

Chapter 0: Science and the Principles of Clear Thinking

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- **My goal - to give you example and practice in how a good scientist thinks and how we arrive at knowledge – Astronomy is just the setting.**
- The “Cosmic Perspectives” text does give a little on the *process* of science and clear thinking, but not near enough.
- So I wrote “Chapter 0” It’s my own integration of a lifetime of learning on things mental, psychological, and biological on why and how we gain knowledge, any knowledge, not just science’y knowledge.

Key Points from Chapter 0

- Evolution by Natural Selection has equipped us to identify truth – the “light bulb” experience – because it has survival value. If we use it carefully, our brain WORKS!
- **Occam’s Razor** – explanations which require fewer modifications to current understanding and still agree with all observations, have been seen later to be more often correct.
- **Sagan’s Corollary** – extraordinary claims rightfully require extraordinary evidence before they can be given credibility. Regard incredible claims with high skepticism unless and until the promoters provide extraordinary evidence. Beware of psychological, blind-faith-based, or business agendas at work.
- **There is ONE Reality.** Mental health requires we accept this and make our personal conception of reality as close to actual reality as possible. **Reality – that which ACTUALLY exists regardless of beliefs**
- Deep awareness has great survival value, as at least some philosophical traditions recognize
- Science is a mindset. It places “What is the Truth?” as the #1 priority above all other considerations, and determines truth by ASKING NATURE HERSELF
- Pseudo-Sciences: fail the test of evidence, appeal to wishful thinking, do not have “What is the Truth?” as #1 priority.
- Mother Nature does not CARE about my, or your, opinion! She only cares what is TRUE
- Scientific Method: Observation -> Hypothesis -> Test with Observations. If passes all, it’s a Theory. If not, it’s false. Must go back and find a new Hypothesis
- Not testable? It’s not science. It remains mere “speculation” and can claim no likelihood of truth.
- **Weight of Evidence:** the criterion by which we assign the probability of an idea being true.
- Nature and so our well-being too, demands we be RIGHT as much as possible, not that we retreat to granting equal probability to any claim regardless of the evidence, to perhaps satisfy tribal conventions.
- Science can DISprove wrong ideas, but rarely can it PROVE the one and only correct one, because there may be refinements to the best current theory which have not yet been discovered and yet which agree with all observations made so far, plus more observations yet to come.
- Claims that the human mind is incapable of grasping truth, and that Truth is only to be found in holy books, are self-contradictory. Blind faith leaves one at the mercy of whomever that faith has been invested in.

Be Patient...

- Because I feel this chapter is so vitally important to convey, I'll be saying the key ideas in many different ways as we go along.
- If you ***get it*** right away – congratulations! If not, maybe later on there'll be another way of saying it, later, which will click with you.
- OK, onward....!

One More Vital Point Before We Launch...

- My greatest goal here to empower you. To help you learn trust in your own powers of thinking and judging truth.
- ...to see you learn to **“Trust in the Force, Luke!”**
- To trust in the innate powers of thinking that Nature granted you.

Empowerment Means...

- I want to help you be armed against those who would try to command your obedience through fear, tribalism, and disrespecting your mind's ability to see, think, and defend your conclusions with fair evidence.
- To the extent this succeeds, you will have a more exciting, benevolent, and giving life to the rest of society.

The Nature of Thinking Clearly

*“The most incomprehensible thing about the universe is, it is comprehensible” –
Albert Einstein*

- In context, he almost certainly didn't mean this literally, but instead as dramatic emphasis.
- **Is it surprising that the Universe is comprehensible?**

No. Not Surprising at all. The Brain and Mind are products of evolution by Natural Selection, “Proofs in the pudding” they work, given proper operation by the owners

- Natural Selection is Simple... we are not all equally genetically gifted to solve the problems of survival.
- Those better able to survive and thrive tend to leave more descendants who, to some extent, genetically inherit this higher “fitness”, and therefore leave more offspring, who then also inherit some aspects of this fitness as well.
- Thus, favorable traits tend to spread through the population, unfavorable traits tend to die out.
- **If our brains didn't work, we'd have long ago gone extinct.**

Each Species tends to be Distinguished by Having a Distinctive “Edge”

So, what makes us, *Homo sapiens*, good competitors for the resources necessary for life?

It's not our speed, our physical defenses, our camouflaged skin, spines, hard shells, ink jets, etc.

Our Minds, of Course!

- The evidence says that minds are the perceptual internally experienced manifestation and result of the biochemistry of our physical BRAINS.
- They are not a dis-embodied ghostly “spirit” floating unconnected from physical brains. When brains die, we have no reputable evidence that the associated mind remains.
- Natural selection applied to humans means, we evolve better and better BRAINS.

How do you Know when you've understood something?

- What is the actual experience of understanding?
- What are the experiential cues that signal understanding? After all...
- Without the cues, you'll never know if you're driving your organism life effectively. There needs to be that feedback.

The “Light Bulb” experience!

- The “light bulb” – Too many of us did not have teachers or parents who pointed out how important it is to recognize it and to seek it.
- **It is the gold standard for a genuine grasp of Reality – it’s a biological response, correlated with brain chemistry and visible in functional MRI (fMRI) activity.**
- Why did we evolve to have this experience? Because your survival and well being, especially 10,000 years ago before Social Security, depended critically on arriving at correct understandings about the World.
- **The “light bulb” is as vital a biological signal as any other biological signal – pain, pleasure, hunger, thirst, anxiety... without genuine understanding, you will fail at the challenges of life, no matter how many pats on the back you get telling you you’re a superstar.**

The “Light Bulb” goes on...

...when new understanding is integrated into previous understanding in a non-contradictory way.

Reason – is the art of identifying truths and integrating them in a non-contradictory way into our knowledge base. Our brain evolved this capacity in the forward part of our gray matter; the “forebrain”

But, you may say... what of all the cognitive biases and pitfalls that psychologists say are so widespread?

- Yes, these biases and pitfalls indeed are out there. But KNOWING about them (as we'll see) is a giant step towards correcting for them, towards being more open to seeing if you've fallen into one of those pits.
- Sinking into a conclusion that no one knows anything, is far too pessimistic – the astoundingly rapid progress of science testifies to that.

Getting to the Light Bulb – Requires CARING

- Without **caring**, there is no learning. Why? Because making mental connections requires **focus** and hence *mental effort*, hence mental and physical **ENERGY. Raw Calories!**
- Your brain has 2% of your mass, but uses 20% of your chemical energy. Organisms will not spend energy without a good reason – we are **parsimonious**. In the parlance of ecology, we are “optimal foragers” – constantly evolving so as to get what we want and need with the minimum expenditure of personal energy.
- Energy requires food and that (for most of our evolution) wasn't so easy to acquire as it is today. Hence, CARING about learning is essential for learning to happen.

I've Concluded: Nature decided that the most effective reward structure for accomplishing clear thinking...

- ...would involve short term, medium term, and long term systems.
- Let's look at the Short-Term system first.
- How did Nature impel us to engage in the energy-consuming activity of discovering valid knowledge, even before the survival value of that knowledge could take effect?

Curiosity; the Desire for Clarity...

- ... is nature's built-in **short-term** motivation to exert that mental effort.
- The **medium term reward** is the inherently pleasurable "**light bulb experience**" which comes from the satisfaction of that biological drive – it **feels** good! The "*ah hah!*" moment. As it should - it's a concrete expression of your power to control your life.
- If you're not curious, learning will be extremely difficult. Reconnect with your native curiosity (otherwise, in today's competitive world – you're doomed!)

The Long Term Reward Mechanism

- ...is successful coping with Reality.
- At seeing the success of your thinking manifested in your life, you look back and put it all together into a conclusion...
-"this was a good strategy! Let's do more of this!"

Cultivating the Desire for Clarity.

- Without a genuine, honest desire for clarity, it probably will not come.
- The DESIRE for CLARITY is the emotional evidence that you do indeed have truth as your #1 priority, over other regrettable but all-too-human temptations.
- In each conversation or mental activity – notice whether you **Desire Clarity**, or instead are more swayed by less useful motives (e.g. to avoid painful awarenenses, to prove you're right, to prop up a fragile ego, to manipulate or curry favor among others, etc.)

For me - It's the touchstone of any rewarding human relationship

- If a person doesn't show this fundamental desire for clarity, I know the relationship will have major limitations.
- **If you meet such a person – treasure him or her!**
- **They are rare and uniquely enjoyable people to count as friends.**

It sounds so obvious, it's almost banal

- But yet, it's not. Too many people do not have a consistent desire for clarity.
- Very often, they fear what that clarity might confront them with.
- More – if one hasn't already cultivated this mental state, then making a sincere, unrestricted **commitment to clarity** can feel VERY frightening.

Committing to the Premise: “I just want to know the truth” – can feel terrifying

- To exaggerate just a little...
- The feeling is... ***“What?! You’re wanting me to commit to opening that Pandora’s Box called Truth, without first knowing what’s in it? Suppose what’s in there forces me to confront aspects of myself, my life and my belief systems that I fear might shatter my fragile hold on self-value? I can’t take that kind of risk!”***

Fear: Like Jumping off the Empire State Building



And yet – it's also like diving into a refreshing mountain lake



Getting in might be intimidating at first, and even a bit shocking

- But soon you're excited, and experiencing life with much more energy and self-confidence
- Enjoy the mystery of what you might discover, and let go of the notion you must never be shown wrong, lest your self-respect be shattered.
- Genuine self-respect isn't based on never being wrong. It's instead on what you DO when you discover you're wrong.

The Blocks to Clarity

- We have the ability to **deflect** our awareness away from clarity, sensing when it will lead to confrontation with truths which are uncomfortable.
- Too many of us do it all the time.
- When we habitually do this, it becomes automated.
- *The organism is always trying to be parsimonious with energy consumption – it senses this repeated behavior as something it now should automate and save you the time, stress, and energy consumption of conscious confrontation... and so...*
- **It becomes a habit. And it short-circuits beneath conscious awareness.**
- Then it's **tough** to break. Don't let it get to that point, if possible

But with practice and sincere desire...

- ...you can learn how it feels at the moment of deflection...
- And instead, put yourself back in control by remaining focused on **wanting clarity of understanding - the truth - as your #1 priority.**
- You *can* break habits. It's an empowering experience

In My Years at Cabrillo...

- ...I'm increasingly noting the unfortunate temptation of some to try to shut down any mention, any inquiry, any bringing into awareness of these issues.
- This is part of how repression works. A repressed person works to silence the sources stirring thoughts and questions long habitually deflected because they are perceived to threaten the ego, or tribal alliances, or other perceived values.
- In fact, though, they **can** be a source of growth through challenge.
- **This open challenge to ideas is ESSENTIAL to the art of Critical Thinking – one of the Core Four Missions of Cabrillo College, as it should be for all higher education**

Now: What, actually, do you DO – to grasp understanding?

- You take all of the aspects of the issue to be grasped, and try to hold them all in focus at the ~same time. That's not quite possible, so a better description is this...
- It feels a lot like juggling, as you pay attention to all the juggled things as close to “at once” as your brain focus can muster.
- This is your mind's strategy for spotting contradictions.
- Hold two things in focus at the same time and if they contradict each other, you'll get a certain **mental experience** - a sensation of “clashing”

If they are without contradiction and in harmony, there's a very different and more pleasing feeling that happens:

The beginning of the Light Bulb

- But, to hold two things in focus at the same time takes mental ENERGY, takes FOCUS. Takes CARING. Takes WILL POWER and the DESIRE to do so.
- Holding two things in focus at the same time, it feels to me, takes more than twice the mental energy and willpower of just one thing
- This is part of the problem, it's too tempting to not make the extra effort if **focus** is an unfamiliar experience.

