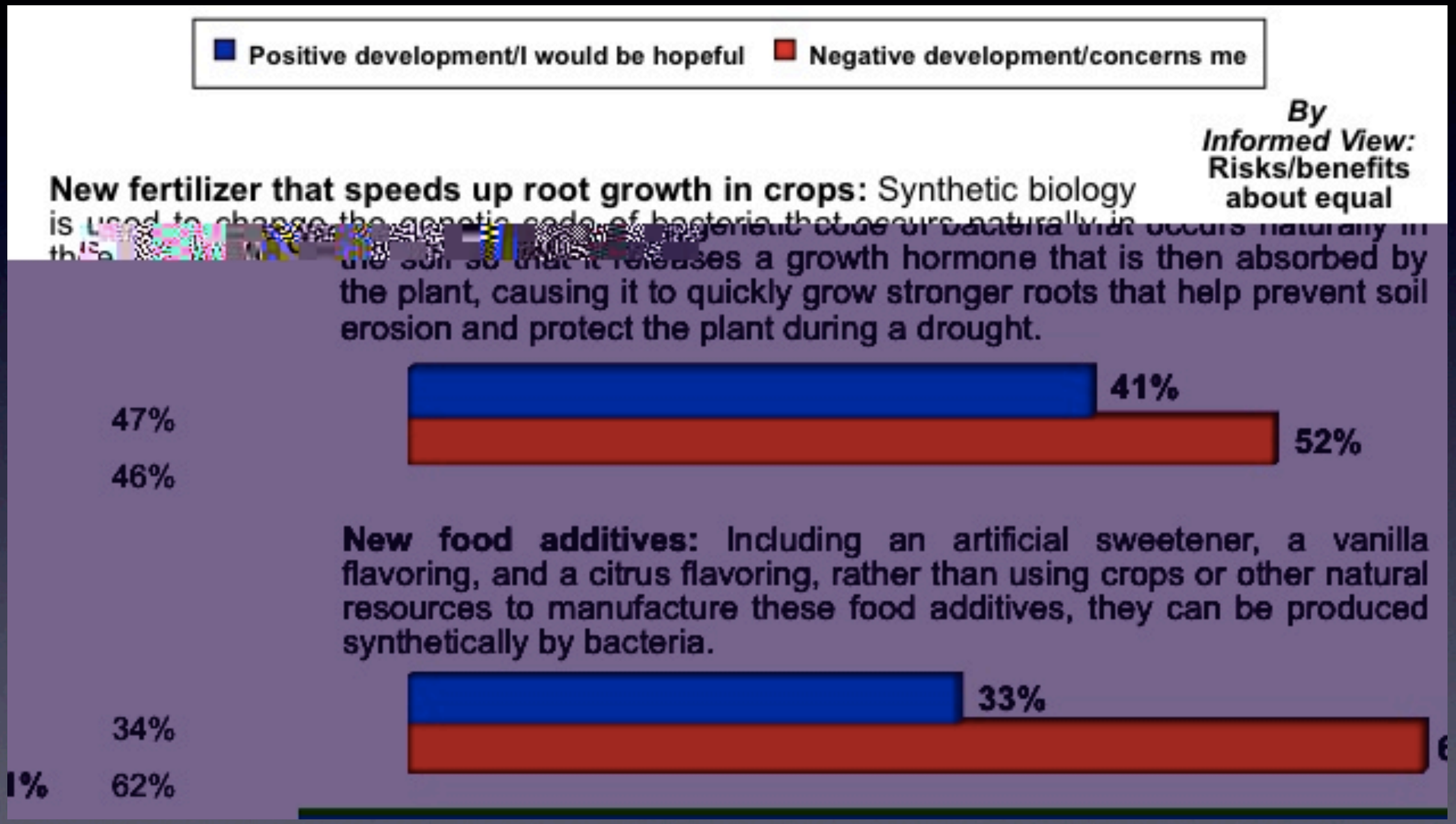


Application: Mosquitoe-bourne Disease

Synthetic biology can be used to **engineer new versions of insects, such as mosquitoes, to help control diseases like West Nile virus**. The insects are modified using synthetic biology so that their offspring die or so that male insects are sterile, thus reducing insect populations that spread the disease. These new types of mosquitoes have already been released in Brazil and the Cayman Islands, and there is discussion of releasing them in Key West, Florida. If a mosquito-borne disease became an issue in my neighborhood:

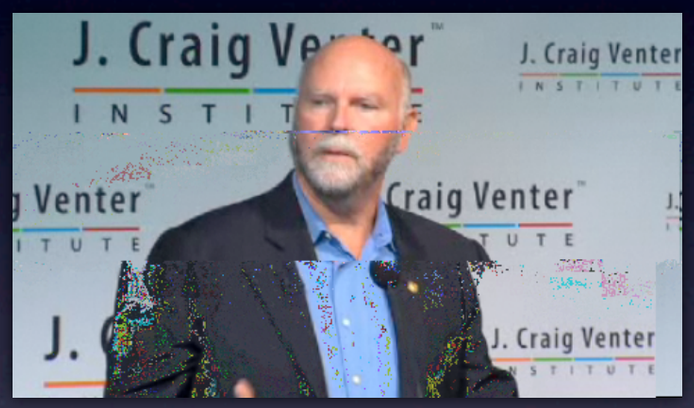


Food-related Applications

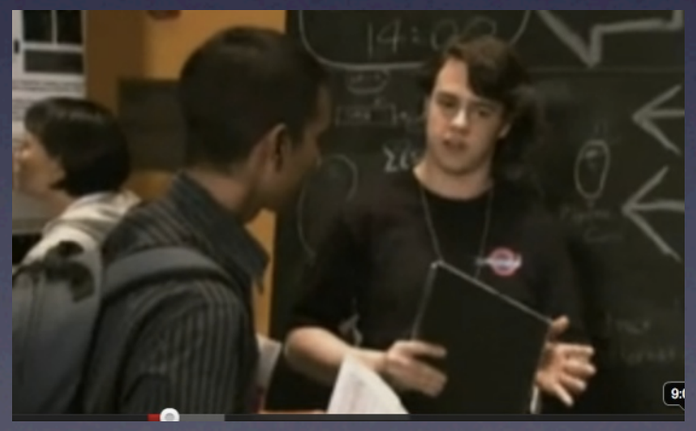


Messengers Matter

Drew Endy: "very academic; came off as very neutral; used words (like scaffolding) that helped me understand, explained it as structure, not process."



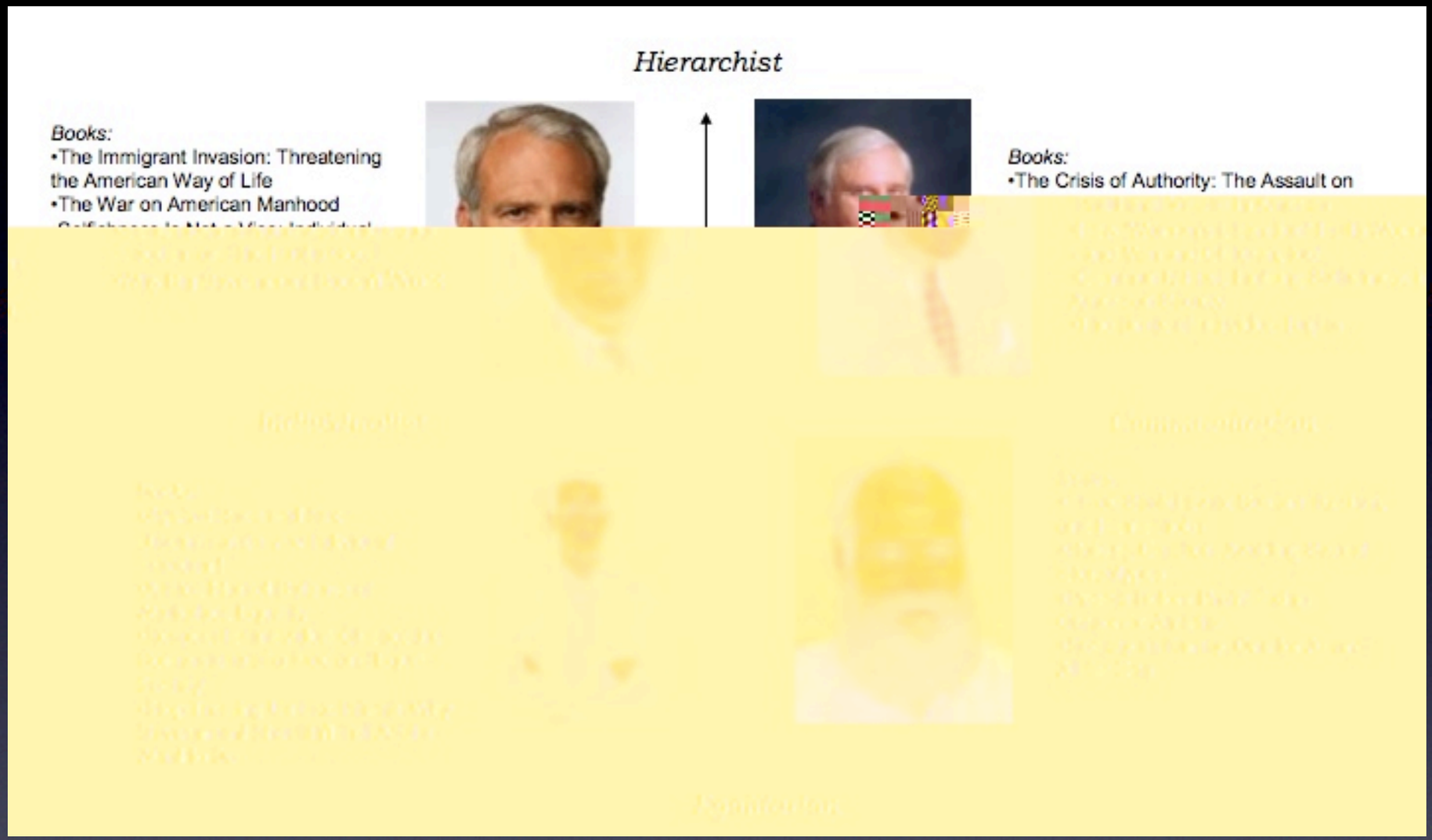
Craig Venter: "sounded creepy; very robotic; did not even seem remotely in touch with the positive stuff; he was scary; he could be the bad guy in all the superhero movies."



