COGNITIVE BIAS, THE "ELEPHANT IN THE LIVING ROOM" OF SCIENCE AND PROFESSIONALISM

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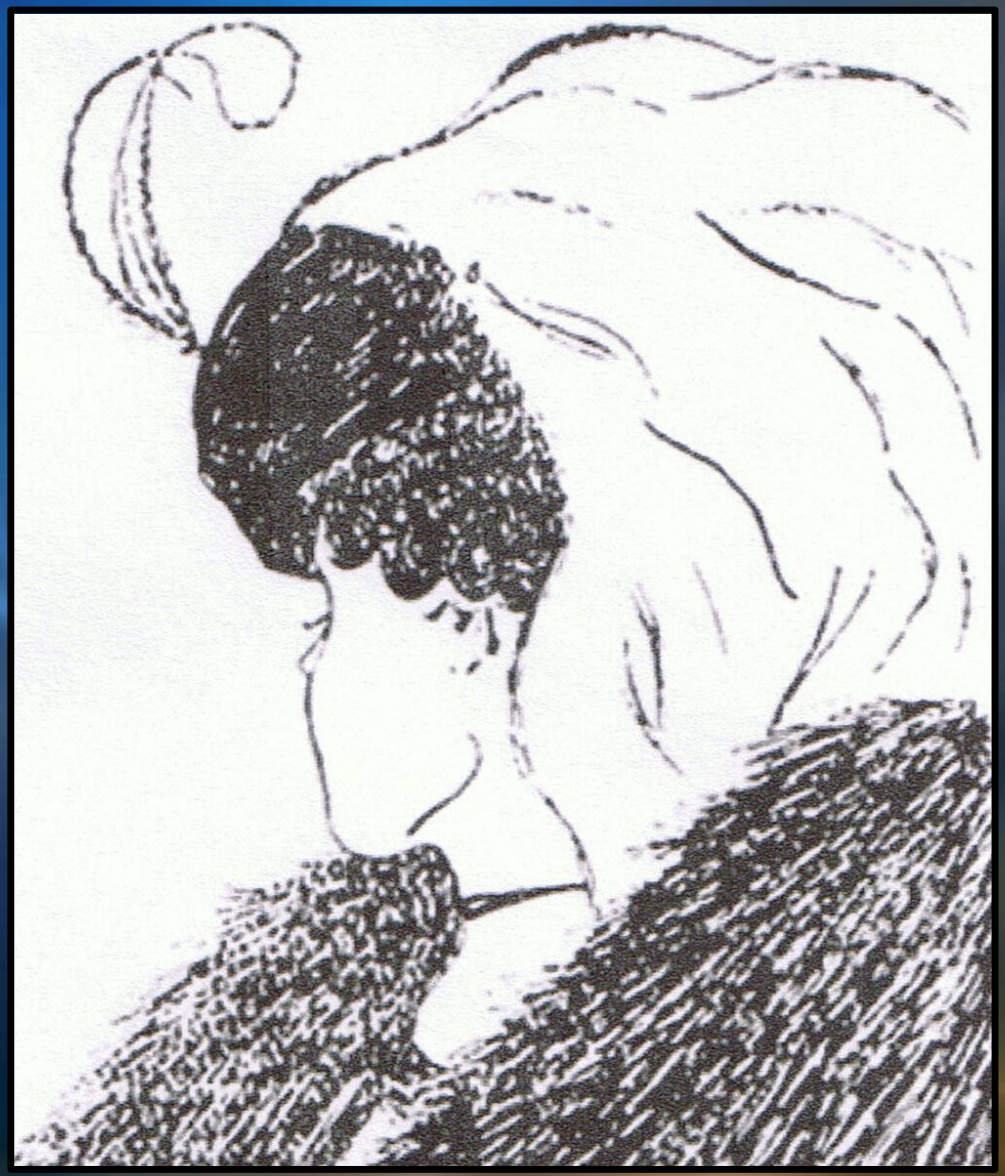
AAPG Distinguished Lecturer, 2015-17

COGNITIVE BIAS:

- **Inherent thinking errors made in acquiring and processing information … preventing us from accurately grasping reality, even if confronted with the data needed to form an accurate view.**

INSTRUCTIONS:

- Without discussing it with anyone nearby, write down what you see on the next slide _____

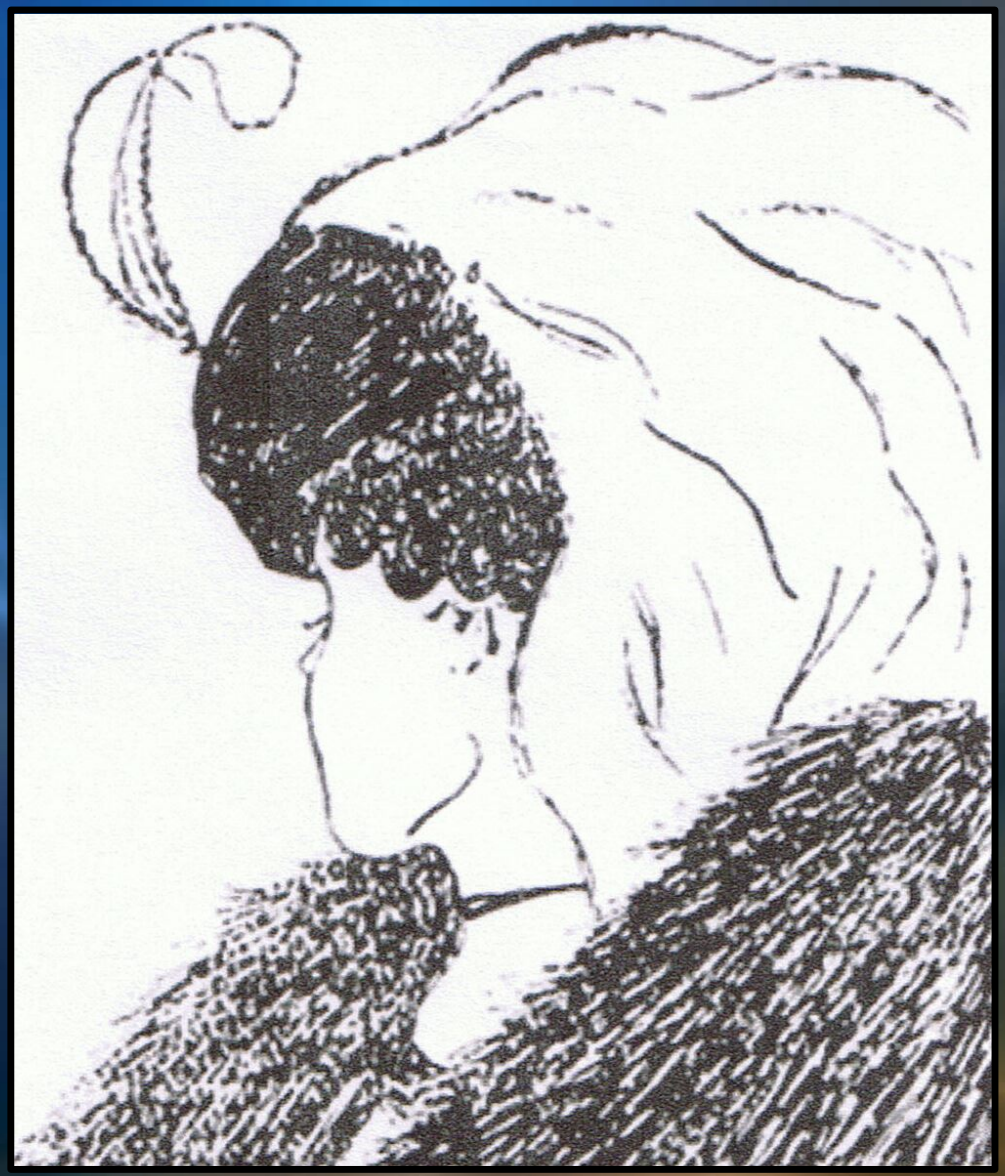


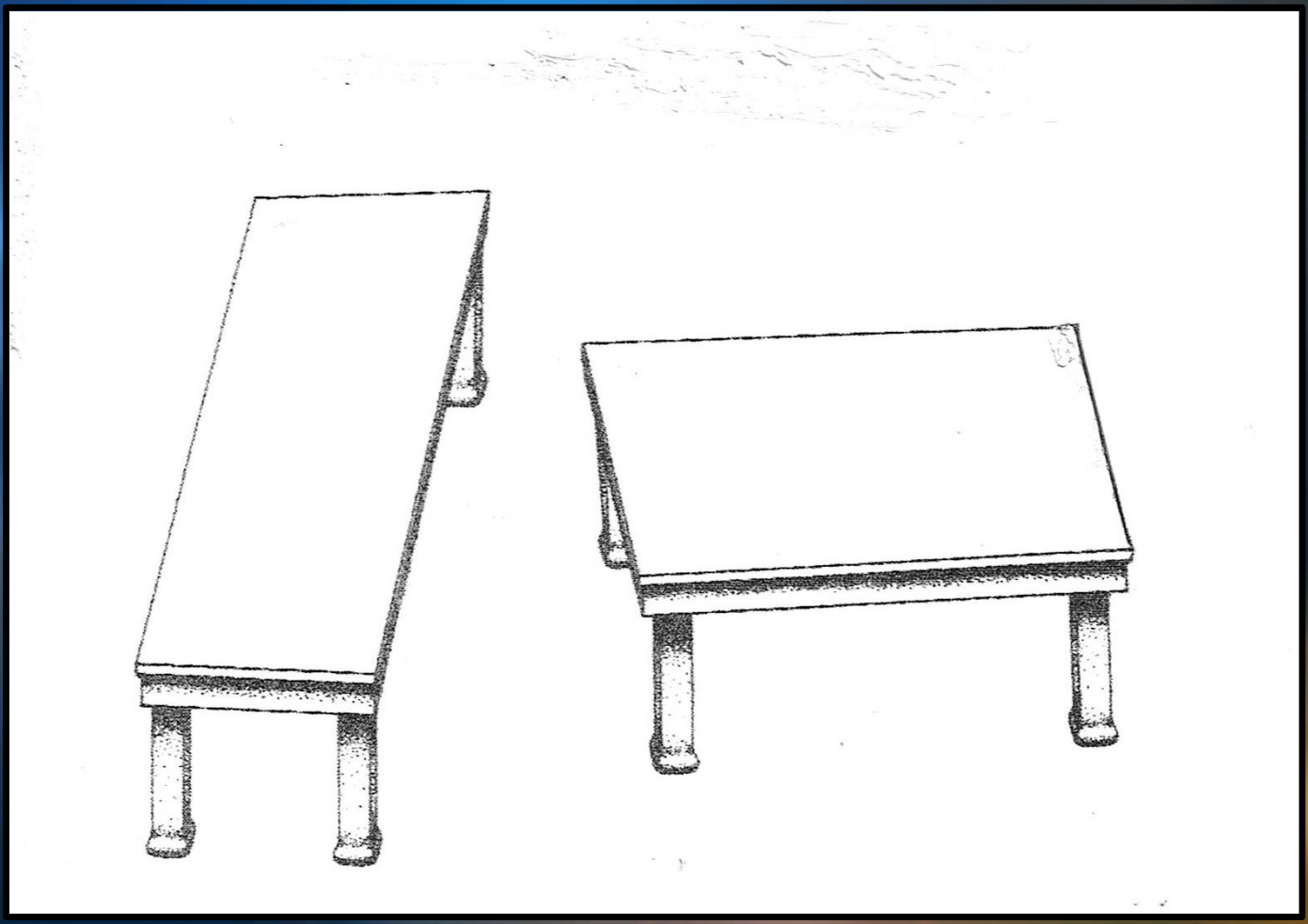
QUESTION:

- If you saw a young woman, please hold up your hand ____

QUESTION:

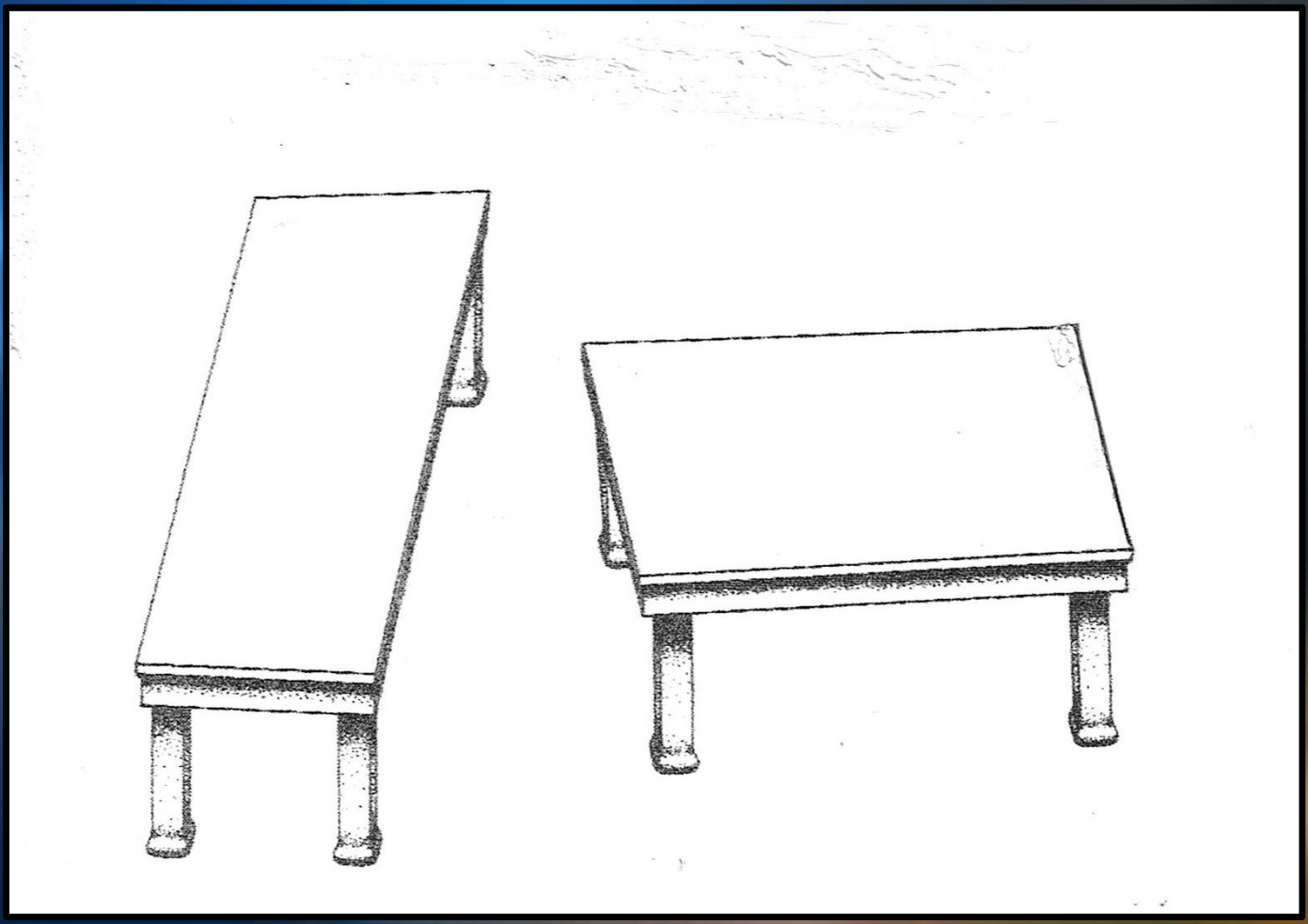
- If you saw an old woman, please hold up your hand ____

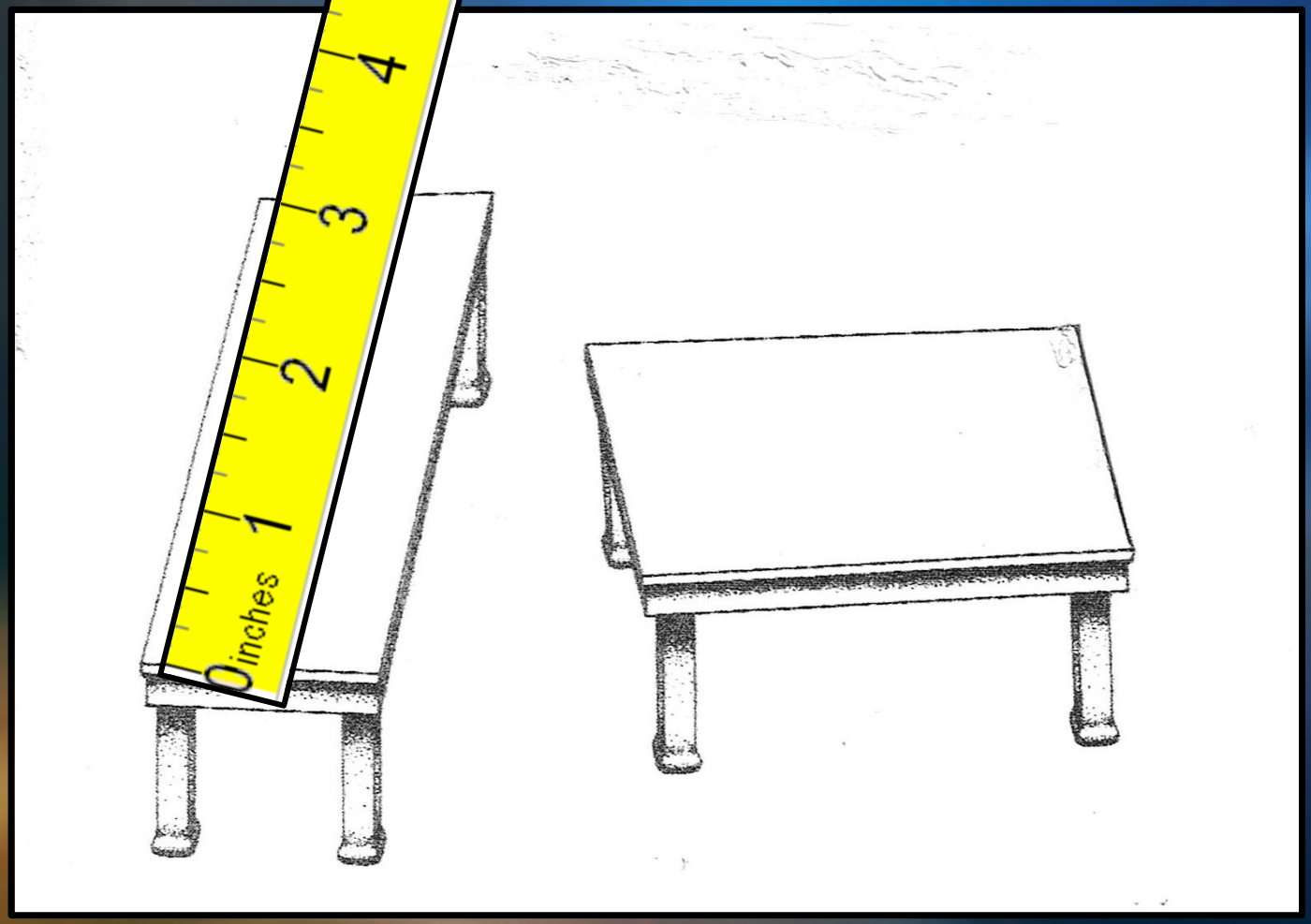




QUESTION:

- Which table is longest, the one on the left or the one on the right?
- Write your answer down _____

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1
2
3
4
5

OPTICAL ILLUSIONS:

TWO TYPES --

Conceptual
Dimensional/Testable

COGNITIVE BIAS:

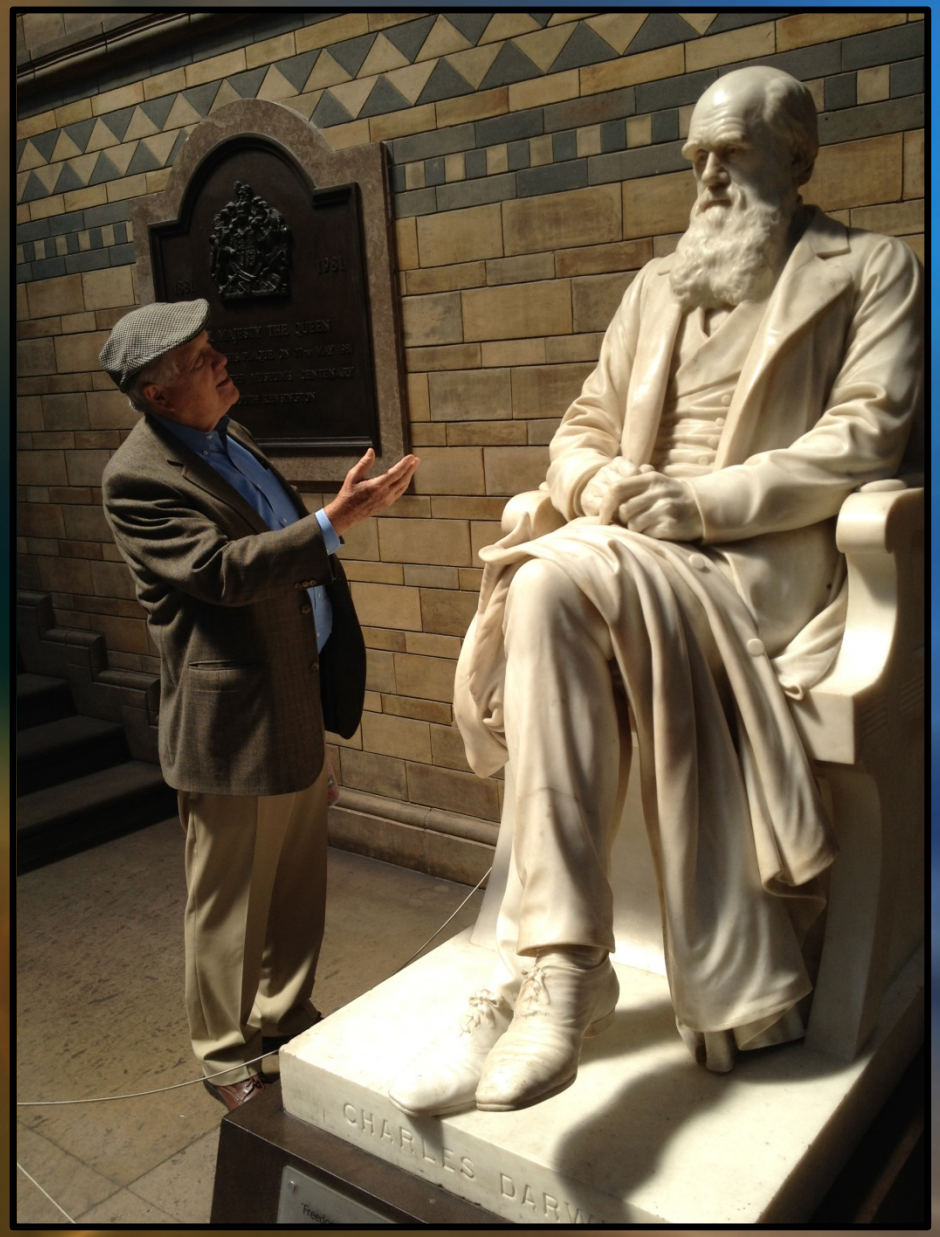
- Inherent thinking errors made in acquiring and processing information … preventing us from accurately grasping reality, even if confronted with needed data to form an accurate view.
- Analogous to optical illusions – the error remains compelling even if one is fully aware of reality.
- Intrinsic to human thought, so any system of acquiring knowledge to describe reality must include mechanisms to control for bias.
- May result from holding to one's preferences and beliefs regardless of contrary information
- Just knowing about common biases doesn't guarantee that you are free from them.

WHY IS THIS IMPORTANT?

We depend upon modern Science to address and assess issues affecting the well-being of our Society. So it is essential that scientific results be as objective – free from Bias – as possible.

Accumulating research results show that Cognitive Bias is much more common in Science and Industry than previously realized -- and often not even examined-for.

Recent experience within the E&P sector has provided methods and experience for detecting and correcting Cognitive Bias that may be useful to other branches of Science.



Public Regard for Objectivity of Science

Geoscience in Petroleum E&P

TASKS FOR E&P GEOSCIENTISTS

1) Find Prospects

2) Measure Them Objectively

   a) EUR → Profitability (if Success)

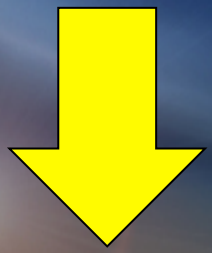
   b) Chance of Success

3) Communicate Objectively

PROBLEM: TECHNICAL OBJECTIVITY IN E&P GEOSCIENCE

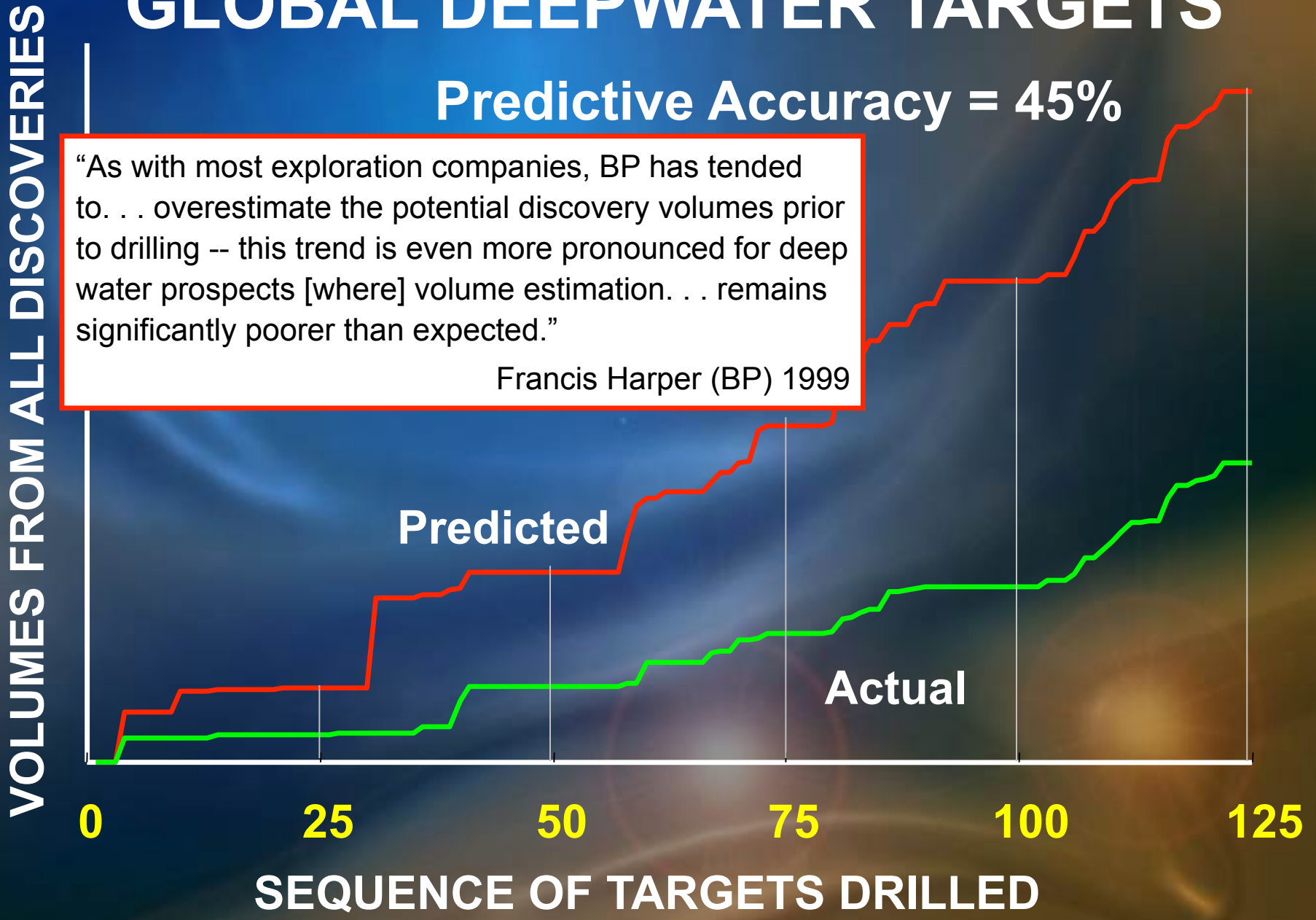
SCIENTIFIC & GEOTECHNICAL RESULTS

UNCERTAINTY, COMMERCIAL PRESSURES & SELF-INTEREST



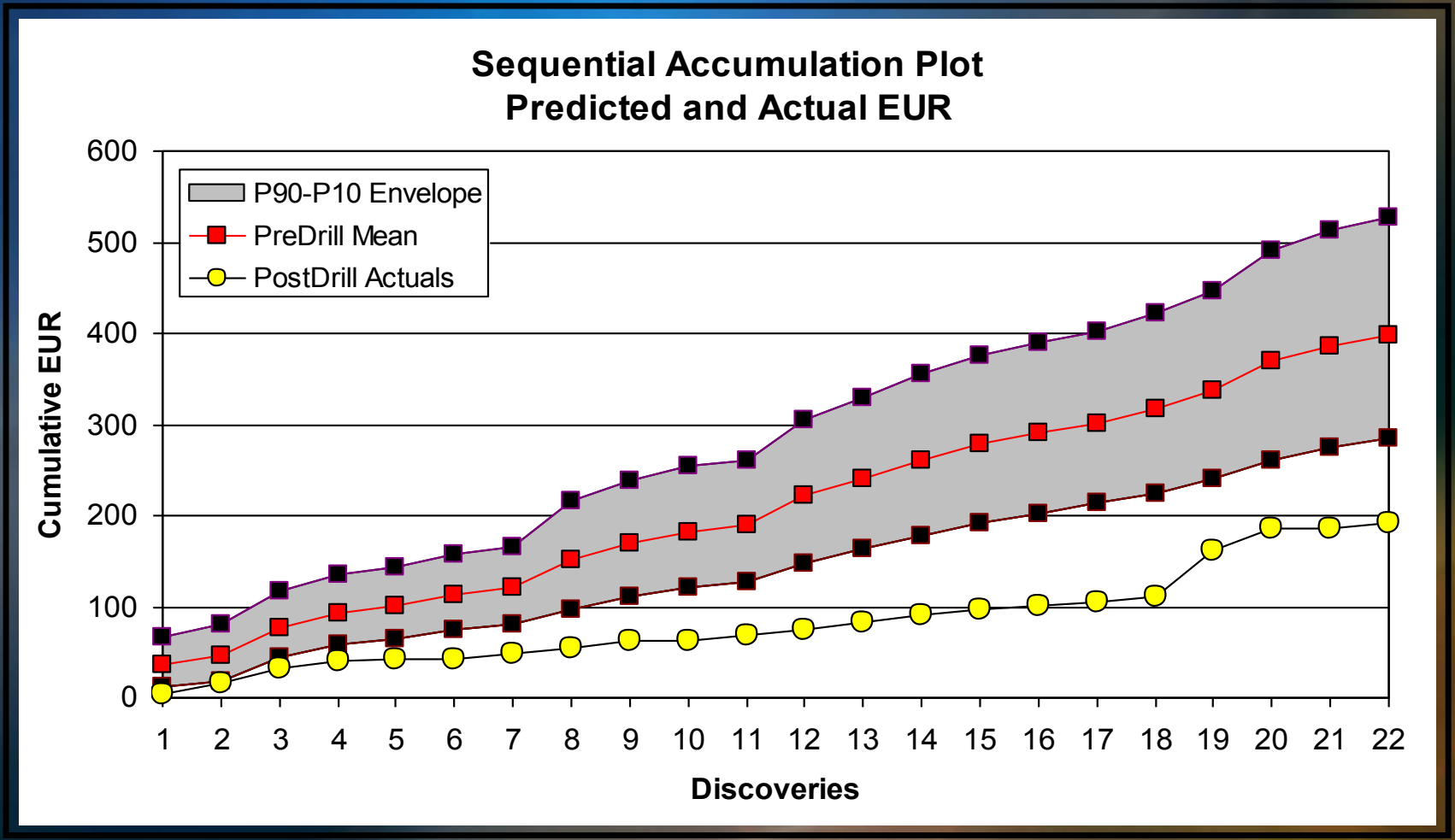
UNDER-PERFORMING PROJECTS!