If you don't do this mentally active cross-checking...

- Then you don't get the opportunity to find the logic or illogic of its connection with the rest of your assumptions or knowledge
- **This “juggling” must be learned by constant practice, till it becomes an automated habit.**
- As a **habit**, it takes much less mental energy to make happen.
- We may slip into saying those who master this are “more intelligent”. But it's really just that they've practiced to the point of automation, so most of their energy is freed for other challenges.
- The evidence is that “intelligence” is a very fluid thing, and not the fixed IQ number we once thought long ago.
- My (and many others') personal experience, is that ***we raise our IQ's with practice in: Honoring the Desire for Clarity, in all things***

Emotion and Clear Thinking



- It's a common but incorrect assumption that emotion and clear thinking are at war.
- On the contrary: Spock is NOT who we should seek to embody.
- Psychologists wisely recognize that ***“In order to think clearly, you need to be able to feel deeply”*** – ***Nathaniel Branden***. Because repression operates on both at the same time. Blocking awareness of thoughts is also to block their **meaning** to you – and so is to block awareness of what you feel.

Our Mind and our Senses – It's ALL We've Got. It's all ANYone's Got

- There **IS** no alternative to using your mind to discover where truth is. Think about it - How **could** there be?
- Trust a Guru? First, how would YOU KNOW he's the "true" Guru to trust? There are plenty out there, after all. YOU have to make that decision. Try as you might you simply canNOT avoid the responsibility for thought.
- And Guru's are just human beings too. They must reach their convictions by use of the same human capabilities we all have.
- You can't avoid that it's your mind that decided which competing Guru to follow.

Trust a Guru Because He Threatens You with Damnation if You Don't?

- But then - your motivation is not a desire for clarity.
- **It's fear.**
- A very anxious, unpleasant way to live your one and only Life.

A mind filled with undigested, unchecked factoids is unable to judge the truth of new information. The “light bulb” has been unscrewed!

what the hell is that?



oh,
just my mind

Guru's, if they truly respect you...

- ...will encourage your sovereignty, encourage healthy use of your mind, skepticism, and desire to seek the experience of genuine understanding.
- Sadly, we have seen there are plenty of motivations for false gurus to try and turn you in exactly the opposite direction; towards blind faith.
- Is it at all credible that, unlike all humans, **THEY** have a secret pipeline to Perfect Truth that bypasses the mind and senses? Very dangerous to your self-mastery to hand over your person to an outsider in this way.

What is their evidence that it is *The Divine* talking to them, and not simply themselves talking to themselves?

- ... or trying to allay their own anxiousness by recruiting others into their belief systems?
- There are too many tragic historic examples to list here.
- Extraordinary claims rightfully demand extraordinary evidence, as Carl Sagan wisely observed.
- And yet, from the gurus - extraordinarily compelling evidence is not what is offered.

The Authoritarian Mindset

- Rote memorization of undigested factoids? You'll get NO light bulb.
- No light bulb? Then no understanding has yet happened.
- Don't let yourself be intimidated, or seduced, into accepting the undigestable by "Authorities".
- Ask – ***“What reasoning, what evidence, makes you say so?” That includes confronting your teachers too!***

“There is a cult of ignorance in the United States, and there always has been. The strain of anti-intellectualism has been a constant thread winding its way through our political and cultural life, nurtured by the false notion that democracy means that ‘My ignorance is just as good as your knowledge.’”

—Isaac Asimov, quoted in [“America’s Cult of Ignorance and the Death of Expertise”](#)

Institutional Abandonment of Critical Thinking

- There is a culture growing – a culture of intellectual abdication of this most important of teachings, in our institutions.
- Instead of championing and defending their members who demonstrate HOW clear thinking happens, and that there are tested standards for judging truth, they are instead so afraid someone might not like what is said, regardless of validity, that they pressure for [betraying the very foundations of science](#) (NYU psychology and sociology professor Jonathan Haidt)
- Ironic, that schools proclaim their goal of teaching “critical thinking”, but so often betray it in actual fact.

Realize the Sensitivity of my Task, of Teaching How We Gain Knowledge

- There is no way it can be done without pointing out the fundamental incompatibility between science, and the explicit demand for blind faith.
- Without a deep respect for your own mind's ability to grasp understanding, "knowledge" instead degenerates into mere memorization of "factoids", or blind obedience born of tribalism.

I Want You to Learn to Trust Your Own Mind's Powers

- ...not those who would try to commandeer your obedience through peer-pressure, fear of lawyers, eternal Hell-fire, or other intimidation tactics.
- The vast majority of scientists are secular humanists, and the U.S. is unusual among Western countries in being as strongly religious among non-scientists, as it is.
- The antipathy towards science, which is growing much as it did in the Dark Ages, especially among conservatives, is a dangerous but not unexpected result.

I welcome all students to my classes, and only ask them to open their minds with a sincere desire to grasp understanding within an atmosphere of academic freedom

- I respect and welcome all students. But ideas are not people. And some ideas are toxic to human well being and therefore any respectable system of ethics.
- And realize no part of anyone's grade is determined by their belief system, nor will any exams have any personal questions about your beliefs. Nor will religion even be discussed after Chapter 0 and a bit of astronomy history.
- **Respect your fellow students'** desire for this intellectual adventure, and don't seek to shut down conversation.

An integrated mind of ideas that fit together without contradiction, vs. a jumble of disconnected and unusable factoids.

- You get a sharp feeling of dissonance when confronted with something that makes no sense...
- But!... ONLY if you have an integrated mind all “of a piece” to start with. That’s a vital fact often unappreciated.
- A person whose mind is filled with a jumble of undigested factoids gets neither a dissonance nor a light bulb when confronted with new ideas.
- He’s disabled his biological gift for grasping understanding, by not having first engaged **the desire for clarity at the start**
- **There’s no easy solution. You’ll have to laboriously haul out and question all the undigested factoids and exert mental effort to get/ or not get/ the light bulb experience as you keep the wheat and toss the chaff**

The “light bulb” vs “confirmation bias”

- Be alert to the felt internal distinction between these two. The “light bulb” proceeds from a place of strong curiosity and willingness to know whatever the truth is, regardless of your current ideas. When you “get it”, you experience the “light bulb”.
- Confirmation bias begins out of a place of anxiety, and then if the thought put before you agrees with your prejudice, you feel a relief and some amount of relaxation from the fear. It’s not the “light bulb”.
- These two experiences are different and if you pay attention, they feel different too.

There is

Only ONE

REALITY

The MEANING of the word “Reality” was set Generations Ago by the Great Philosophers

- And, we **NEED** a word to designate the **objective, actual Truth of what really exists, independent of anyone’s beliefs.**
- Those who want to re-define it as simply a person’s individual belief state, need to come up with their **OWN** new word instead.
- **Hey! “R-E-A-L-I-T-Y” is already taken!**
- Because if they don’t, they play into the hands of those who would have you believe there **IS** no Reality, only “opinion”, leaving you a very short step away their ability to manipulate you.

My “Perception and Conception of Reality” =

My “PACOR”

- We all have unique experiences and perhaps non-overlapping conclusions. We all have our own PACOR (a useful but awkward word I’ll create here. An ugly word? Sorry – the beautiful word “REALITY” is already taken.)
- This obvious truth does not violate the usefulness of the notion of an objective external Reality, which is the ground underneath the basis of our individual PACORs.
- The goal of mental activity is to get your PACOR to be in as close and harmonious a relationship with the one true REALITY as possible. Only then can you hope to think and act with effectiveness in supporting your own life and happiness, and those you care about.

Reality = That Which Exists!

”Reality is that which, when you stop believing in it, doesn’t go away” – Phillip K. Dick, author of “Blade Runner”

- Everything that is real will fit together without actual contradiction, by logical necessity...
- Why? Because the alternative is - our brain doesn't work
- But if our brain doesn't work, **nothing** we say can be trusted, *including the claim there's more than ONE Reality*
- This is important - **Claiming multiple Realities is self-contradictory, and self-disempowering**

But Rick! What about Parallel Universes and the Many Worlds Interpretation (MWI) of Quantum Mechanics?!

- Sigh.
- We can get lost in the weeds here, in an area we still are only barely coming to work through.
- But I can say this. The “you” and “I” in this thread of the fabric still obey the laws of physics, biology, brain chemistry, and the rest, and always have, even if quantum entanglements diverge copies into multiple later threads – those too obey QM and all the rest. “Real” may have more nuance if MWI is true, agreed.

Keep hand firmly on wallet

- You should be annoyed at those who want you to forget the very notion of an objective REALITY, that no one's opinion is any better than any other's.
- The goal of our mental activities should be to align our ideas of what's true to be as much overlapped with actual evidential REALITY as possible
- Nature equipped us to be able to do just that, if only we would learn and exercise the discipline to do so.
- Otherwise, we'll find ourselves banging our heads against a tough wall when trying to make progress in life.

In the Brave New America of Today...

- You are getting a look at how this destruction of your ability to think is done...
- ~Everything is labelled as “Fake News”, thereby discouraging you from trying to make the distinction between real and fake;
- Language is distorted to the breaking point, and delivered as if it is the honest truth;
- The “Big Lie” technique, so prominently used for Adolf Hitler’s propaganda machine by Josef Goebbels in 1930’s Germany, has returned to 21st Century America.

It's easy to disprove the false notion that *“There IS no Reality – Only Opinion”*

- Life requires constant maintenance and energy. It is a fight against the 2nd Law of Thermodynamics – a victory of **order** over **disorder** and decay.
- If we were lost in a delusion of unreality, with nothing but “opinions”, none demonstrably better than another, we'd fail, and survival (and your opinions) would have ended long ago.
- You **MUST** accept the responsibility for effortful, successful thought, if life is to be sustained. Mistakes will be made, but that does not invalidate that the mind **can** grasp Reality, if nurtured properly.

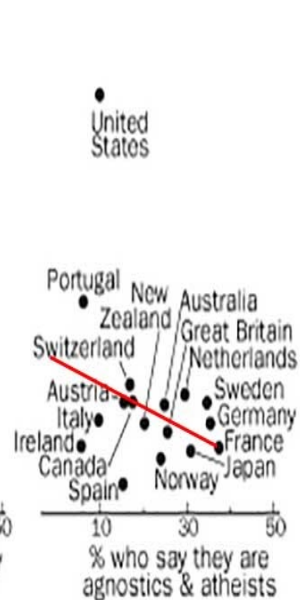
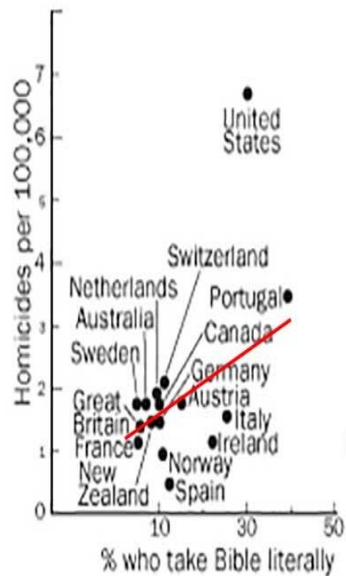
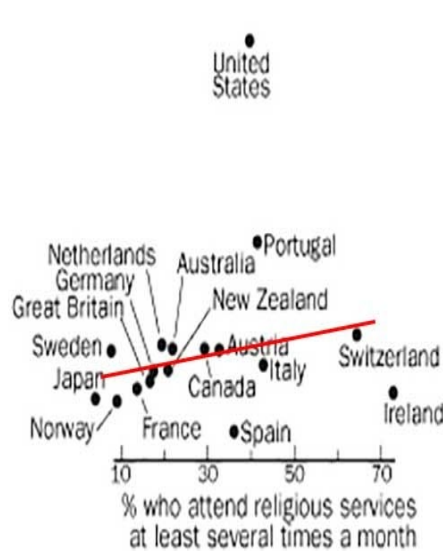
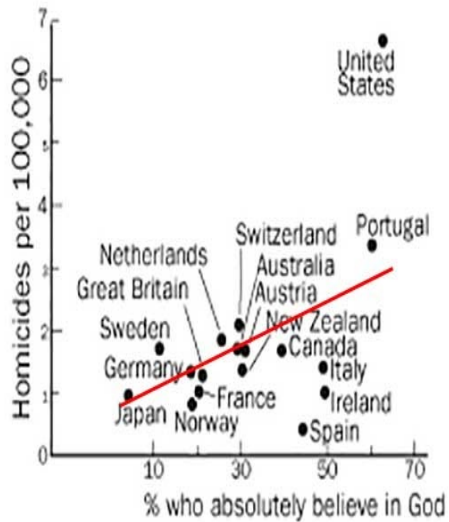
This is even true in the realm of ethics

- Many would have you believe the notion that we should never judge cultural values, lest we be accused of “discrimination” and offend someone who may be attached to them.
- Humans have a specific nature, driven genetically for optimal fitness in the real world. There are, therefore, specific requirements in order for optimum happiness and well-being as individuals and as a society: **And THESE must be the proper framework for ethics.**

Ethics and Food for thought

Some contend that the Supernatural, in the form of religion, while scientifically wrong, is still essential for ethical behavior. But the evidence argues the opposite ([Paul 2005](#), discussed [here](#)).