International Genetically Engineered Machines (iGEM) competition: "Fantastic because it's college kids, working together. Our youth are doing things for the better. Uplifting."

But: "If you are not schooled in what they are talking about, it can be kind of horrifying."

Messengers for Synthetic Biology?



"[People] will almost certainly decide whom to trust in exactly the way they normally do, namely, by assessing *who it is in the debate at hand who seems most like themselves.*"

Kahan, D. et al (2008): Biased Assimilation, Polarization, and Cultural Credibility: An Experimental Study of Nanotechnology Risk Perceptions

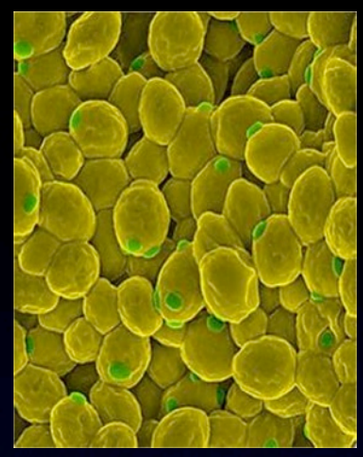
Watch the Metaphors

Term	Negative - Neutral	Neutral - Positive
Software		●
Computing		●
Machine		●
Circuits		●
Chassis		o
Factories	●	
Biobricks	o	
Living Foundry	o	
Legos	o	

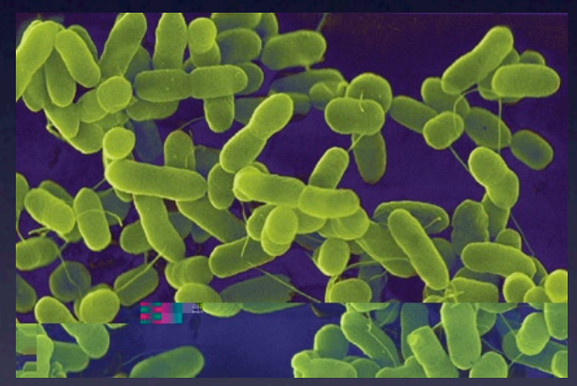
o = people found these terms confusing, associations were difficult

Do the Organisms Matter?

Yeast...we put it in our bread, we eat it, we drink it. Yeast is good.



It is more scary with something like *E.coli*.



People don't have *E.coli* in the cabinet to season your food or anything

I am ok if they take out the thing that makes it [the organism] dangerous.

Take-Away Lessons

People know little about synthetic biology and initial attitudes toward it are mixed.

Lack of understanding, "what if" scenarios, and religious/ ethical considerations fuel opposition to synthetic biology.

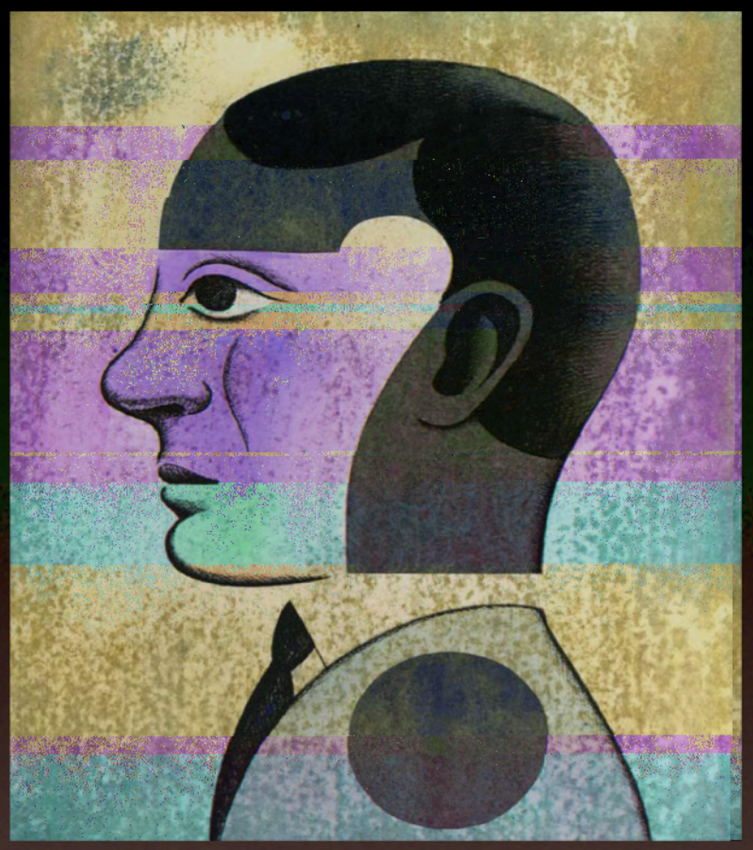
Applications to medicine and the environment are seen as compelling, with important benefits.