GLOBAL DEEPWATER TARGETS



Harper 1999

Sequential Accumulation Plots Help Track Program Performance



After Clapp and Stibolt, 1991

COMMON COGNITIVE BIASES IN E&P

1. *Confirmation Bias*: Ignoring Data that Don't Fit Our Theories
2. *Overconfidence*: Predictive Ranges are Too Narrow
3. *False Analogs*: Unrepresentative models
4. *Anchoring*: First Estimates bias Final Estimates
5. *Motivational Bias*: Self-interest Influences Estimates

E&P COGNITIVE BIAS

COMMON CAUSES --

- Premature identification of *"The Answer"*
- Personal Hubris/Arrogance
- No consistent system for Project Assessment
- Lack of Perspective
- Lack of Imagination
- Laziness
- Excessive Personal Self-interest
- Unrealistic limitations of Time and Budget
- Inadequate comparison of *Risk* vs. *Reward*
- No Post-audits
- Faulty Reward System: *Activity* vs. *Results*

BIGGEST CHALLENGE:

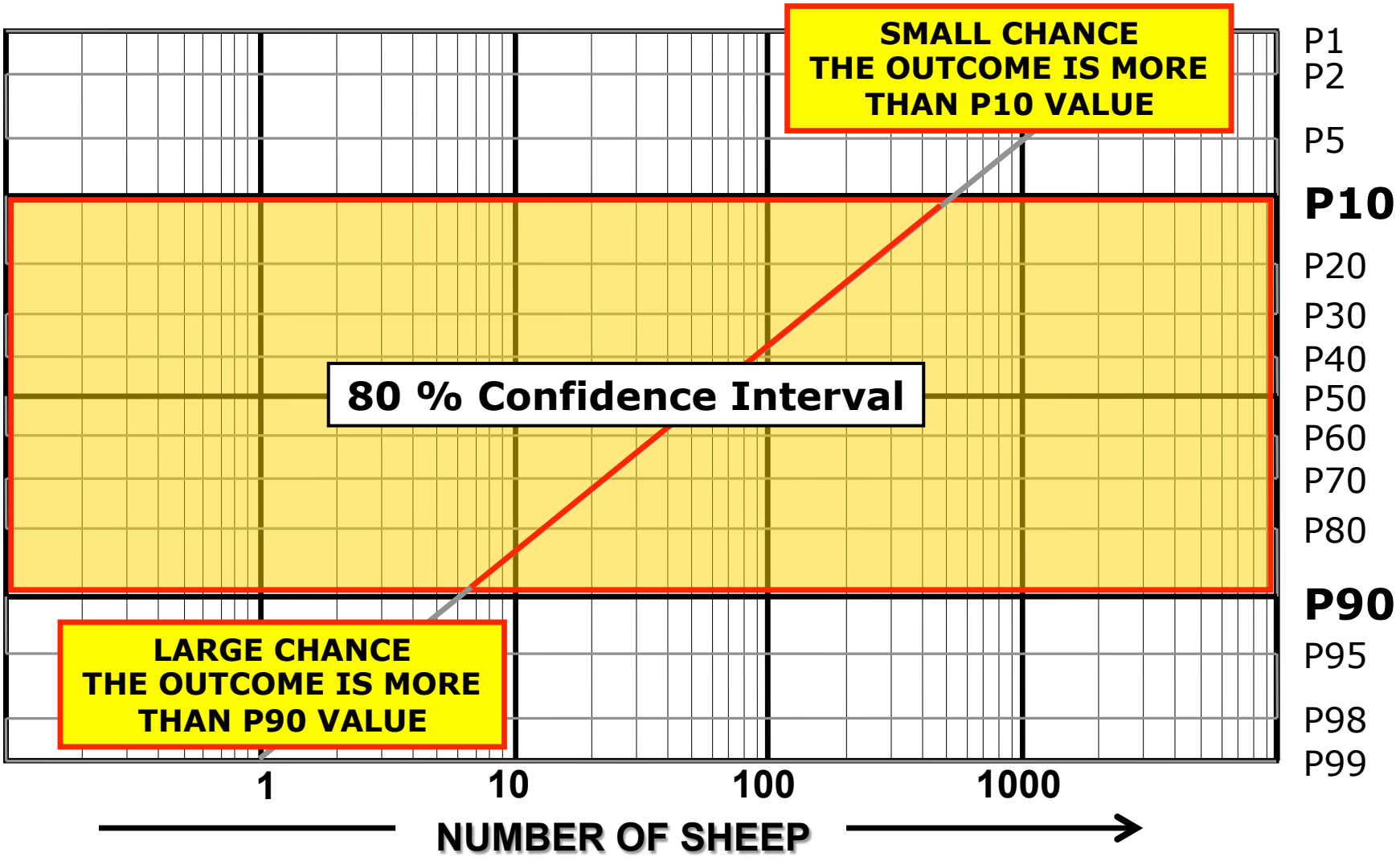
Convincing Educated Technical & Management Professionals that THEY are subject to Cognitive Bias . . . . .

. . . JUST LIKE EVERYONE ELSE!

EXERCISE

How Many Sheep Are There?

ESTIMATING WITH PROBABILISTIC RANGES



Write down P90 and P10 estimates for the flock of sheep:

P90 = ___ > low number

P10 = ___ > high number

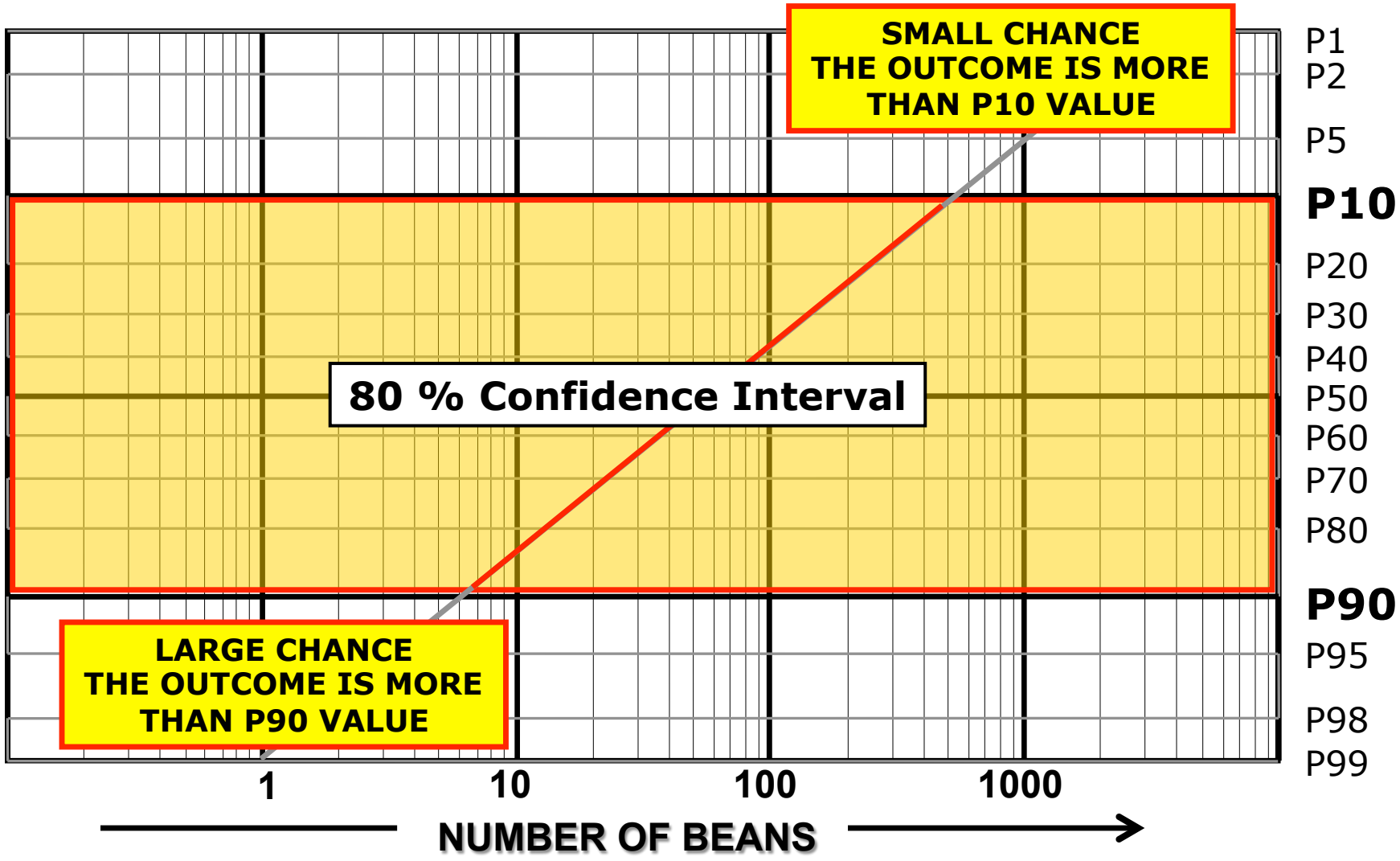
UNCERTAINTY:

IF YOUR RANGE INCLUDED 175

. . . . HOLD UP YOUR HAND!

How Many Beans Are There?