The murder rate in a country is instead strongly correlated to the religiosity of its citizens. Conversely, the stronger a society's acceptance of **Evolution by Natural Selection**, the lower their murder rate. You see that worst, by far, is the United States.



Figures 1 & 2—There is a positive correlation between religiosity and homicide rate. Redrawn from Gregory S. Paul's Figure 2 (<http://moses.creighton.edu/JRS/2005/2005-11.html>).

While many preferences don't conflict with our ultimate welfare

- ...Chocolate or vanilla? Straight or rainbow? Black or white?, *etc.* and therefore are neither moral nor immoral, it would be absurd to argue that we shouldn't "discriminate" against e.g. Nazi Germany fascism, feeling it is merely engaging in alternate cultural choices and we shouldn't be judgmental.
- Neither is supernaturalism winning here. The ["Argument from Authority"](#) remains a logical fallacy, here as elsewhere. Worse, it can be a trap to compel allegiance to behavior and ideas not fairly won by logical evidential conviction.

Another Iconic Quote on Good Attitude Here...

- The famous economist John Maynard Keynes, annoyed with someone criticizing his changed position on monetary policy, responded: ***“When my information changes, I alter my conclusions. What do YOU do, sir?”***
- *It’s been paraphrased: “When the facts change, I change my mind. What do YOU do, SIR?”*
- Meaning: Don’t “self – identify” with knowledge outside your control. If the evidence and judgement currently say OK, then ride with it. Until and unless it proves to be false, then let go of it.

***"Every lie we tell
incurs a debt to the
truth. Sooner or later
that debt will be paid."***

- Valary Legasov, investigator of the
Chernobyl nuclear disaster

“If you’re going to make a big jump in science, you’re very likely to be unqualified to succeed, by definition”

- James Watson, Nobel Prize winning discoverer of DNA

You Will Learn as You Go

- *“Movies and pop culture get this all wrong. The idea of a single ‘Eureka!’ moment is a dangerous lie. It makes us feel inadequate since we haven’t had ours. It prevents people with seeds of good ideas from getting started.”*

- Mark Zuckerberg

Ponder the exhilarating exchange...

- ...we might get if we challenge a scientist on a conclusion, and a lively uncovering of differing evidence and reasonings proceeds, leading to at least one, or both, learning some valuable things, and changing their conclusions.
- And both likely approaching closer to the truth.

Just to Qualify...

- While the **National Institute of Mental Health** [agrees](#) that anxiety is indeed the organism's signal that something important to your well-being is remaining unidentified and unacknowledged, emotions in general (including anxiety) are mediated by brain chemicals, and it's possible that organic physical damage unrelated to thinking errors may independently also cause anxiety and other feelings (although this is much less common than the psychological causes I am describing – see the **National Institute of Mental Health's (NIMH)** description of Anxiety [here](#)) with the many studies showing “talk therapy” is much more successful than drugs.
- It may also be that any unacknowledged “Reality” is not due to repression through habitual avoidance, but instead is because the relevant reality is very complex and despite sincere efforts at achieving clarity, is still elusive.

Contrast the Break-Neck Speed of Scientific Progress...

- ...with the endless unmoving political and authoritarian dogma wars... bloody, cruel, and unlistening for centuries.
- Why is this so? Because good scientists will quickly acknowledge when the evidence reveals their ideas to be in conflict with the evidence. They **learn**, and move on. Scientists **listen** to Reality.
- This is rarely so in politics and authoritarian areas, as the great Cornell University planetary scientist **Carl Sagan** observed as well (see his quote on a later slide here). Essential to realize... (next slide)

**How Much Does Mother
Nature Care About My
Opinion?**

Zero... that's how much!

- Mother Nature **doesn't** care about my opinion! Nor anyone else's.
- She cares about only one thing –
- **What is TRUE**
- It is WE who must learn and conform to Mother Nature, not to dogmatically demand the other way around
- It's up to us to use our Mother Nature-given abilities to discover **what is TRUE** as best we can accomplish, accepting the responsibility that we can make mistakes, and then as quickly as we can, acknowledge those mistakes so we can get on with getting it right.
- **It is arrogant for us to dictate to Mother Nature what is true, in violation of evidence.**

One of the Most Vivid Light-Bulb-Moments for Me...



In a crowded theater in 1985, seeing the premier of “Witness” ...

- In one scene Rachel (Kelly McGillis) says “But Mr. Book (Harrison Ford), you said we’d be safe here!” (after John Book discovers the killer he seeks is a colleague policeman, and things go bad) and he responds in a resounding voice:
- “Well I was WRONG!” while responding to the new Reality, with gusto and with action.
- I’d never heard such an admission made so undefensively, so naturally, so completely without apology, and with such enthusiastic willingness to instantly accept the new situation completely. No one in my childhood or neighborhood ever showed such a refreshing attitude.
- It made an impact on me!
- Again - It’s OK to make mistakes. We WILL make them! Learn from them and move on, with exhilaration! Being unwilling to accept the **responsibility for thought** leaves you vulnerable to those who want power over you, for whatever reason.
- And then you suffer THEIR mistakes, a much less exhilarating experience.

**So. Do you want the red pill,
or the blue pill?**





- *"You take the blue pill", Morpheus says, "and the story ends. You wake up in your bed and you believe whatever you want to believe. You take the red pill - you stay in wonderland and I show you how deep the rabbit hole goes. Remember, All I am offering is the truth. Nothing more."*
- **Take the Red Pill. It leads to a life that's fun and exciting, and successful in ways that count**

Now Hold On...

- A friend and professor advised me to take ***“The Matrix”*** slide out, as it calls up associations with Q-Anon, which I gather is a “conspiracy theory” group.
- I don’t follow these “Conspiracy Theory” groups. But **“The Matrix”** was an interesting thought-provoking film and did have this convenient way to lift the scales from your eyes – a red pill.
- It’s just a fun every-day reference.

PseudoScience ...

- When people use the trappings and jargon of science to lend an aura of credibility and high-mindedness to an otherwise bogus body of thought, we call this a pseudo-science
- Tarot cards, pyramid power, past lives, homeopathy, astrology, water divining,... the list is almost endless.

From Carl Sagan...

“Pseudoscience differs from erroneous science. Science thrives on errors, cutting them away one by one. False conclusions are drawn all the time, but they are drawn tentatively. Hypotheses are framed so they are capable of being disproved. A succession of alternative hypotheses is confronted by experiment and observation. Science gropes and staggers toward improved understanding. Proprietary feelings are of course offended when a scientific hypothesis is disproved, but such disproofs are recognized as central to the scientific enterprise.”

(continued on next slide...)

***“Pseudoscience is just the opposite.
Hypotheses are often framed precisely so
they are invulnerable to any experiment that
offers a prospect of disproof, so even in
principle they cannot be invalidated.
Practitioners are defensive and wary.
Skeptical scrutiny is opposed. When the
pseudoscientific hypothesis fails to catch fire
with scientists, conspiracies to suppress it are
deduced”***

**– Carl Sagan *“The Demon Haunted World”*
p. 37**

Astrology

- Astrology is an excellent place for us to pause and apply some science to a popular and astronomically relevant subject.
- It will illuminate some key ideas...
- A 2008 Harris poll found 31% of Americans believe in Astrology, and another 18% are “not sure”.
- That’s half of America!
- Amazing; but true.

Yet, belief has nothing to do with it

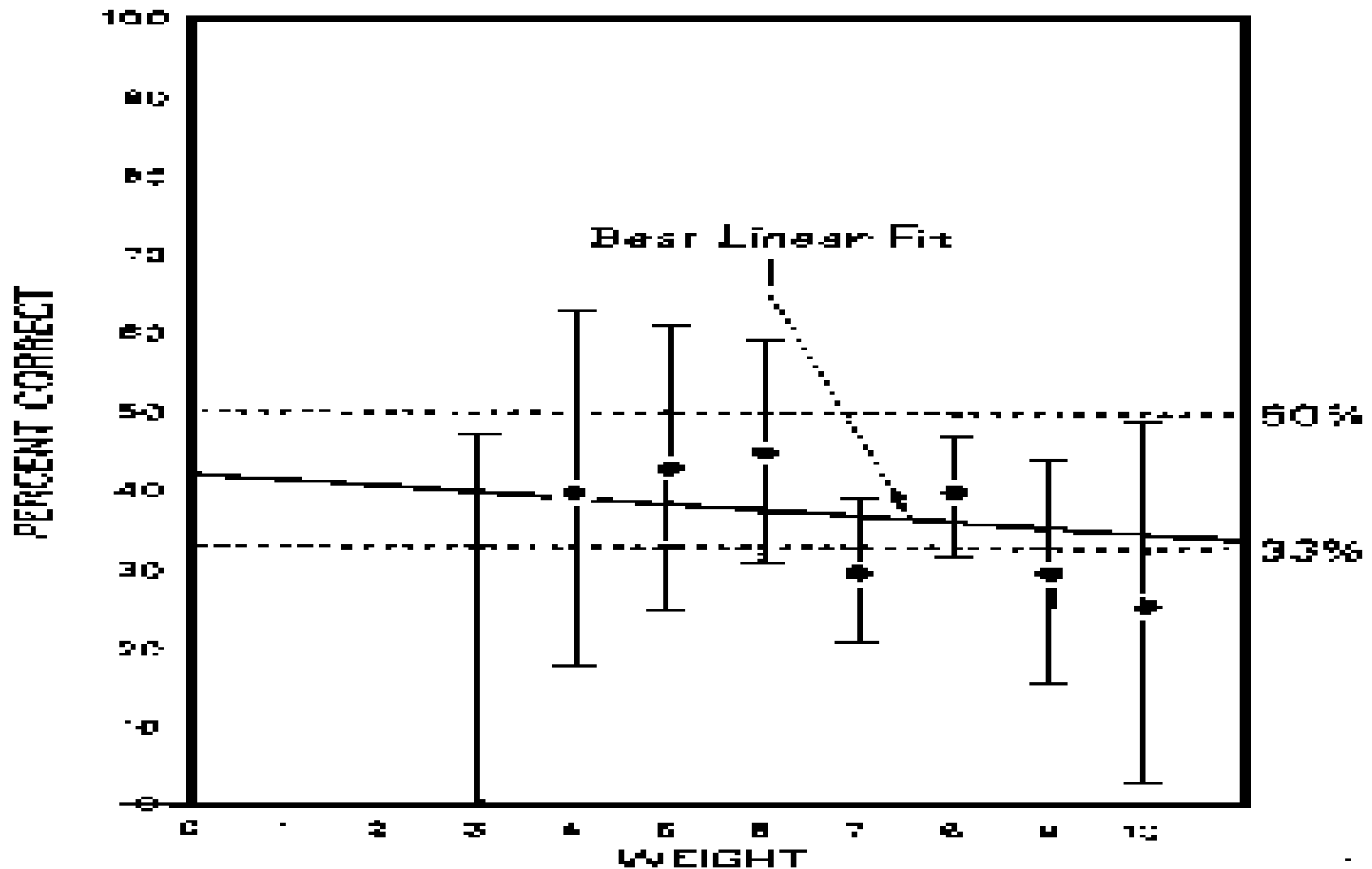
- **Astrology is testable** and therefore within the reach of science to make a solid verdict.
- It's been tested many times. **It fails – completely**. (see my link page later) How interesting that so few astrology fans in my experience have any interest in this telltale fact. Psychology, rather than a desire to really know, seems to be what's going on.
- Consider [MacArthur Award winner Dr. Shawn Carlson's test of Astrology](#), with the help of astrologers, back at UCLA in the mid '80's