Messages that emphasize the benefits of synthetic biology to people's lives enhance support while messages that play on people's fears about unintended consequences stoke opposition.

Messages that use a positive tone and comprehensive explanations in layman's terms are preferred over messages with more scientific jargon.

Regulation, contained environments, and oversight are seen as key to assuaging fears about unintended consequences.

Communications Challenges



What is synthetic biology?

Also, define what it isn't

Is this a big deal?

"The ability to design and create new forms of life marks a turning-point in the history of our species and our planet."

Freeman Dyson, commenting on the Venter research

"Craig has somewhat overplayed the importance of this"

David Baltimore, CalTech

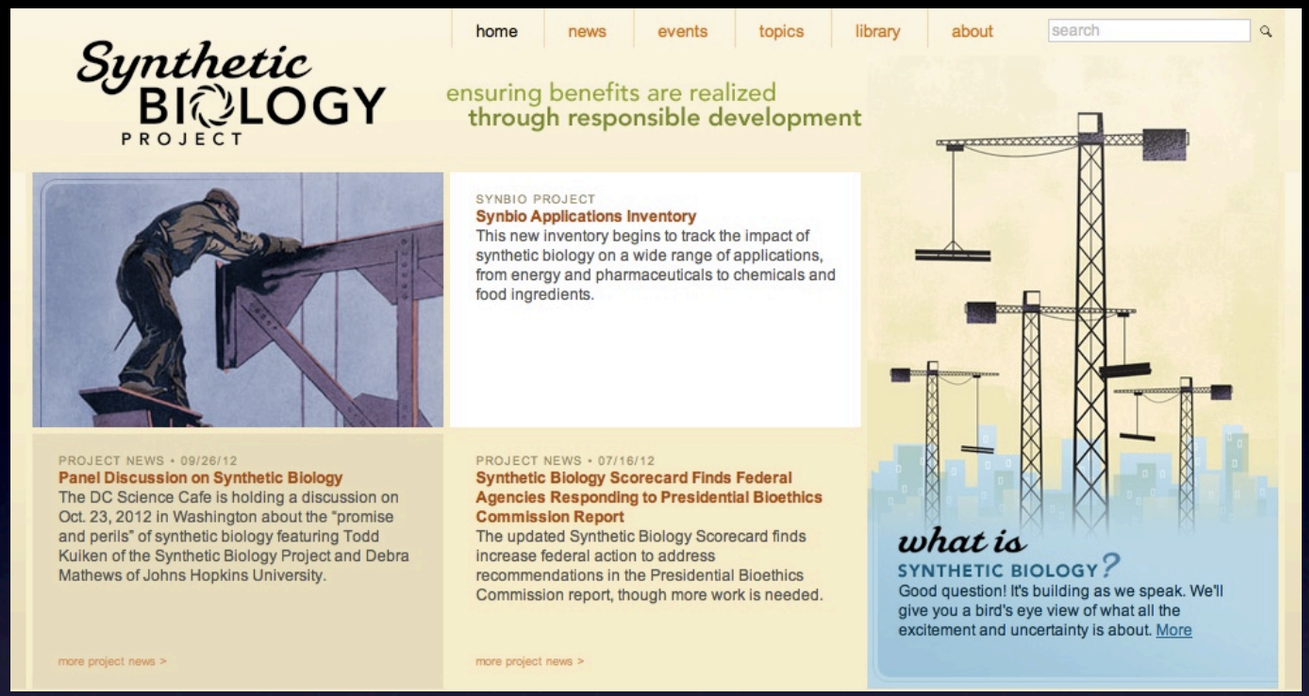
How will this impact individuals and society?

What can go wrong?

If something goes wrong, who is in charge of fixing it?

And, can they?

“Continue to go forward, but please be careful.”



More information at:

www.synbioproject.org