ESTIMATING WITH PROBABILISTIC RANGES



Write down P90 and P10 estimates for the following bean slide:

P90 = _____

P10 = _____

Write down P90 and P10 estimates for the previous bean slide:

P90 = _____

P10 = _____

If your P90 – P10 Range Includes

PLEASE RAISE YOUR HAND!

TESTING FOR BIAS:

1. What % of Audience had a P90-P10 range that included 1780 (=80% Confidence)??

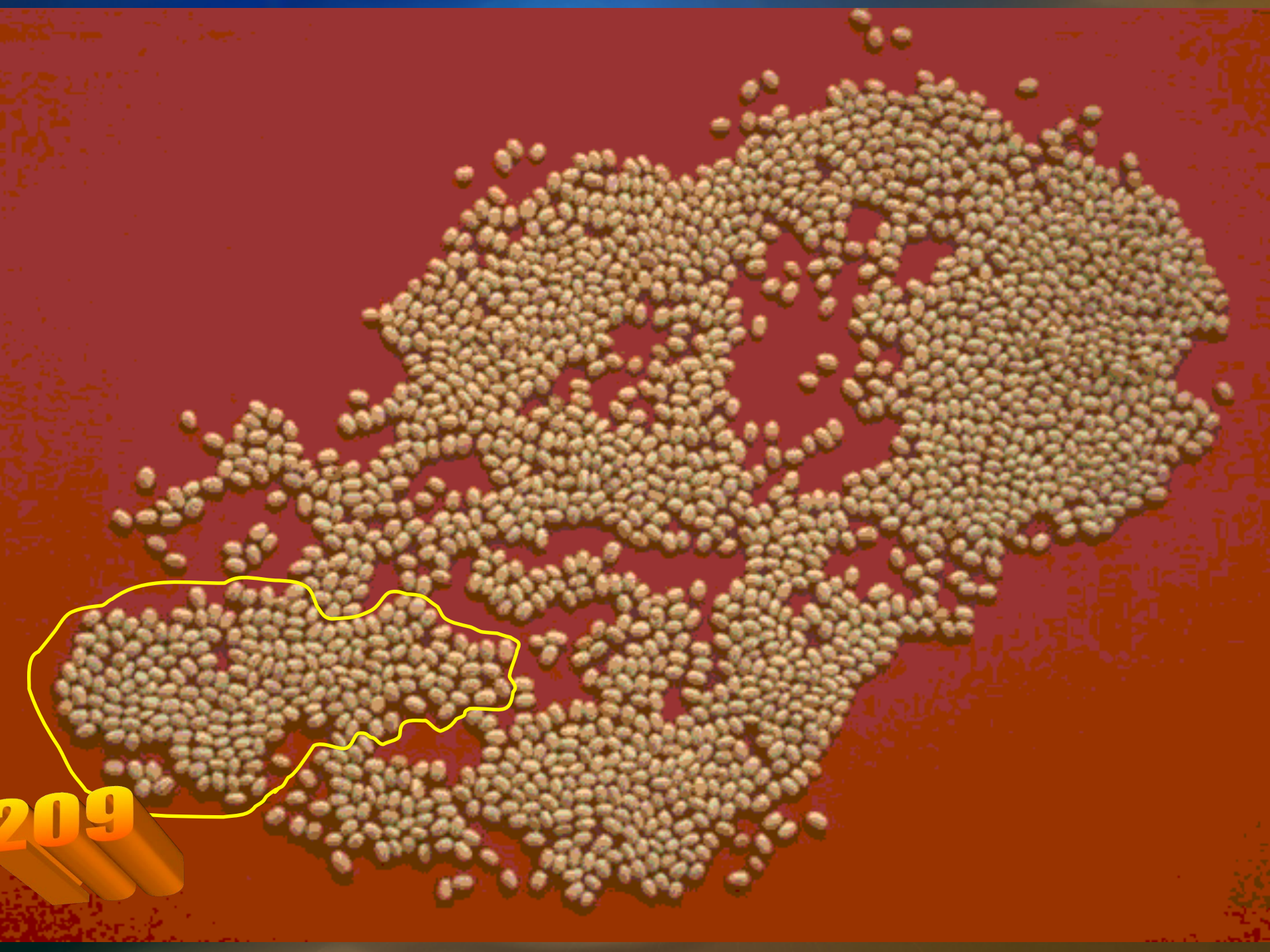
   OVERCONFIDENCE = RANGES TOO NARROW

2. Test for Conservative vs. Optimistic

   HOW MANY HAD RANGE LOWER THAN 1780?

   HOW MANY HAD RANGE HIGHER THAN 1780?

MESSAGE:
ESTIMATING BIAS IS ENDEMIC !


209

CHARACTERISTICS OF E&P VENTURES:

- High uncertainty
- Technology clarifies, doesn't eliminate uncertainty
- Prospecting process leads to advocacy
- "Science" reinforces apparent confidence
- Hard to see prospect in detached "repeated-trials" perspective
- Desire not to bring bad news leads to creeping over-optimism

EARLY PRAGMATIC MEASURES FOR REDUCING BIAS IN E&P VENTURES

- Reserves Definitions (SEC)
- Licensing/Certification of Engineers and Geologists
- Use of Outside Experts
- Engineers ("Conservative") vs. Geologists ("Optimistic")
- Individual Rules of Thumb (esp. Executives!)
- Informal Endorsements of Dependable Operators and Experts
- Threat of Lawsuits and Public Exposure

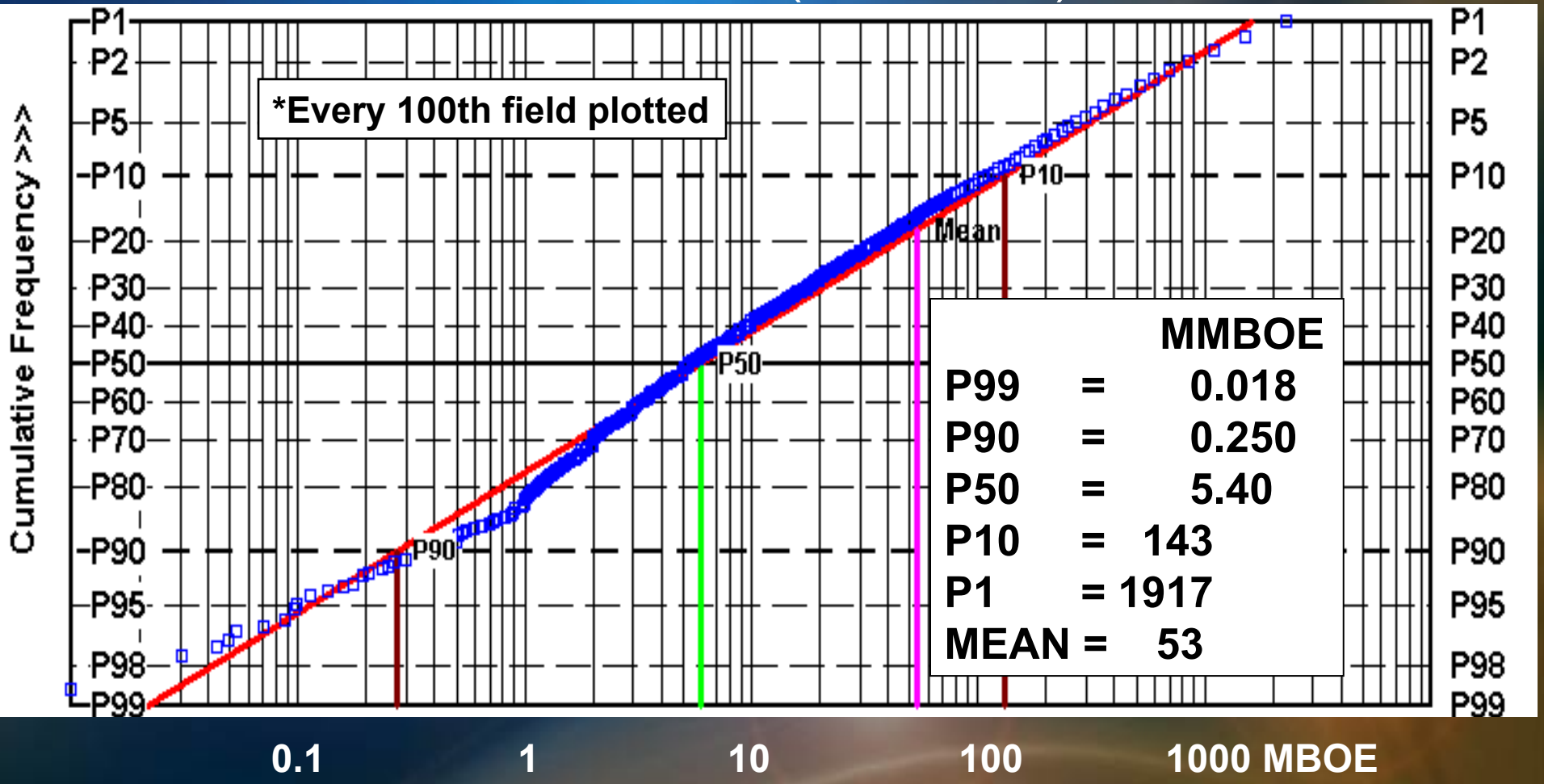
Underlying Causes & Remedies of Bias Not Addressed!