- **28 astrologers selected by their peers as the best astrologers, and 116 real people**
- For each client's chart, astrologers were provided three anonymous personality profiles - **one from the client and two others chosen at random** - and asked to choose the one that best matched the natal chart. All personality profiles came from real people and were compiled using questionnaires known as the **California Personality Inventory (CPI)**. The CPI, a widely used and scientifically accepted personality test, measures traits like aggressiveness, dominance, and femininity, etc, from a long series of multiple-choice questions the person themselves fills out.
- Graph showing percentage correct vs. Weight for astrologers' first-place choices in CPI-profile natal-chart matching: The best linear fit of the data is consistent, within standard error, with the predicted line of zero slope. No significant tendency is shown for the astrologers to be more correct when they rate a CPI as highly matching a natal chart. In fact, if anything they were **LESS** correct.

- The study strenuously attempted to avoid anti-astrology bias by making sure astrologers were familiar with the CPI and by incorporating many of the astrologers' suggestions.
- At the same time, to prevent testers from inadvertently helping astrologers during the test, the project was designed to be double-blind, where neither astrologers nor testers knew any of the answers to the experimental questions.
- **Despite astrologers' expectations, the astrologers could correctly match on average only one of every three natal charts with the proper personality profile.**
- **This is the same proportion predicted by random chance.**

- In addition, astrologers in the study fell well short of their own prediction that they would correctly match one of every two natal charts provided, (which itself seems to show not much confidence... Really? You'll only bet on Astrology being right here just half the time?)
- **Even when astrologers expressed strong confidence in a particular match, they were NOT more likely to be correct, Carlson found.**
- **In fact, the MORE confident they were, the MORE often they were wrong.**

FIRST CHOICE



Weight: how confident the astrologers were that their guess of which person/chart matched was correct. High weight = high confidence. Notice that the more confident the astrologers were in picking the right astrological chart, the more often they were **WRONG**.

Astrologers participated strongly in the design and execution of the experiment, but note their reaction to the results

- *"The astrologists' reactions so far have been pretty much what I expected," Carlson told the [SKEPTICAL INQUIRER](#). "The astrologists whom I didn't test are saying that the test was not fair because I did not test them. Of course, if I had tested them instead, and they had failed, then the astrologers I actually tested would now be saying that the test was not fair because I did not test **them**."*

"I attended an NCGR party - I was the only non-astrologer in the house" - Carlson

- *- to discuss the research shortly after it was published. The discussion was, to put it politely, energetic. I have not yet received a serious scientific challenge to the paper."*
- The newsletter of the **American Federation of Astrologers Network** published a response in January (1986). *"I was very disappointed to see that it largely consists of **personal attacks,**" Carlson said. He said its few substantive criticisms are attributable to ignorance of his experiment, of the CPI, and of basic scientific methodology"*.

If You're an Astrology Believer

- ... here's where you can put into practice the proper mindset we've just talked about...
- Here's a [page on the science and evidence on whether astrology](#) actually works.
- Key take-away point: If there is no correlation (and no anti-correlation), then there is NO EVIDENCE of any cause/effect between planets and personalities.
- And therefore: NOTHING needing EXPLANATION.
- Feel no need to search for amazing, subtle, undiscovered mechanisms by which planets could affect personality. The time to do that, is only if there were EVIDENCE of correlation.
- NO CORRELATION means NO EVIDENCE, for any influence or cause/effect relationship

Don't be taken off guard by the claim “Correlation is not Necessarily Causation”

- True. But entirely irrelevant and misses the point. The point, is an entirely different statement – Zero correlation is strong evidence that there is no causation involved.
- In other words - correlation is a bare minimum for causation to even be a possibility.
- So, yes - correlation does not prove causation – true enough. But lack of correlation IS STRONG evidence there is no causation.

Natural vs. Paranormal

- If the mind works, then there's ONE Reality. Reality being that which actually exists. In other words, "the Natural".
- The idea of the paranormal provides no explanatory power. And postulating the paranormal de-motivates looking for a non-contradictory natural explanation.
- If we can't explain it yet, we work harder till we can. If the "paranormal", after rigorous testing, proves good, there may be more work to do to fill in the spaces between this and what is already well established.
- History shows the success of this work ethic.

“I do not feel obliged to believe that the same God who has endowed us with sense, reason, and intellect has intended us to forego their use.”

- Galileo

Claiming “Supernatural” is saying no natural explanation is ever possible for what you’re trying to explain, and that’s just plain arrogant

- **And conversely, it’s also a statement that your brain doesn’t work!** If your brain doesn’t work, then you can make no statement about the Supernatural. It’s self contradictory to make any claim at all.
- This last point is key – to start with the claim that your mind cannot be trusted to find Truth, invalidates the very claim itself, since it is **said by a Mind you have begun the sentence by utterly distrusting!**
- Realize too that **“What can be asserted without evidence, can be rejected without evidence”** (C. Hitchens)
- Here’s a great TED talk on how a **“Haunted House” actually was a house with a carbon monoxide leak,** which mimics the symptoms people ascribe to “feeling haunted”.

“But Rick – I believe that Belief System X is Completely True!”

- ...If someone says this, I will take them at their word... no argument from me; they're the expert on what they believe.
- But if instead they make a statement about **EXTERNAL** reality, and so is accessible to all of us, so that their claim is: *“Belief System X is completely true and all alternative such belief systems are False Beliefs!”*, then they must be bound by evidence and logic to demonstrate that contention if they want others to respect its supposed truth.
- And if you begin with the assumption that logic, reason, evidence have no validity – then you've just forced yourself back to the more limited statement at top of this slide. I would say to them – **“Please, then, phrase it correctly”**.

Systems: Open, and Closed

- A “closed” system is one in which we invent the primary building axioms and building blocks of that system. **All** of them. **We** make the rules.
- Examples are language, and mathematics.
- Within a closed system, you can do proofs*, since the boundaries of the system are defined by us, and so are known.
- *However, there’s a big proviso here. The very **appreciation** that you **HAVE** proved something, is and must always remain – a fuzzy squishy “light bulb feeling” inside your own brain, and **THAT** will always remain only indicative of validity by all the “proof’s in the pudding” arguments I’ve given before. It’s not “provable” as an absolute certainty of infallibility. Nature gave us reasoning, but it’s not a no-effort guarantee of infallibility.

But REALITY is NOT defined by us, it is OBSERVED by us, and we have to DISCOVER as much of it as we can, and to try on, to test out, rules that govern it.

- ... by observation, not by dogmatic fiat.
- And so final “proofs” are usually not possible.
- I’d been teaching these ideas for 34 years...
- And then in May 2020, I come to a [March 2020 interview of mathematical physicist Roger Penrose](#), commenting on something I’d not studied before: [Godel’s Incompleteness Theorem](#), and realized that these ideas I’ve been presenting are the essence of his central Incompleteness Theorem

Godel's Incompleteness Theorems

- ...state that within a logical system, not all true statements are provable. The Wiki article linked may seem forbiddingly formal and difficult.
- However, the interpretation, many contend, is simply that the algorithms of “proof” are themselves outside of the system, and therefore complicate assessing their truth.
- They rely on your FEELING the light bulb of understanding on seeing the evidence, and that takes commitment and personal growth...

As An Infant...

- We are still helpless, and
- We cry when we are uncomfortable, and count on someone else – Mom or Dad - to solve our discomfort
- And we cry louder if they don't immediately attend and solve our trouble.
- Not a pathology... just the way things are at that age (and that age only, we hope!)

One day in childhood, we wake up...

- And realize there's a world out there beyond our skin. Curiosity drives us to try to make sense of it, to make valid predictions, to survive and thrive.
- Slowly, we evolve beyond simply crying, signalling a caretaker to solve our discomforts
- We form hypotheses and we test them, and we can make mistakes. There's nothing in evolutionary biology that enforces a wished-for infallibility in that enterprise, only that with care, our batting average can be high.

- As an older child, we delight in exploring our physical world, gathering facts about it.
- As an adolescent and teenager, we begin to think in terms of principles.
- We appreciate the wider world in which we must live, and are motivated to find the principles which are in harmony with designing a happy life.
- By our late teens, while brains are still not yet fully developed, we begin to understand the World does not owe us a living.
- And that full self-confidence only comes from learning independent competence, and that using our minds is the path to this.

As a Full Adult...

- We discover there are laws which govern existence – not only physics laws, but laws of human biology and the resulting human psychology. We have a specific nature.
- We learn that the path to a happy life comes from mastering the understanding of these laws, and accepting them.
- We learn that self-confidence is earned by “proof’s in the pudding” successful thinking, and in the perfecting of our skills.

Some of us fail along this path to maturity

- Slowed, delayed, even aborted development can happen.
- It can happen through tragic circumstances.
- Or it can happen through failure of proper developmental thinking.
- And it can happen, unfortunately, by choice.
- If we see ourselves as helpless victims, we fail to see the new choices we could make, and instead stay stuck. Are we open to better thinking, or not? That's the issue.

The “algorithm” is Reason

- And it’s got a good track record. But effortless infallibility seems the yearning of too many philosophers, driven [anxious and depressed almost beyond endurance by Godel’s Incompleteness Theorems](#), for almost a century now.
- But scientists have moved on – Nobel physicist Richard Feynman says it well, by [great example](#)
- Evolutionary biology gave us a tool for understanding the World that is “good enough” to survive and thrive. That is what energy parsimony equates to; not perfection. That’s asking beyond the point of diminishing returns.

There is the unfortunate temptation to take psychological issues and turn them into philosophical verities.

- *“We know EVERYTHING, with certainty and minimal effort”*
- *“We know NOTHING. The mind is just a tool of self-deception”*
- Both are wrong. We can't escape the risk of making hard effortful thought, and yet still be wrong. It seems unfair, to some, alas. Nature says simply ... deal with it!

The proper response to someone who claims that the Mind is incapable of knowing anything is...

- ...show them that their incapable mind can't therefore be trusted to make ANY statements whatsoever, since there is no capability to draw the boundary of where your mind works and where it does not – not once you start by such basic distrust. That's a vital self-contradiction rarely acknowledged.
- Humans have clearly made incredible progress in successfully mastering the understanding of Reality, and that says our minds DO work, given proper care.

Logical Fallacies

- A logical **fallacy** is a pattern of reasoning that is consistently wrong due to a flaw in the logical structure of the argument.
- A logical fallacy is contrasted with what we may call an informal fallacy, which may have a valid logical form, but be false due to the characteristics of its premises or its justification structure.
- Here's [a pretty good list of logical fallacies](#)

Logical Fallacy Examples:

- **Argumentum Ad Hominem:** “Your claim is wrong because you’re a jerk!”
- **Argument from Divine Appeal:** “We can take your land because God ordered it”
- **Argument from Consequence:** “Human-caused global warming must be false because otherwise it would be too costly for me, or trample my freedom”
- **Argument from Ignorance:** “You can’t PROVE humans evolved from simpler life forms because we weren’t there to see it, so it must be false”
- **Argument from Motives:** “Osama Bin Laden wanted us out of Afghanistan, so we MUST keep up the fight”
- **Argument from the Club:** “I’m right, and if you don’t agree I’m going to whack you with this lead pipe!”
- **Argument from the Bandwagon:** “2 billion people believe in the Tooth Fairy, they can’t all be wrong”
- **Argument from the Big Lie:** A claim is repeated so often and is so outrageous, no one would say such a thing unless it were true.
- **Argument from Authority:** Valuing authority badges over evidence or truth. “Dr. Nolthenius has a PhD, so he MUST be right!”
- **Argument from Missing Bad Premise:** “When did you stop beating your wife?” (assumes you ever STARTED beating your wife in the first place).
- **Argument from irresponsibility:** “Yeah I was absent Monday, but you can’t ding my attendance record - I was too hung over from partying!”
- **Argument from Effort:** “I deserve an A, because I worked hard on that assignment!”
- **Argument from Equivocation:** Using a term deliberately in a way the audience will understand differently than the truth, like Clinton’s defense in the Monica Lewinsky affair
- **Argument from Stereotyping:** “Women are better housecleaners than men”
- **Guilt by Association:** “He’s a Republican, so you can’t trust anything he says”
- **Lying with Statistics:** “Gas prices are cheap! As a percentage of the National Debt, gas is far cheaper now than 50 years ago”.

Science: Is Asking Nature Herself What is True

- In nearly all areas, we're all scientists (or should be)
- Clear thinking is a skill and a good habit... and it's exciting and fun too.
- It feels so good to let go of all those filters to knowing, filters having to do with your fears or tribalism, and simplifying your priority to just:

What Is The Truth?

Now, how you emotionally feel about that truth is also an important question. But it's a very different one and it should be asked at a different time. Not when you're trying to figure out **WHAT** the truth **IS**.

Confronted with Uncomfortable Truths?

- We'll first respond (as every healthy human does) by experiencing our feelings about that truth.
- Psychologists show that our feelings are a kind of instantaneous summing up of whether what's in front of us is "for us" or "against us" according to our genuinely experienced values.
- But are they valid values? So...take those feelings and place them off to one side, and then ask the key questions...
- **Is this true? What's the evidence? Does it fit with well-verified knowledge I have or can gather. How can I energize and raise my awareness and engage my Desire for Clarity here?**

- But far too many of us have failed to reach true adulthood... and react only from our feelings. Feelings which may proceed from our biases and be less concerned with truth. Perhaps use our feelings as a manipulative weapon against others in order to shut down the source of an uncomfortable truth.
- Institutionalizing this orientation is increasingly being recognized as highly dangerous - it's saying that you will never again learn anything important **that is new**; so anything challenging your current belief system is to be shut-down immediately without debate.
- Colleges and Universities used to be places where evidence, logic, and analysis was practiced to arrive at Truths. That culture, unfortunately, has changed

“IN SCIENCE IT OFTEN HAPPENS THAT SCIENTISTS SAY, 'YOU KNOW THAT'S A REALLY GOOD ARGUMENT; MY POSITION IS MISTAKEN,' AND THEN THEY WOULD ACTUALLY CHANGE THEIR MINDS AND YOU NEVER HEAR THAT OLD VIEW FROM THEM AGAIN. THEY REALLY DO IT. IT DOESN'T HAPPEN AS OFTEN AS IT SHOULD, BECAUSE SCIENTISTS ARE HUMAN AND CHANGE IS SOMETIMES PAINFUL. BUT IT HAPPENS EVERY DAY. I CANNOT RECALL THE LAST TIME SOMETHING LIKE THAT HAPPENED IN POLITICS OR RELIGION.” — CARL SAGAN

”After I give lectures - on almost any subject - I am often asked, ‘*Do you believe in UFOs?*’. I’m always struck by how the question is phrased, the suggestion that this is a matter of belief and not evidence. I’m almost never asked, ‘*How good is the evidence that UFOs are alien spaceships?*’.”

- Carl Sagan, “*The Demon Haunted World*”, p.78

Nobel physics laureate Richard Feynman, after his elegant and unexpected public demonstration of the flawed “O” rings as cause of the 1986 Challenger Space Shuttle Disaster to a knowing but embarrassed NASA panel in front of TV cameras and the press... had this great quote:



For a successful technology, reality must take precedence over public relations, for nature cannot be fooled.

(Richard Feynman)

Dogmatic Thinking

- Defining yourself by clinging to an idea of unknown validity is a guaranteed path to living in fear, even if you might think it's a warm security blanket.
- **Ally yourself instead to only this idea: I will define myself as someone who abides by a sincere desire to know “Whatever the truth is”**
- Then you are free – free to change your mind as the facts change. Free of anxious worry someone will prove you and your very soul to be wrong.
- You've dis-engaged your very soul and your self-identity from dogmatic adherence to belief systems of unverified validity.

The Wisdom of Non-Attachment

- If an idea you held is wrong, you can let go easily because you never let it **DEFINE** you in the first place.
- Pause and appreciate the power of that statement!
- The great spiritual insights of Taoism and Zen, recognize the inner peace that comes from non-attachment (non-attachment is not indifference!). Focused awareness with letting go of critical self-judgment and egotism.
- For more, see my essay “[On Teaching](#)”, also linked on my home page.

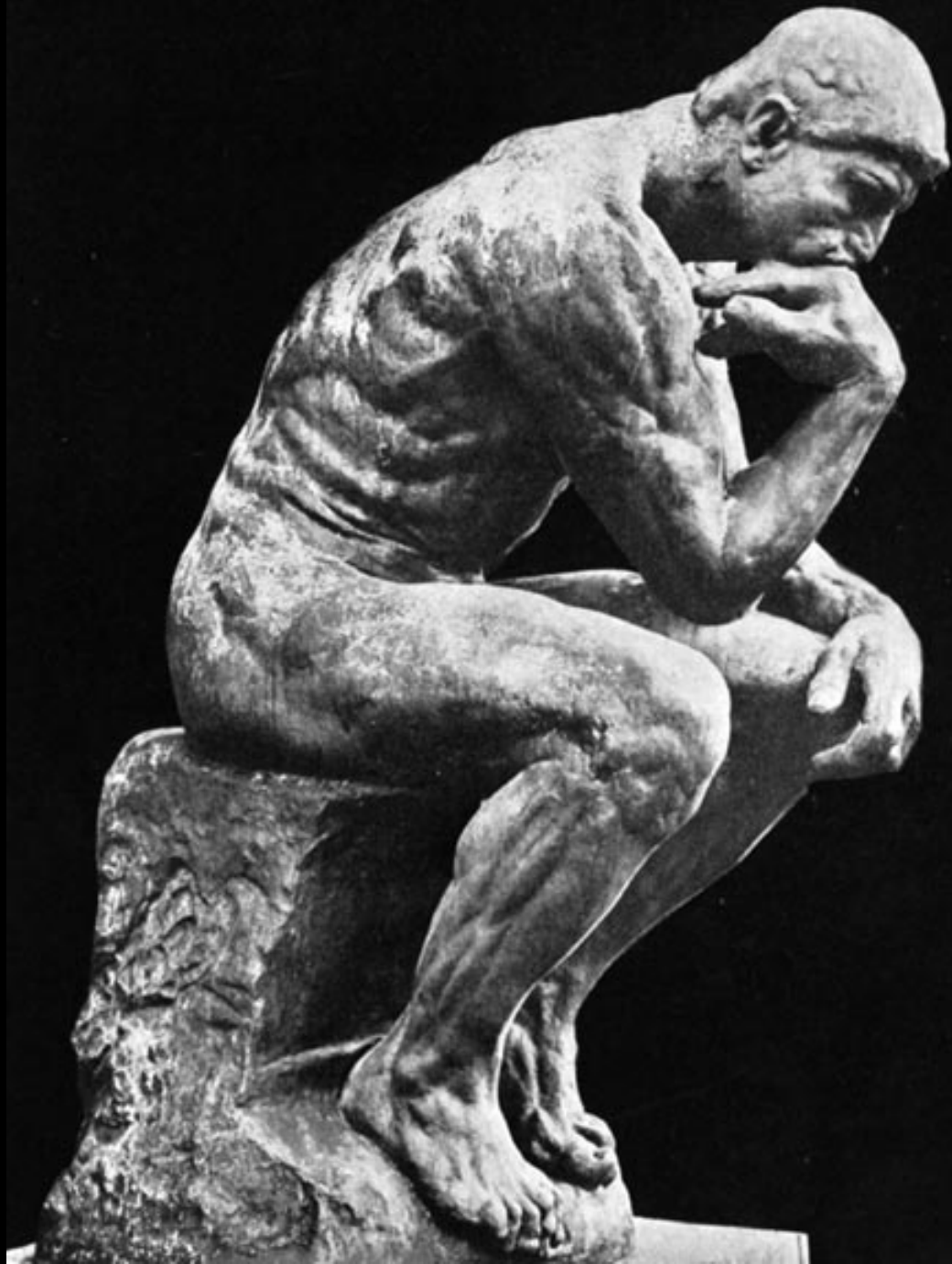
It's OK to acknowledge “*I don't know*”

- Be clear on what you have understood, what you know to be false, and what is still not understood by you.
- Don't be so quick to grasp at a false explanation just to have an explanation. Being able to firmly put an idea into the category “*I need more thought, more investigation to make a judgment for this one*”, is a necessary and relieving thing to do.
- Since genuine understanding takes effort, takes careful investigation, takes perhaps advances in technology... **it takes time, takes patience!**

Being Awake and Aware is a Good Thing!



Good!



Not good



3 Primary Modes of Representing Reality in Internal Experience

- **Visual (pictures, movies)**
- **Auditory (sounds)**
- **Kinesthetic (a visceral sensation using your proprioceptive system)**
- Practice all three. Ponder the best mode for the job at hand.
- Don't accept the popular notion that you are hopelessly wired into some one favored mode and the world must bend to you. That's a rather condescending (and [disproven](#)) notion.

What Science is, and Is Not

- First; don't confuse "science" with individuals who are job classified as scientists! For example, corporate science can often be an oxymoron. See [here](#)
- Here's a link to a good examination of [popular stereotypes of scientists](#)
- Science: It's not nerdy factoids, or geeks in white lab coats...

...or big equations

$$\frac{\partial \rho}{\partial t} + \frac{\mathbf{p}}{m} \cdot \nabla_{\mathbf{x}} \rho + \mathbf{F} \cdot \nabla_{\mathbf{p}} \rho = 0.$$

$$\frac{d\rho}{dt} = \frac{\partial \rho}{\partial t} + \sum_{i=1}^d \left(\frac{\partial \rho}{\partial q^i} \dot{q}^i + \frac{\partial \rho}{\partial p_i} \dot{p}_i \right) = 0.$$

...or Hollywood stereotypes



Peter Sellers George C. Scott

STREET

Dr. Strangelove

Dr. How I Learned to Stop Worrying And Love The Bomb

...or Evil
Doers...