HOW TO MINIMIZE E&P BIAS:

- Reality & Plausibility Checks
- Multiple Working Hypotheses
- Probabilistic Estimating
- Fitting E&P Parameters to Lognormal Expectation
- Employing Group Wisdom
- Managing E&P as a Portfolio
- Performance-tracking of Previous Ventures

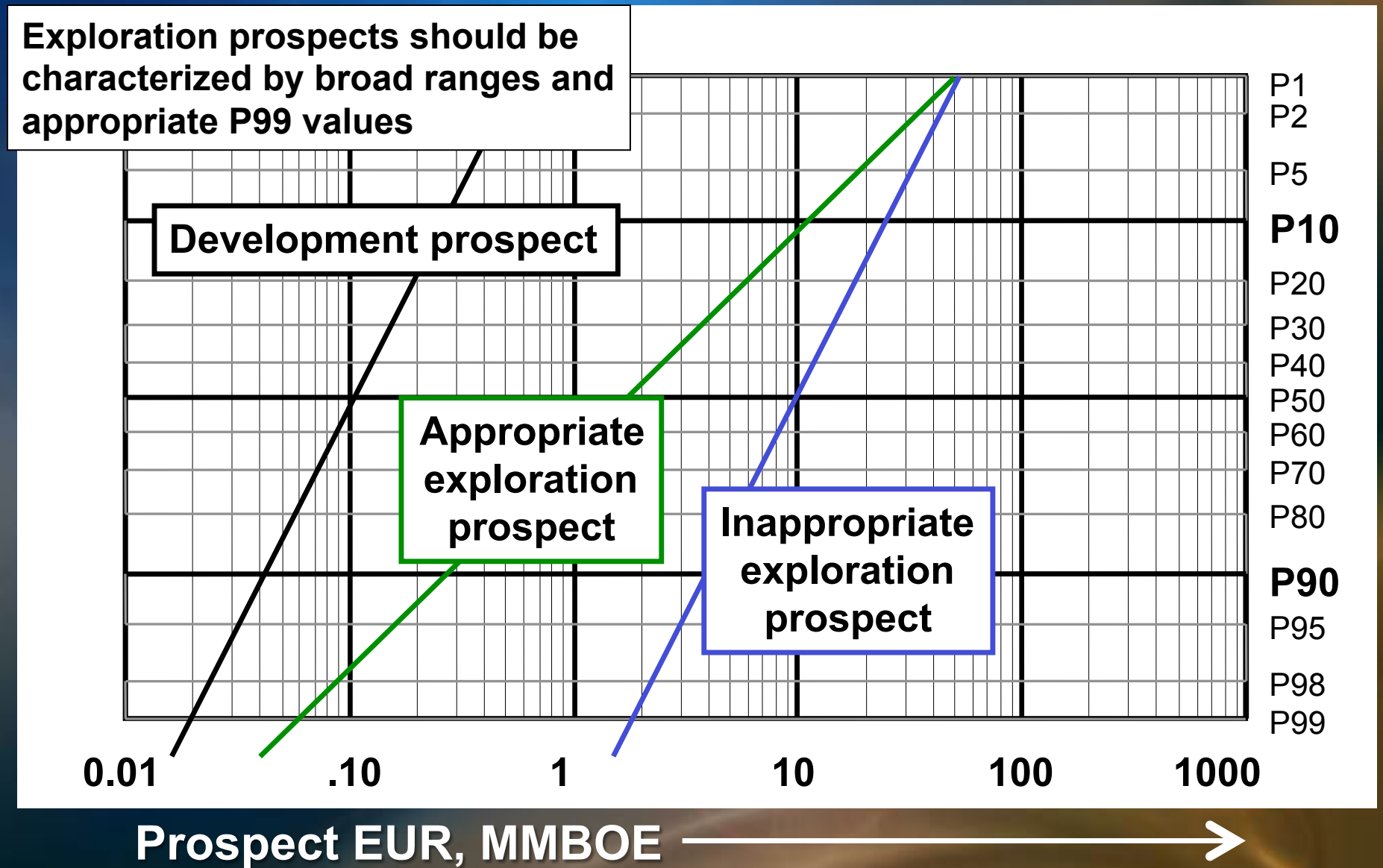
PROCESS FOR REALITY CHECKS

GLOBAL FIELD POPULATION (n ~30,000)*



Source: NRG, IHS

PROCESS FOR REALITY CHECKS



PRE-DRILL PROJECT RESOURCE EURs:

MOST COMMON CAUSE OF PROJECT EUR OVERESTIMATES --

LOW-SIDE (P99) ESTIMATES

MULTIPLE WORKING HYPOTHESES

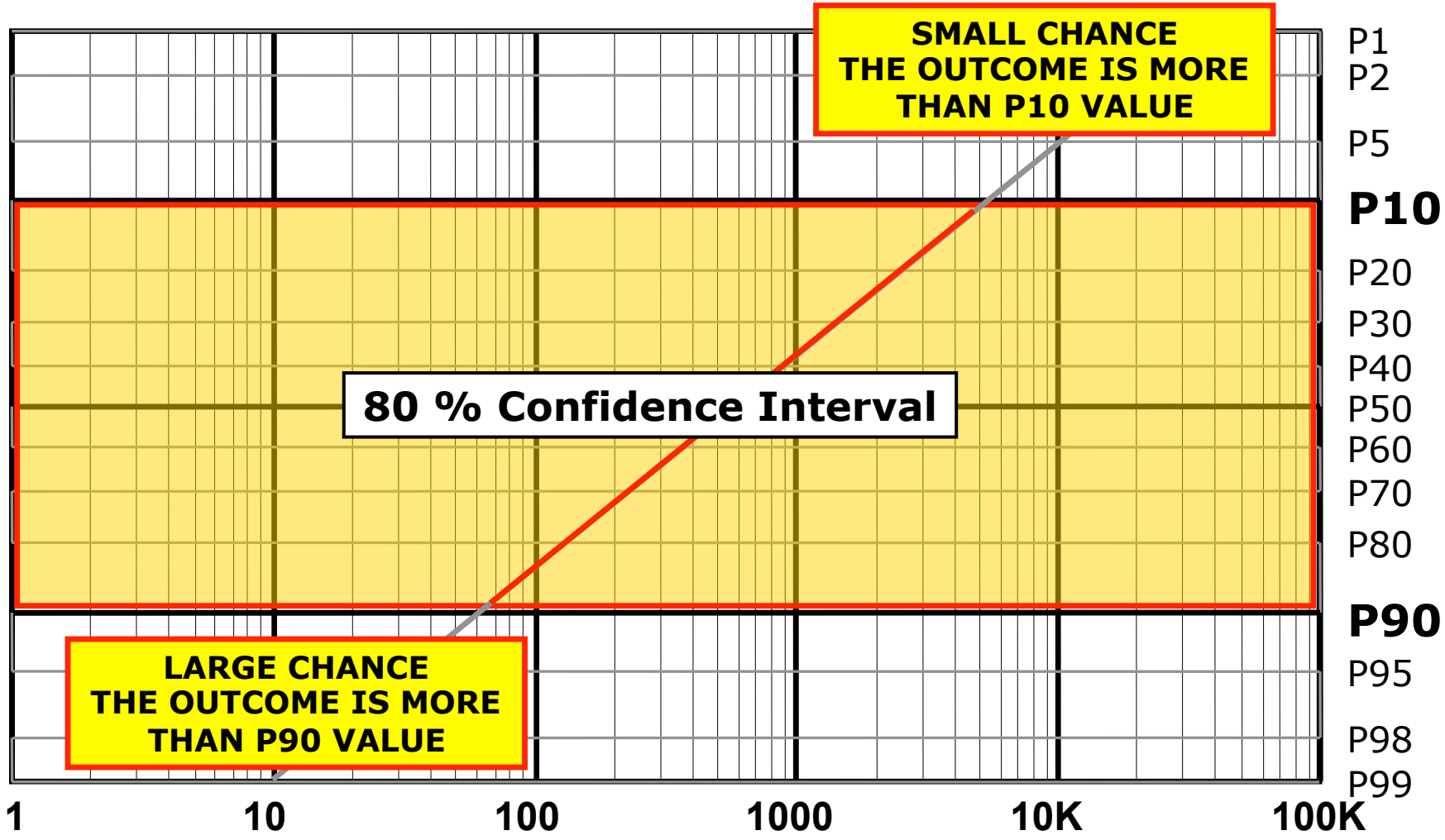
- Pursued Simultaneously, None Championed
- Helps Pinpoint Critical Elements Common to All Possible Scenarios
- Promotes Thoroughness
- Requires Discipline and Imagination
- Allows Later Adjustments

What are the alternative scenarios?

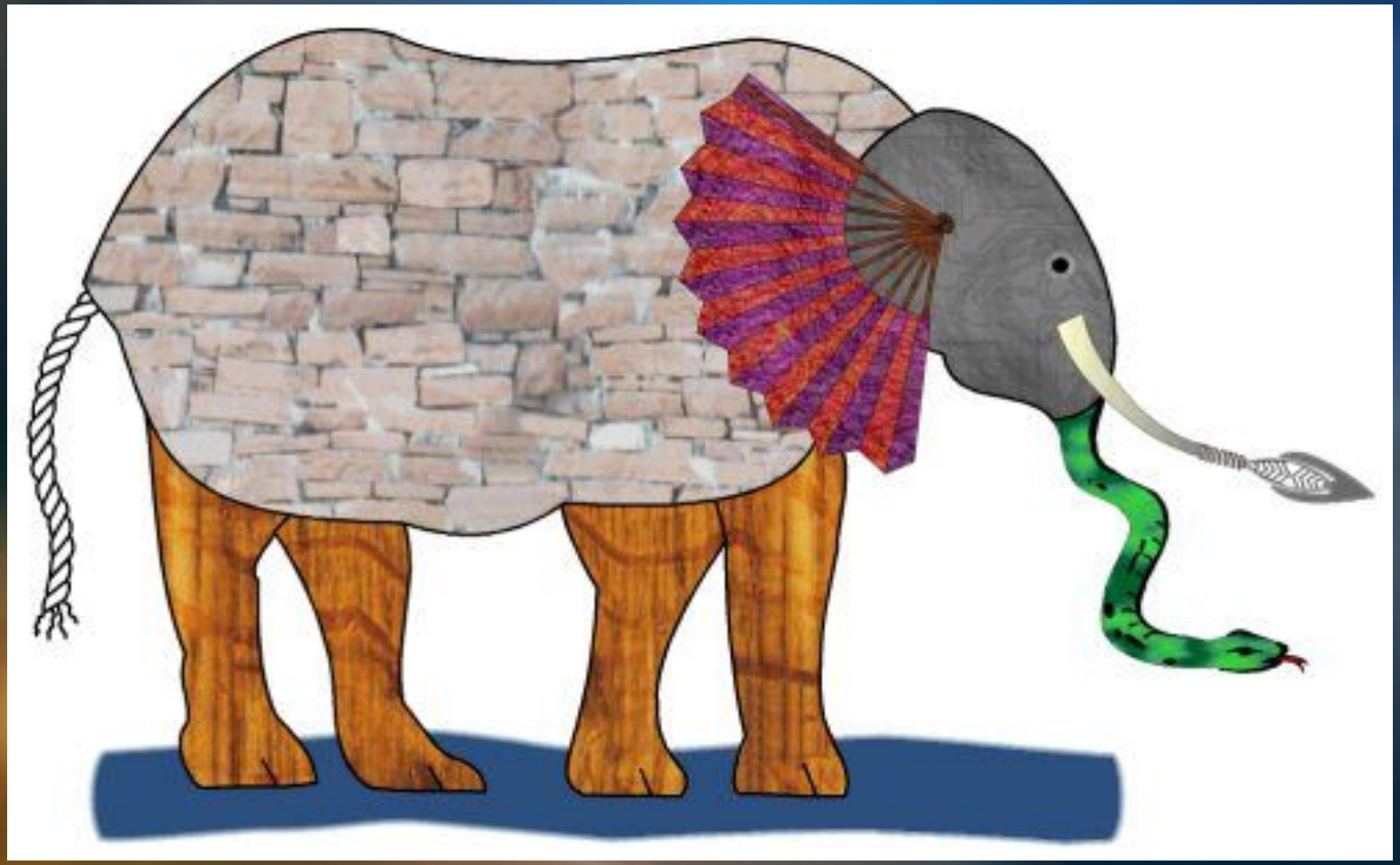
Make more than one map !