...The Essence is Very Simple

- It's asking Mother Nature herself what is the truth about things, rather than your wishes or agendas, and being willing to accept Her answer.
- The *Art* of Science is to find how to ask Her as carefully and revealingly as you can muster
- This is as true in “soft” sciences as “hard” sciences.
- Even in a tricky and subtle science like psychology, if your sincere top priority is to know the truth, you can buckle down and handle the challenges of confronting your biases and self-made blind spots, at least to a significant extent.

Scientists: They're regular, fun, and, good people! Like my astronomer friend Stephane (Queens University, Canada)...



...and this geneticist, who's a Harvard professor, and a rock star with an award from Billboard magazine



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Profile: Pardis Sabeti

By night she's a rocker. By day, she's a Harvard geneticist tracking the evolution of the human genome.

[→ The Musical Geneticist](#)

Find out more from the woman who says the key to her success is that she "sticks around things" she loves. Read [highlights](#) or the [full interview](#).

[→ Ask the Expert](#)

Pardis Sabeti of the Broad Institute answers viewer questions about her life, music, and scientific research.

Watch the Segment

Watch the program July 2 on PBS, or come back beginning July 3 to watch it online here.

- [Links & Books](#)
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**...and Dr. Emily Shuckburgh – climate scientist
and head of the British Antarctic Survey**





**Or Dava
Newman,
MIT Professor of
Astronautics**

Or these guys... er, wait – those are actors



Particle physicist Tom Haine - Johns Hopkins University



Or Prof. Beth Brown – NASA astrophysicist
who specialized in the high energy universe
using satellite missions



Steps of the Scientific Method

- We always begin with
- **1. Observations...** then the brain/mind will look for patterns, to form questions about why this pattern happens
- From a set of observed phenomena, we...
- **2. Form a hypothesis.** A hypothesis is a mechanism which, if true, can reasonably account for the observations.

For too many non-scientists, this is where the process ends

- They like their hypothesis, and they cling to it, even self-identify with it, if it relates to their favored psychological or political/philosophical bent.
- But science wants (and you should want) to know not if it's likable, but if it is true. Science asks Nature if the hypothesis is true, by identifying **tests: looking for logical, observable consequences of the hypothesis**

The essence of science is identifying how to TEST your hypothesis to see if it's in conflict with Observed Reality

- We ask “well, IF this hypothesis **X** is true, then we ought to be able to see **Y**.”
- And we then ponder what experiment could most convincingly reveal **Y**, or conversely, show that **Y** absolutely is not part of Nature, and so **X** can be ruled out.

The Scientific Method – The most efficient way we've found to get the “Light Bulb” experience of genuine understanding

Rock star Nobel Prize winning physicist and speaker, the late Dr. [Richard Feynman – an entertaining 9 minute YouTube on The Scientific Method](#)

- “*Science is what we do to avoid fooling ourselves*” – Richard Feynman
- Test and test again. Ask Nature herself if your hypothesis is valid. If it fails even once, then you've “**RULED it OUT**”. Time to find a new hypothesis.
- But if it passes every test put to it, a hypothesis graduates to the status of a **THEORY**

A Theory ...

- Needs to be taken seriously as a contender for Truth
- It's no longer a guess, it's no longer an arm-chair speculation, it's already passed every reality-based test we've put it through. So it's got to be on the "short list" of contenders for final Truth
- The popular press confuses the term "theory" with "hypothesis", as in "*Oh, that's just a theory*". Wrong! But, understandable I suppose because we love short words full of vowels and not long awkward ones
- Even scientists sometimes get sloppy here, as in "String Theory", which is in fact only a hypothesis which not only hasn't been tested, it may be untestable!

What is a GOOD Hypothesis?

- **1. First and foremost, it must be FALSIFIABLE.** In other words, if it is false, there must be an observational test which shows it is false, even if the test is technologically too difficult at the moment.
- This is where hypothesizing supernatural beings who are omnipotent and all-knowing and yet also undetectable and boundary-less, fail. Such vague supernatural hypotheses are not falsifiable (which does not mean they cannot still be ruled out, on the illogic of the supposed defining characteristics of the supernatural beings. **They can be self-contradictory to the very meaning of the defining words used**)

2. Predictions Should Be Specific

- By this, we mean that the hypothesis must be defined and must have de-limited characteristics.
- ***“If correct, this hypothesis predicts you will see THIS”*** rather than *“If correct, you should maybe see something kinda similar to this sort of thing here”*
- To put it loosely, **your hypothesis must SAY something.**
- If the hypothesis never gets farther than vague, flowery language, it’s just too pat, too conveniently untestable. It can be excuse to give credibility to what is, in fact, **incredible**

3. Predictions Should Ideally be Unique

- In other words, your hypothesis has at least one do-able test whose result is not predicted by any other conceivable explanation. Then, if it passes this test, you will have some confidence this may in fact be *the* correct explanation.
- Uniqueness may or may not be possible, but it's exciting to other scientists if it is – we all want to do work which really advances our knowledge and rules out wrong ideas.

Characteristics of a Good Scientist

- He should accept the Reality of an objective world beyond himself, accept that Reality is not just a figment of his imagination
- He should have an over-riding **Desire for Clarity of Understanding**
- He should have strong curiosity of how things work
- His #1 priority is first, to discover the Truth is, not how he feels about it
- He should accept gracefully that he may not be emotionally comfortable with all his scientific conclusions, and that that is no reason to reject their truth.

Occam's Razor

- ***“Given two or more ideas, all of which are consistent with current observations, the one which is simplest (least conflicts with current best evidence) is most likely to be true”***
- It's not foolproof, but it has proven to be an efficient guide to finding decent hypotheses...
- Note – “most likely”: Nature isn't obliged to obey your notions of simplicity. But it's shown by experience to be the best bet for allocating scarce resources of scientific time and money to take as a good working hypothesis for what's right, until shown wrong.

Savage Chickens

by Doug Savage



©2007 BY DOUG SAVAGE

OCCAM'S RAZOR!

Sagan's Corollary

**“Extraordinary Claims
Should Require
Extraordinary Evidence” –
Carl Sagan**

Sagan's Corollary

- ... is the best protection against getting pulled in by those who want you to buy into their (perhaps poorly motivated) belief system
- Example: The claim that climate change is NOT being caused by humans, when the evidence says so strongly that it is. Don't expect to be taken seriously unless you can **SHOW** why the evidence is either wrong, or badly mis-interpreted, and do so in some detail.
- Don't expect "***proof by loud assertion***" to carry weight with thinking people.
- Claim that the light in the sky you saw last night was a spaceship from another planet? You'd better show convincingly that all more conventional explanations fail. If all you have is your memory and no objective recorded evidence – you should expect heavy skepticism!

OK. Science in Every Day Action...So How Do You Evaluate the Validity of Claims You Hear Out There?

- Consider a medical claim - something that all of us, future scientists or not – will face regularly.
- Consider a claim that some sort of diet or nutrient will relieve your pain.
- We all confront this one, who hasn't had a pain and wanted to fix it?
- Here's what I do...

- First, I'd google it and find the most reputable link on the list, and read it.
- I'd search to find published science JOURNAL papers on this claim.
- I'd pay attention to whether the "journal" was a real and well respected medical journal, or instead was a "trade journal", which are outlets supported not by scientific societies, but profit-driven corporate money.
- If I could find nothing but blog sites, promotionals, and trade journal claims, I'd be pretty skeptical.

The Placebo Effect

- Pain is our organism's signal that something's wrong and we need to "up" our awareness and do something, identify and fix what's wrong.
- If you DO something, even something which in fact does not medically alter the problem, but you believe it will or likely will, or even just might... then your organism dials down the pain signal to some extent.
- Your stress levels may reduce as well, improving your cortisol levels (chronic stress is a well-verified danger to physical health) and helping you in fact heal to some extent perhaps.
- Both of these effects are part of **The Placebo Effect**
- **But if in fact your problem needs pharmaceutical or other real therapy to begin the healing process, your pain will eventually come back later.**

If I found a study on this claim in a high-quality peer-reviewed science journal, like JAMA or NEJM...

- I'd look to see if the study had a large sample of patients
- I'd look to see if it was placebo-controlled. This is vitally important for any malady based on pain perception especially.
- I'd look to see if it was "double blind", so neither patient nor doctor knew if they were getting the real stuff until after the study was over, to further guard against psychological influences from the physician on the patient.
- And, I'd look to see how the study was funded. If it was funded through private profit-oriented corporations, I'd have to look closer
- If all of these were satisfied, and it showed a real effect, I'd tend to accept it.

Industry-Sponsored “Science” Can Instead Be Agenda-driven Non-science

Independent Science Shows Harmful Effects from BPA, while Industry Science Shows None

A recently-published review of scientific studies shows that, in the last 7 years (through November 2005), 151 studies on the low-dose effects of BPA have been published.(37) None of the 12 studies funded by the chemical industry reported adverse effects at low levels, whereas 128 of 139 government-funded studies found adverse effects. These many studies were conducted in academic laboratories in the U.S. and abroad. Even the 12 industry-funded studies have flaws, however. Of the industry studies, two had their positive controls fail—an indication that the entire experiment had failed, not that BPA had not caused an adverse health effect.

	<i>Adverse health effect</i>	<i>No effect</i>
<i>Plastics Industry funded</i>	0	12
<i>Government funded</i>	128	11

Another industry study concluded BPA caused no adverse effect, but an independent analysis of the experiment's data by scientists convened by the National Toxicology Program of the U.S. Department of Health & Human Services concluded that in fact there was an adverse effect. Industry scientists had misreported their own results. The chemical industry relies on an incomplete review of scientific studies by an effort funded by the American Plastics Council at the Harvard Center for Risk Analysis. The panel funded by the American Plastics Council only considered 19 studies in concluding in 2004 that the weight of the evidence for low-dose effects of BPA was weak.(38) As of November 2005, there were 151 published studies on the low-dose effects of BPA.

So, does the new skin cream work?

Result

Rash Got Better Rash Got Worse

Patients who did use
the new skin cream

223

75

Patients who did not
use the new skin cream

107

21

No

Result

Rash Got Better Rash Got Worse

Patients who did use
the new skin cream

223

75

=75%

Patients who did not
use the new skin cream

107

21

=84%

Only 75% who used the cream got better, but 84% who did NOT use the skin cream got better! Now, for extra credit, how will the Big Pharma company who makes the skin cream spin these results?

If the substance wasn't patentable, there may legitimately be no group wanting to spend for a good large-scale study, even if it actually works. Profit, risk/reward, alas

- If it has a plausible, reasonable medical rationale for why it should work, and...
- If it's cheap, ***and if it's harmless***, I'd be willing to give it a try...
- I'd be careful to try to have no expectations either positive or negative, but instead to be neutral, as I waited to see if it relieved my symptoms.
- I'd try "serial trials"; going on it for a time, and then going off it. I'd do it several times, and see if my symptoms changed.

I'd avoid the ***“Rick swears by this stuff!”*** syndrome.

- Even if it seems to work, I'd remain open minded to evidence I'd fallen into the **Placebo Effect**. A sample size = 1 is hard to draw firm conclusions from!
- Still, there's many spices and herbs which have clear larger scale evidence of helping brain function and other benefits through the anti-oxidant mechanism, which is quite reasonable and not paranormal.
- One I just read today is on the memory and mood improvements from including the [orange Indian spice turmeric \(which has curcumin\) in your diet](#) (add black pepper and oils for better absorption). It's not the most flavorful spice in the whole world, but it does add nice color, and an earthiness to many dishes.

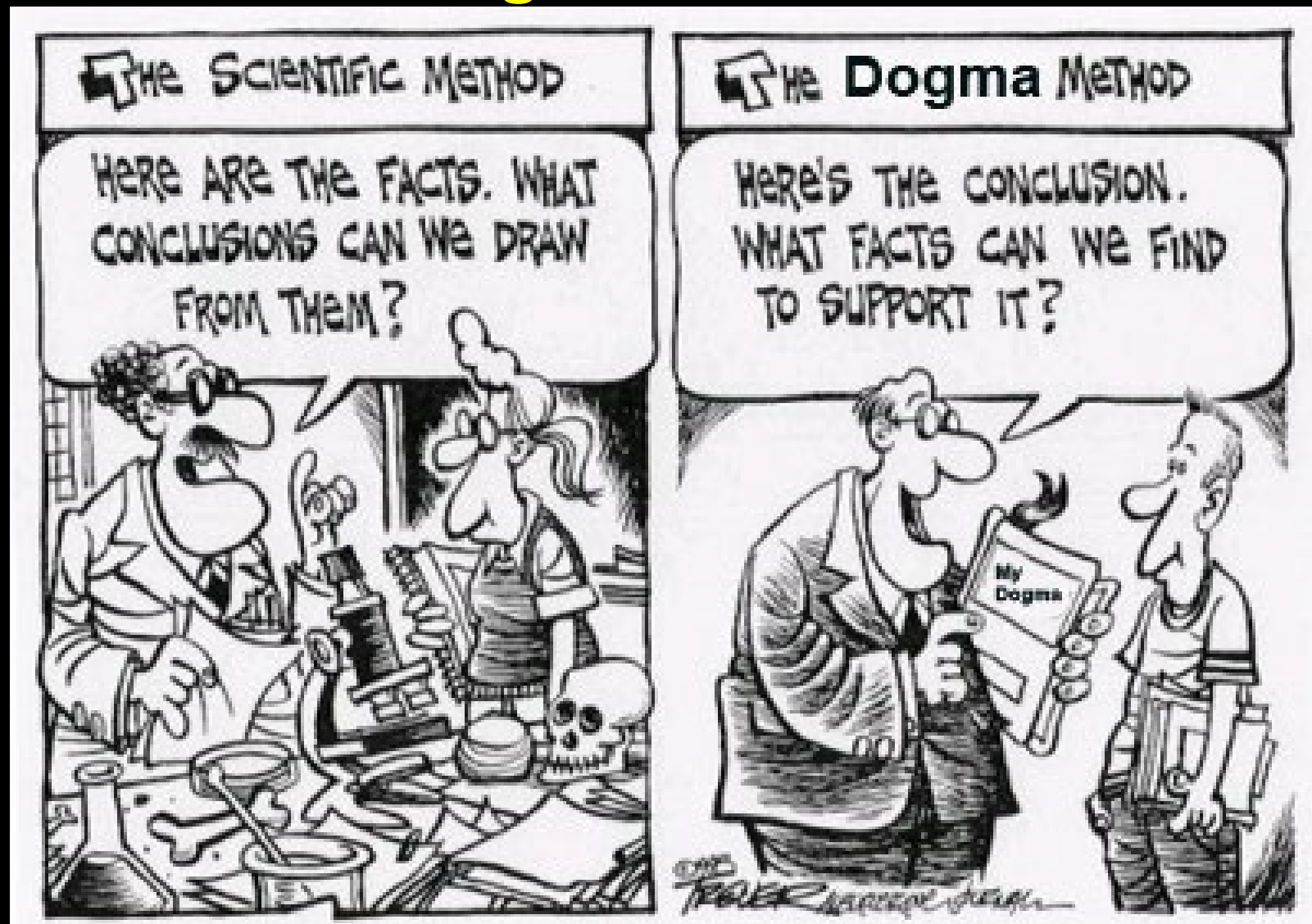
Suppose We're Evaluating a Claim on Climate Change – a Current Issue Full of Well-Publicized but Worthless Claims from Ideologically-driven Interests

- First, I'd look at the source of the claim: scientific journal? or instead fossil fuel corporate-sponsored “trade journal”, right-wing “think tank”, op/ed, or climate denial blog?...
- If any of the latter, and if it was along the expected direction of minimizing or denying human-caused climate change, I'd take note that this study probably was submitted to a real journal and rejected; the quality was not up to snuff.
- Authors will always want to have their work published in a real journal if at all possible, especially if corporations are paying the page charges.
- And I'd note the blatant conflicts of financial interests.

- If it was important and I didn't already know of conflicting evidence, I'd google to find other sources, most especially...
- ...I'd look for it in scientific journals (Nature, GRL, PNAS...) and if THEY confirm the claim, I'd tend to accept it. If there were differing conclusions from other good studies, I'd stay agnostic for now.
- I'd look at the funding of the authors. It's rare not to see the funding agencies acknowledged at the end of a paper. If funded by right-wing or fossil fuel interests, I'd again be very skeptical.

- To help clarify, I'd google and look for other commentary on the paper, with preference to commentary or re-analysis by actual climate scientists.
- I'd look for entries especially in [Realclimate.org](https://realclimate.org/), a blog run by climate scientists, and read the debate there, and follow up on relevant published citations.
- I'd look to see if the authors were employed in academia, where research tends far more to be unbiased and truth-oriented.
- If they were employed in private industry (where the profit-motive rules the decisions), I'd check to see what conflicts of interest there may be.

Don't allow yourself to be manipulated, and don't manipulate others. Be truth-driven, not Agenda-driven



At your Leisure, take a look at a Good Paper Published in a Peer-reviewed Scientific Journal

- [Here's a cool one](#), on a high resolution search for planets around binary stars, The **TATOOINE Project!**

Bayes Theorem

- In order to assign a “weight of evidence” quantitatively in a scientific investigation - a probability for a conclusion to be correct, given certain evidence, Bayes Theorem is central.
- [Bayes Theorem](#) relates the probabilities of conclusions given the probabilities of prior building blocks within the hypothesis, and vice versa.
- It's beyond the scope of this non-mathematical course to go further, but the theorem was first worked out by Thomas Bayes in 1763 (and independently by the great French mathematician Simone Laplace a few years later).
- With the advent of capable computers in the second half of the 20th century, it is now widely used in all of science, including astronomy.
- Proper use can give surprising results – Example: suppose a drug test gives 99% valid positive results for drug users, and 99% valid negative results for non-drug users. Suppose further than 0.5% of people are in fact drug users. So, assume a randomly selected person is tested and tests positive. What are the odds that he really is in fact a drug user?

You're perhaps thinking the answer is roughly 99%?

- The correct answer is: **33.5%**
- Surprised? Teased?
- If you like math, read here about the details of [Bayesian Statistics](#).
- And here's a good compilation of links to astro and [science-related importance of Bayesian Statistics](#)

Frequentists vs. Bayesians

DID THE SUN JUST EXPLODE?
(IT'S NIGHT, SO WE'RE NOT SURE.)

THIS NEUTRINO DETECTOR MEASURES
WHETHER THE SUN HAS GONE NOVA.

THEN, IT ROLLS TWO DICE. IF THEY
BOTH COME UP SIX, IT LIES TO US.
OTHERWISE, IT TELLS THE TRUTH.

LET'S TRY.
DETECTOR! HAS THE
SUN GONE NOVA?



FREQUENTIST STATISTICIAN:

THE PROBABILITY OF THIS RESULT
HAPPENING BY CHANCE IS $\frac{1}{36} = 0.027$.
SINCE $p < 0.05$, I CONCLUDE
THAT THE SUN HAS EXPLODED.



BAYESIAN STATISTICIAN:

BET YOU \$50
IT HASN'T.



Nerd-humor. (You have to realize the “neutrino detector” keeps the rolled dice hidden). And you only lose \$50 if you also die at dawn!

From “On Teaching”

- Please read my online essay “[On Teaching](#)”, which says more about my philosophy of teaching, and also about proper teaching of science. For here, we’ll just borrow a quick look...
- **BIAS.** What is BIASED teaching?

Unbiased = Accurately Aligned with the *Weight of Evidence*

- **BIASED** teaching in science, is teaching which fails to present the actual “weight of evidence” for/against an idea. Whether by intent or by failure to prepare.
- “Unbiased” does NOT mean you give equal credibility to all ideas or all proponents of ideas in a given area. That’s not “unbiased”, it’s cowardly and may also be abject “political correctness”.
- Classic modern example: Is today’s global warming caused by human actions or not? A science-ignorant press, and poorly motivated instructors, may give you both sides as if there’s a genuine scientific debate. – the truth is, the scientific debate was settled many decades ago – WE are causing global warming. ALL of it! The “other side” (~<2% of climate science workers) is largely funded by Big Oil and right-wing think tanks. See [The Politics and Science of Climate](#)

Martian canals – seeing what you want to see? The eye/brain in 1888 thought it saw little hints of dark spots which the brain connected into “canals”. Hubble Space Telescope shows otherwise



The “Face on Mars” – The Brain is a pattern-making organ. Don’t let flim-flam artists use this against you (next slide with better camera)