Chamberlain, 1931

ESTIMATING WITH PROBABILISTIC RANGES

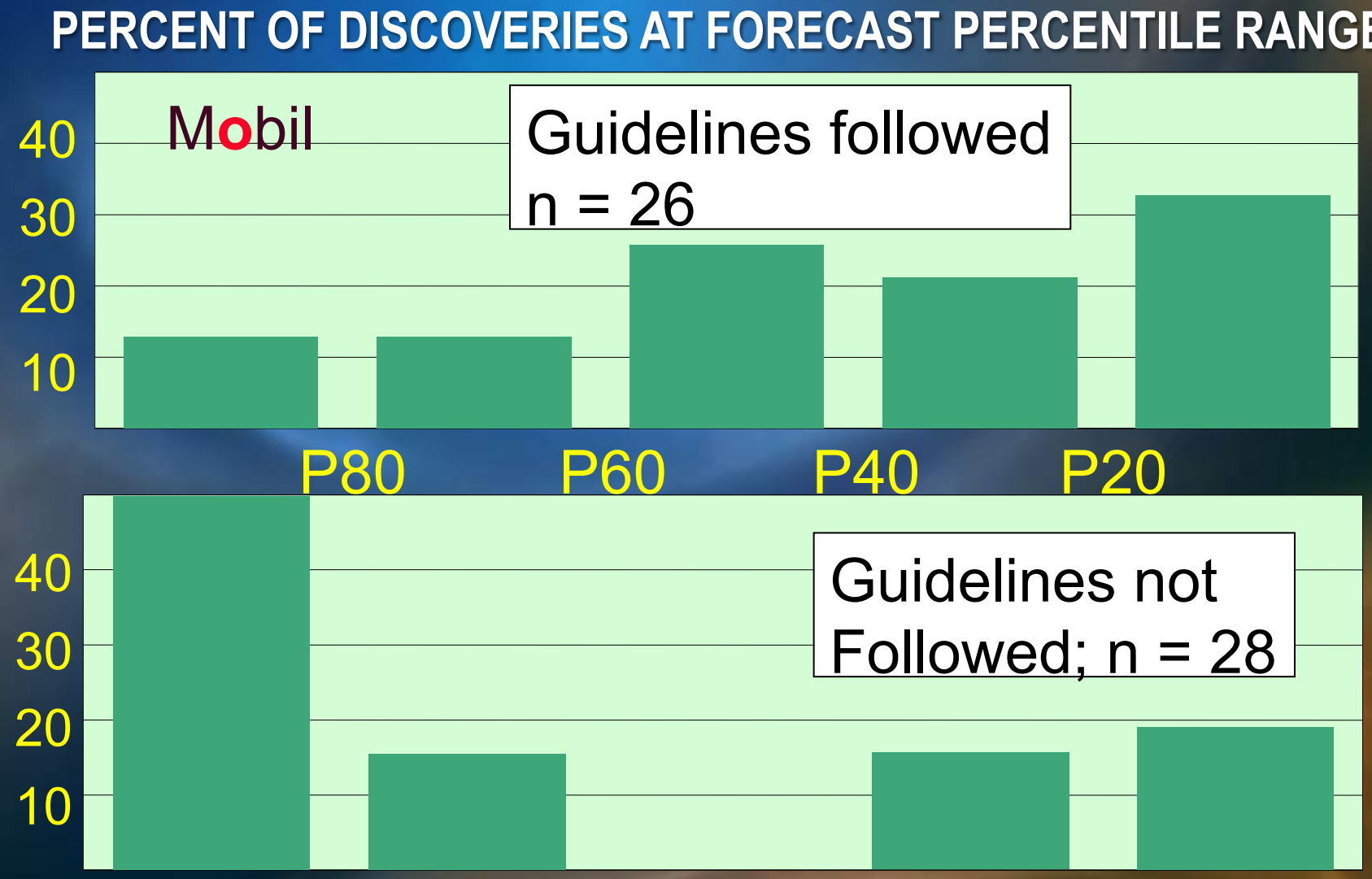


GROUP WISDOM: Independent Multiple Estimates



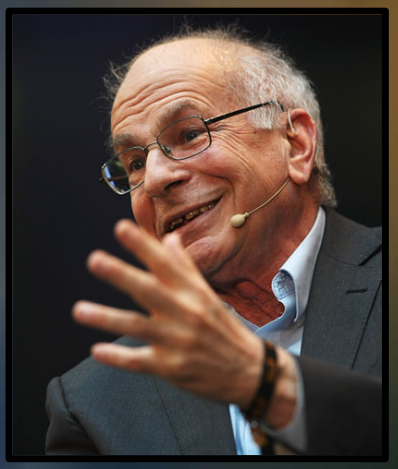
John Godfrey Saxe's (1816-1887) version of the famous Indian legend

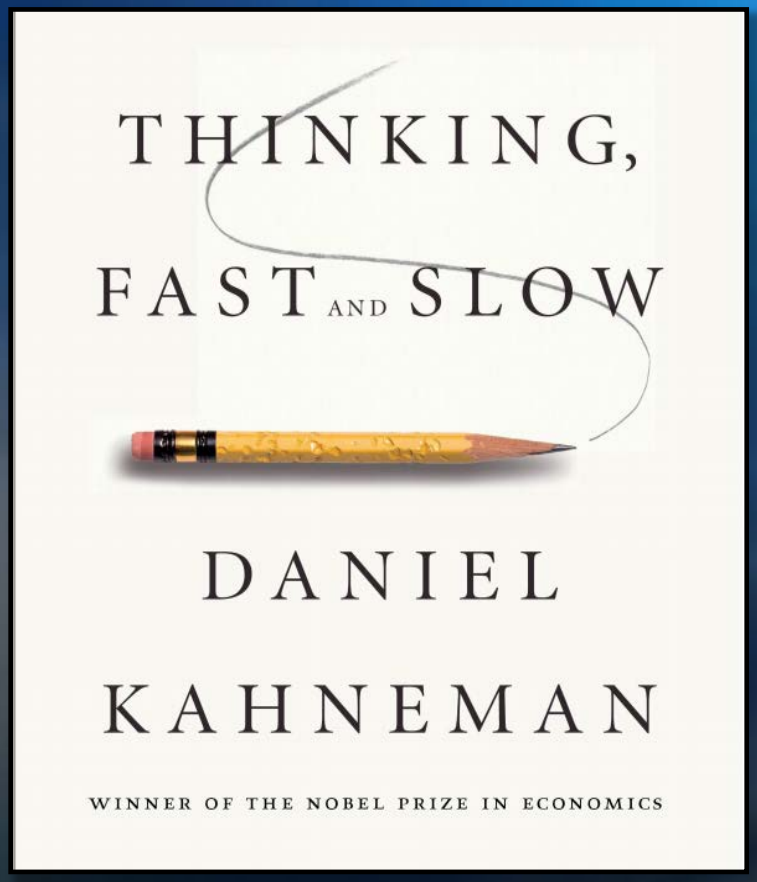
DO RISK ANALYSIS SYSTEMS REALLY WORK?



Citron, Cook, and Rose, 2002

THE ULTIMATE AUTHORITY





- SYSTEM 1 (FAST) uses association and metaphor to produce a quick and dirty draft of reality.
- SYSTEM 2 (SLOW) thinks deliberately and rationally, arriving at reasoned choices.
- But SYSTEM 2 tires easily and often accepts the unreliable story about the world that SYSTEM 1 feeds it.

Does this all go back to Plato vs. Aristotle?

OPTICAL ILLUSIONS:

TWO TYPES --

Conceptual
Dimensional/Testable

COGNITIVE BIASES

TWO PRIMARY DECISION-MAKING PROCESSES

- **SYSTEM 1: operates automatically, quickly, with little or no effort**
  - Intuitive process. Impulsive, emotional & often unconscious action
  - Associated with fight-or-flight response; default option
  - *"Thinking Fast"*

- **SYSTEM 2: uses controlled and conscious mental activity**
  - Invokes critical, deductive and logical thinking
  - Requires deliberate effort
  - *"Thinking Slow"*

Cognitive Biases

System 1 (Thinking Fast)

- Is in the older part of our brain in evolutionary terms (supports quick decisions that follow our instincts and intuition)
- Receives incoming information before System 2 does
- Is more prone to error (bias) in complex or uncertain situations
- Biases in judgement and decision making are not necessarily detrimental or irrational

System 2 (Thinking Slow)

- In evolutionary terms, is in a more recent part of our brains
- Evolved to manage uncertain situations where System 1 fails
- Using System 2 in decisions or situations of uncertainty can often lead to feeling uncomfortable
- We don't have time to apply System 2 to all daily decisions

“People will go to almost any length to avoid thinking.”

Ed Capen, 1984

OK, so we have methods for coping with Biases that are *Testable / System 2* -- How to deal with *Conceptual / System 1 Biases CONSTRUCTIVELY* ?

Problem: It does little good for me to tell you that your judgment and opinions are biased.

(The Voice of Bitter Experience: *Avoid discussions in Public about POLITICS and RELIGION !)*

Solutions:

- **Maintain respect & communication (Haidt, 2013)**
- **Focus on Process and Decisions**
- **Performance-tracking to provide evidence of Reality**

But wait – there's more to this….

Am I as Biased as You?

Emily Pronin, *et al.* (2004): *Objectivity in the eye of the beholder: Divergent Perceptions of Bias in Self versus others*

How We See Ourselves and How We See Others

- People see themselves differently from how they see others. They are immersed in their own sensations, emotions, and cognitions at the same time that their experience of others is dominated by what can only be observed externally.

- This basic asymmetry has broad consequences. It leads people to judge themselves and their behaviors differently from how they judge others and those others' behavior.

- Often, those differences produce disagreement and conflict. Understanding the psychological basis of those differences may help mitigate some of their negative effects.