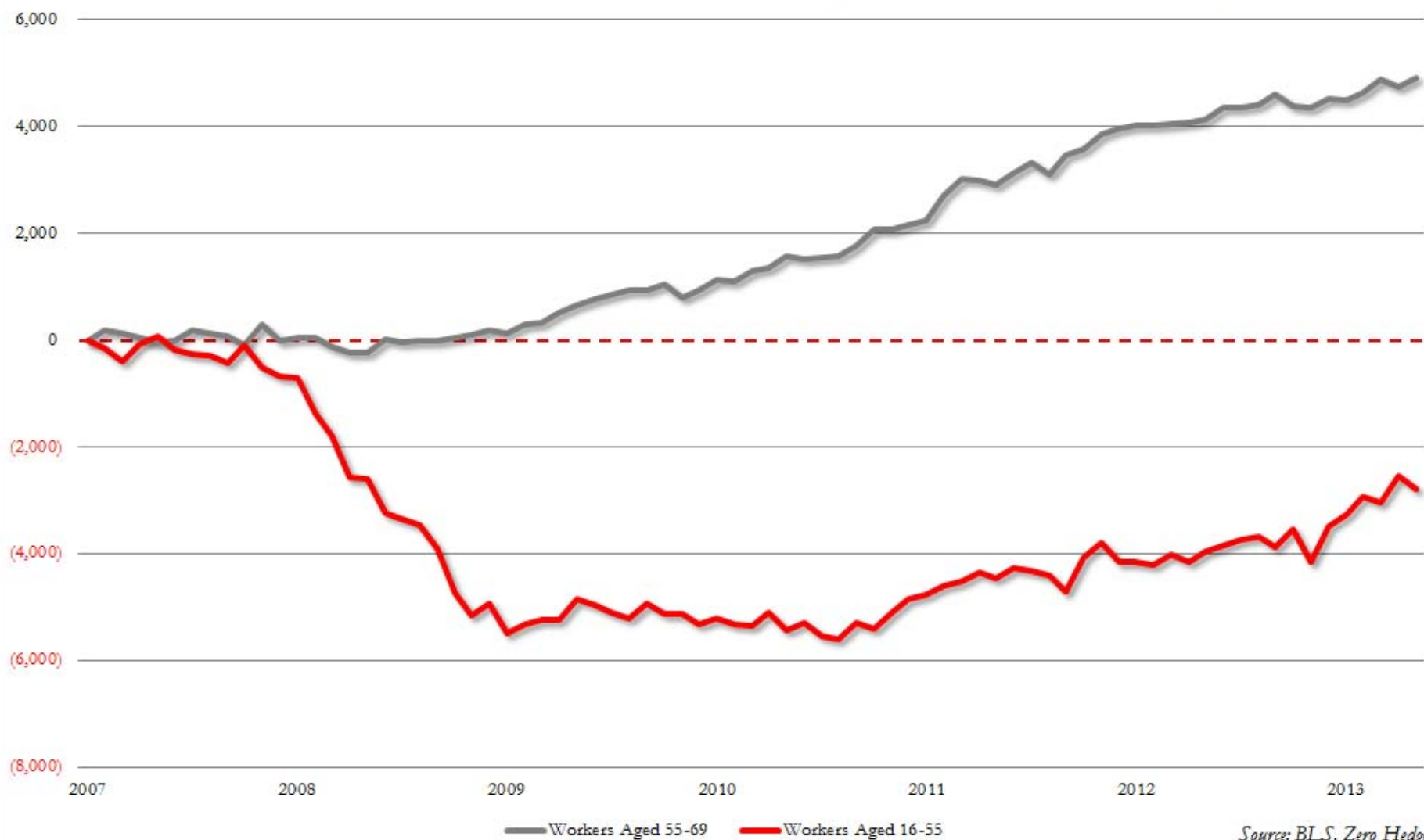


Clear Thinking – It's How to Get a Job Too

- According to many recent studies, American schools give students a very inflated notion of their competence, vs. the reality.
- There are political motivations, as well as misguided but well-meaning attempts at raising self-esteem which encourage this.
- In fact, genuine self esteem can only come from knowing you are well-anchored to reality and trained yourself in the proper use of your mind.
- In today's job market, the ways of those “old fashioned” schools of yester-year are more in demand by employers. Inflated notions and inflated grades don't go very far with those who are paying real money for real results.

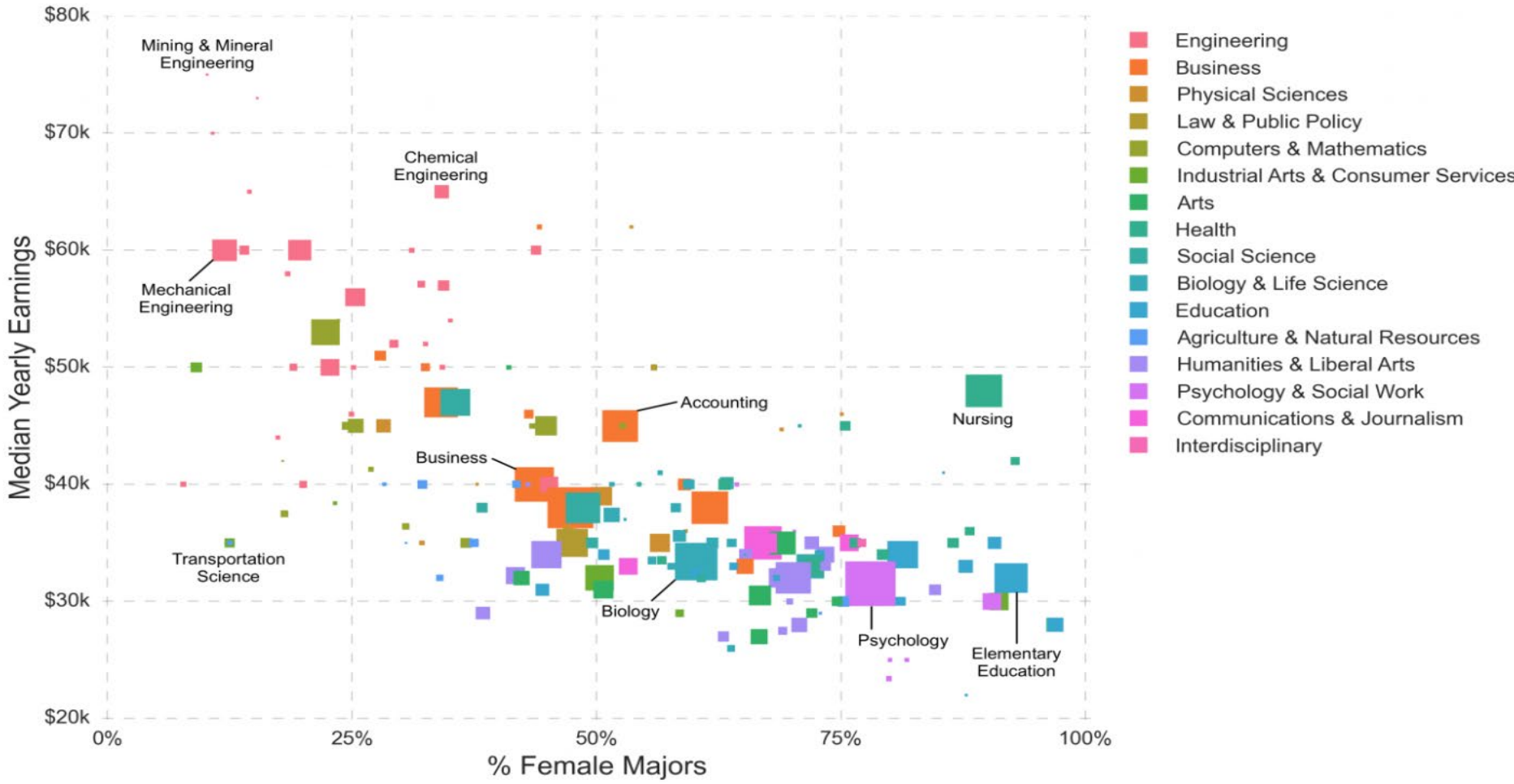
Since the Great Recession – Younger Workers Not being Hired Near as Much

Cumulative Workers Added: 54 and Younger vs 55 and Older ('000s)



Recent Graduates: Salary and Gender Ratio: There's two very discouraging patterns here. Can you spot them?

U.S. college majors: Median yearly earnings vs. gender ratio



Data source: github.com/fivethirtyeight/data/tree/master/college-majors
Author: Randy Olson (randalolson.com / [@randal_olson](https://twitter.com/randal_olson))
Notes: Each square is a college major sized by the square root of the number of recent graduates
The largest major, Psychology, has had 393,735 recent graduates

On the Subject of Choosing Your Life's Work

- When I think of mistakes I've made along the way, it always comes back to this imperative...
- **Think of what you can do with your life that will surround you with QUALITY PEOPLE.** People who can inspire you, you can learn from, who are better than you in important ways. And follow your personality too – that's what science says.
- We need inspiration, above all else, to make a real Go of life. Ideally we find it not only in great art, but in our present experiences with real people - People who have learned important truths that you may not yet have learned, who can teach you by living example.



Young people on mobile phones (stock image).

Credit: © akhenatonimages / Fotolia

Happiness is not a warm phone, according to a new study exploring the link between adolescent life satisfaction and screen time. Teens whose eyes are habitually glued to their smartphones are markedly unhappier, said study lead author and San Diego State University and professor of psychology Jean M. Twenge.

Forget the ear buds, the video games, the chattering distractions that the commercial interests want to hook you on, while they take your dollars and leave you endlessly unfulfilled –

That's right where they want you!... So you'll be primed to buy the “next big thing” in a new (vain) hope of finally being fulfilled. **Higher FaceBook use is correlated with lower emotional and physical health** (2019)

I can't help wondering...

- ...if this kind of research is related to other studies showing that poor mental skills when teenagers is predictive of later development of Alzheimer's Disease ([Huang et al. 2018](#)).
- It's not genetic, it's cultural. And the Great American Mind has long since left, as we descend into a new Dark Ages. [American students are fully 4 grade levels behind their Chinese counterparts in the language of Nature: mathematics.](#)
- Exercise your mind... use it, or lose it.



Happiness, at a primal level, comes from intimate awareness and connection with what is REAL. We're designed to operate best in **REALITY**. Because ultimately we know, in the privacy of our own minds, when we're fooling ourselves, and it's an unhappy place. We relax and return to health, by simple focused awareness. Zen masters realized this centuries ago

The Universe Revealed by Science... IS Magical

- But Astrology and other bogus pseudosciences? It's time to let go. Let's evolve...
- You want to go slack-jawed with awe? Ponder quantum mechanics, study modern cosmology, the Multi-Verse!
- Science is much MORE magical because it is Nature herself talking to us, not make-believe. When you see a great, inspiring film, isn't it much more inspiring if you learn it is a **true** story?
- And the best reason... science is just plain FUN.
- So: toss dogmatism, learn to be humble (don't dictate to Nature what she is and is not), enjoy the mysteries, and re-assume the responsibility of independent thought.
- Get comfortable with a certain amount of uncertainty, and give respect to ***the weight of evidence***,
- Be open minded... but....

Consciousness – It's not As Cosmic as You May Have Been Led to Believe

- A lot of “New Age” pseudo-science was given license to flourish by an old interpretation of Quantum Mechanics that is thankfully being abandoned.
- The “[Copenhagen Interpretation](#) of Quantum Mechanics” included the notion that conscious observation collapsed the Schroedinger Equation wave function to a discrete fixed clear observation. It seems to give some sort of cosmic primacy to “consciousness”.
- But it never made sense, and the alternative – the “[Many Worlds](#)” interpretation just seemed to have way too many worlds!
- But now, we're appreciating that this boggling interpretation actually is more parsimonious with basic quantum ideas, and shows the deep contradictions in the Copenhagen Interpretation, there is a growing interest and support.
- This slide is TOTALLY beyond anything you are responsible for knowing – but it's highly interesting!

Don't be so
open-minded
that your brain



falls out

Key Points from Chapter 0

- Evolution by Natural Selection has equipped to identify truth – the “light bulb” experience – because it has survival value. If we use it carefully, our brain WORKS!
- **Occam’s Razor** – explanations which require fewer modifications to current understanding and still agree with all observations, are more often correct.
- **Sagan’s Corollary** – extraordinary claims rightfully require extraordinary evidence before they can be given credibility. Regard incredible claims with high skepticism unless and until the promoters provide extraordinary evidence. Beware of psychological or business agendas at work.
- **There is ONE Reality.** Our mental health requires we accept this and make our personal conception of reality as close to the one REAL reality as possible, or anxiety and lowered quality of life results.
- Deep awareness has great survival value, as at least some philosophical traditions recognize
- Science is a mindset. It places “What is the Truth?” as the #1 priority above all other considerations, and determines truth by ASKING NATURE HERSELF
- Pseudo-Sciences: fail the test of evidence, appeal to wishful thinking, do not have “What is the Truth?” as #1 priority.
- Mother Nature does not CARE about my, or your, opinion! She only cares what is TRUE
- Scientific Method: Observation -> Hypothesis -> Test with Observations. If passes all, it’s a Theory. If not, it’s false. Go back and find a new Hypothesis
- Not testable? It’s not science. It remains “speculation” and can claim no likelihood of truth.
- Weight of Evidence: the criterion by which we assign the probability of an idea being true.
- Nature and so our well-being too, demands we be RIGHT as much as possible, not that we admit equal probability to any claim regardless of the evidence.
- Science can DISprove wrong ideas, but rarely can it PROVE the one and only correct one, because there may be refinements to the best current theory which have not yet been discovered and yet which agree with all observations made so far and more that are only later made.
- Claims that the human mind is incapable of grasping truth, and that Truth is only to be found in holy books, are self-contradictory. Blind faith leaves one at the mercy of whomever that faith has been invested in