PRONIN, ET AL., 2004

EXERCISE: SENSING OUR OWN COGNITIVE BIASES BY DISCERNING THEM IN OTHERS --

1. *"GMFs are too Dangerous"* : Agree? _____ ; Don't know? ___ ; Disagree?____

2. *"Vaccinating Kids is too Dangerous":* Agree? ___; Don't know? ___; Disagree? ___

3. *"Man-made Global Climate Change is too Dangerous":* Agree? __; Don't know ?___; Disagree? ___

4. QUESTION A: *IF YOU THINK OTHERS' ANSWERS SHOW BIAS, DO YOU THINK YOURS COULD TOO?*

5. *QUESTION B: SOURCES OF YOUR INFO? MANY & DIVERSE? _____; FEW & UNIFORM? _____*

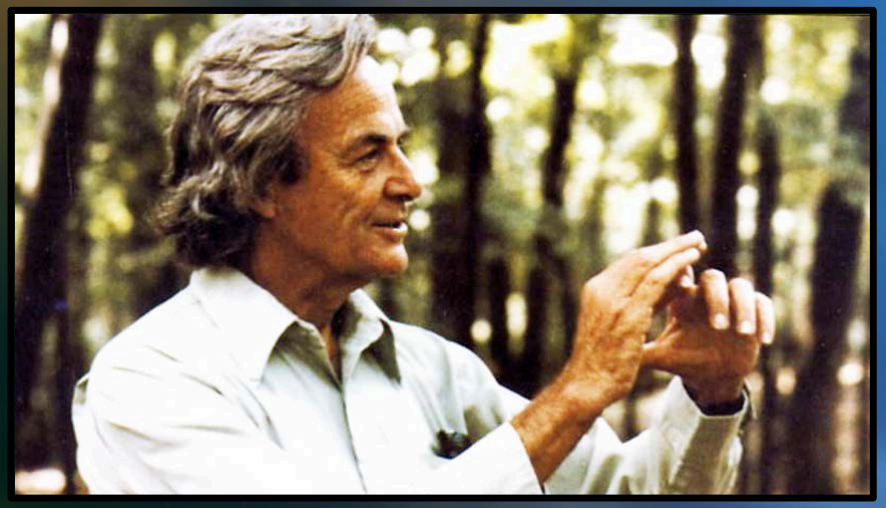
***BACK TO SCIENCE*:**
WHY IS ALL THIS IMPORTANT?

Most Scientists recognize the existence and operation of Cognitive Biases much more in other Scientists than in themselves. Private-sector Scientists have ways to cope.

Many Public-sector Scientists recognize the existence of Cognitive Bias in scientific work theoretically, but very few practice active measures to control it in their own work.

Is this because there is little or no penalty (or timely reputational consequence) for erroneous conclusions?
Is this an Accountability issue?

FEYNMAN ON COGNITIVE BIAS:



- ***" The first principle is that you must not fool yourself – and you are the easiest person to fool".***

- **Dedicated practice of the Scientific Method is Key:** ***". . . a kind of scientific integrity, a principle of scientific thought that corresponds to a kind of utter honesty -- a kind of leaning over backwards."***

-- RICHARD FEYNMAN (1918-1988) NOBEL LAUREATE (1965).

AMERICAN FOLK HUMOR: *"Everybody talks about the weather, but nobody does anything about it. (MARK TWAIN)*

WESTERN SCIENCE VERSION: *"Everybody talks about cognitive bias, but nobody does anything about it."*

. . . BUT MANY E&P GEOSCIENTISTS & ENGINEERS DO SO, *ROUTINELY*!

PROBLEM – How to transfer the E&P experience in coping with Cognitive Bias to WESTERN SCIENCE ?

MOTIVATIONAL BIAS – REAL LIFE EXAMPLES

"Who wants to hear actors talk?" H.M. Warner, Warner Brothers (1927).

"Television won't last because people will soon get tired of staring at a plywood box every night." Darryl Zanuck, movie producer, 20th Century Fox (1946).

"Fooling around with Alternating Current is just a waste of time. Nobody will use it, ever." Thomas Edison, Inventor and Entrepreneur (1889).

MOTIVATIONAL BIAS --

- **IN PETROLEUM GEOSCIENCE: Selective use of data that overstate the EV of a project in which the Geoscientist perceives personal benefit in getting the Company to drill.**

- **IN PUBLIC GEOSCIENCE: Selective use of data supporting findings that are more likely to attract funding or to promote favored personal sociopolitical philosophies.**

- ***BOTH ARE CONFLICTS OF INTEREST ; BOTH ARE UNPROFESSIONAL !***

SCIENTIFIC MISCONDUCT AT USGS (2008-16):

- Long history of questionable results from Mass Spectrometer analysis in Energy Resources Inorganic Geochemistry Lab (Denver). 2nd report from Interior Dept Inspector General finally led to Lab shutdown Feb. 25, 2016 (No action by USGS on first IG Report).
- Data underpinning 24 research projects costing $124 Million now seen as unreliable. USGS scientific reputation compromised with partner-research organizations and funding agencies.
- EXAMPLE: Several research projects analyzing chemical composition (trace elements) of water in Northern Arizona public lands were used to support 20-year moratorium on mining activity in nearly 1 Million acres of Federal Lands.
- USGS has been very slow to contact concerned agencies to acknowledge and correct problem.

MOST PUBLISHED SCIENTIFIC RESEARCH FINDINGS CANNOT BE REPRODUCED:

- **"47 of 53 published results of cancer-research papers were irreproducible." -- *Nature* (2012)**
- **" . . . 80-90% of claims from scientific studies in major journals fail to replicate." -- *Forbes* (2014)**
- **"39% of published psychological research could not be reproduced." – *Science (2015)***
- **"The case against Science is straightforward: much of the [current] scientific literature, perhaps half, may simply be untrue." Richard Horton, editor-in-chief, *Lancet*, quoted in *London Times* (3/4/2016).**

"RESEARCH MISCONDUCT DEGRADES TRUST IN SCIENCE & SHOULD BE A CRIME AKIN TO FRAUD"

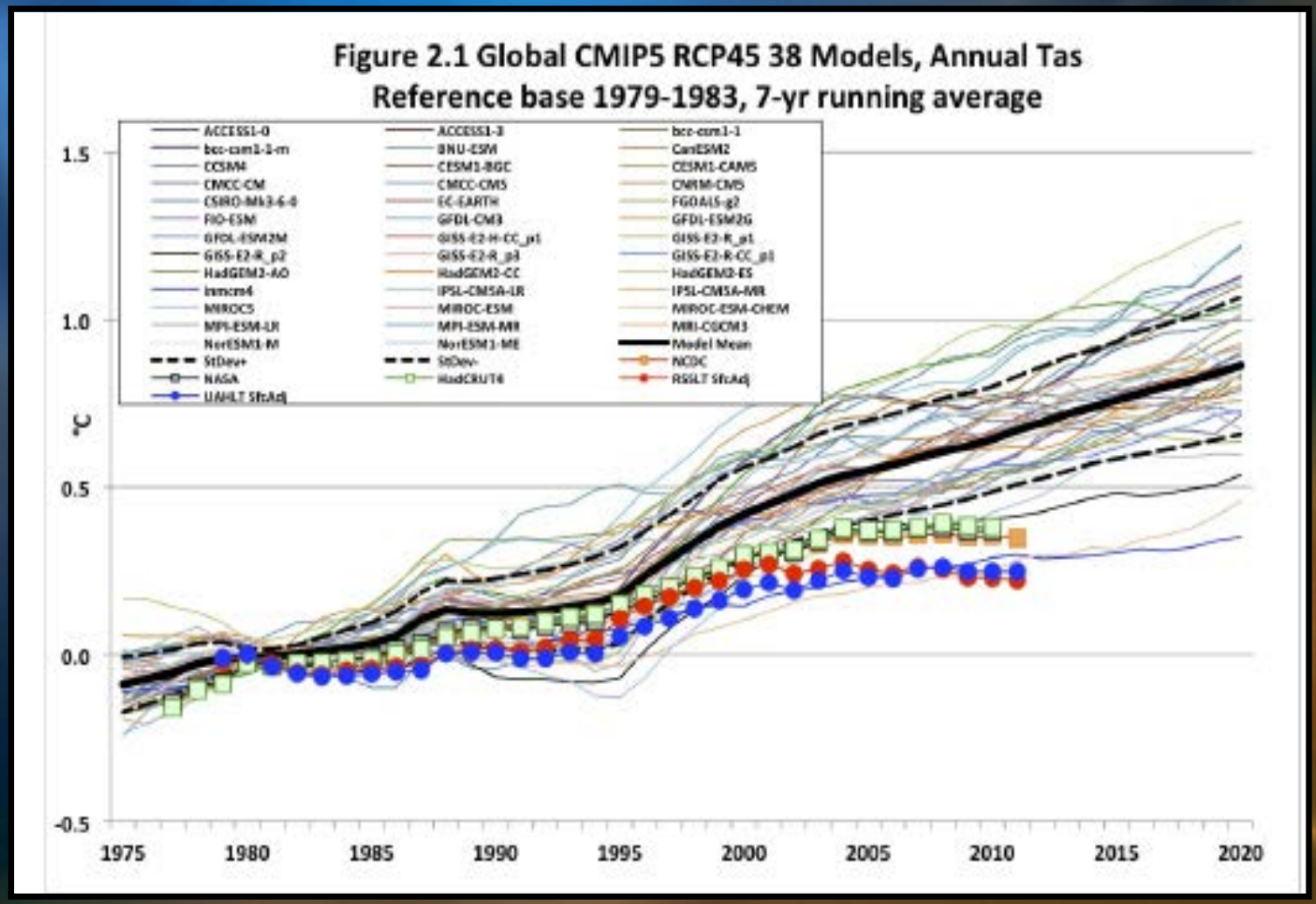
- "*After 30 years of observing how Science deals with the problem, I have sadly come to the conclusion that it should be a crime, for three reasons. First . . . [some] people have been given substantial grants to do honest research, so it really is no different from financial fraud or theft. Second, we have a whole criminal justice system that is in the business of gathering and weighing evidence – which universities and other employers of researchers are not very good at. And finally, Science itself has failed to deal adequately with research misconduct."* – Richard Smith, Editor of the *British Medical Journal* (1991-2004), founding member, Committee on Publication Ethics and ex-Trustee, UK Research Integrity Office.

- . . . QUOTED IN ***NEWSCIENTIST***, SEPTEMBER 15, 2014

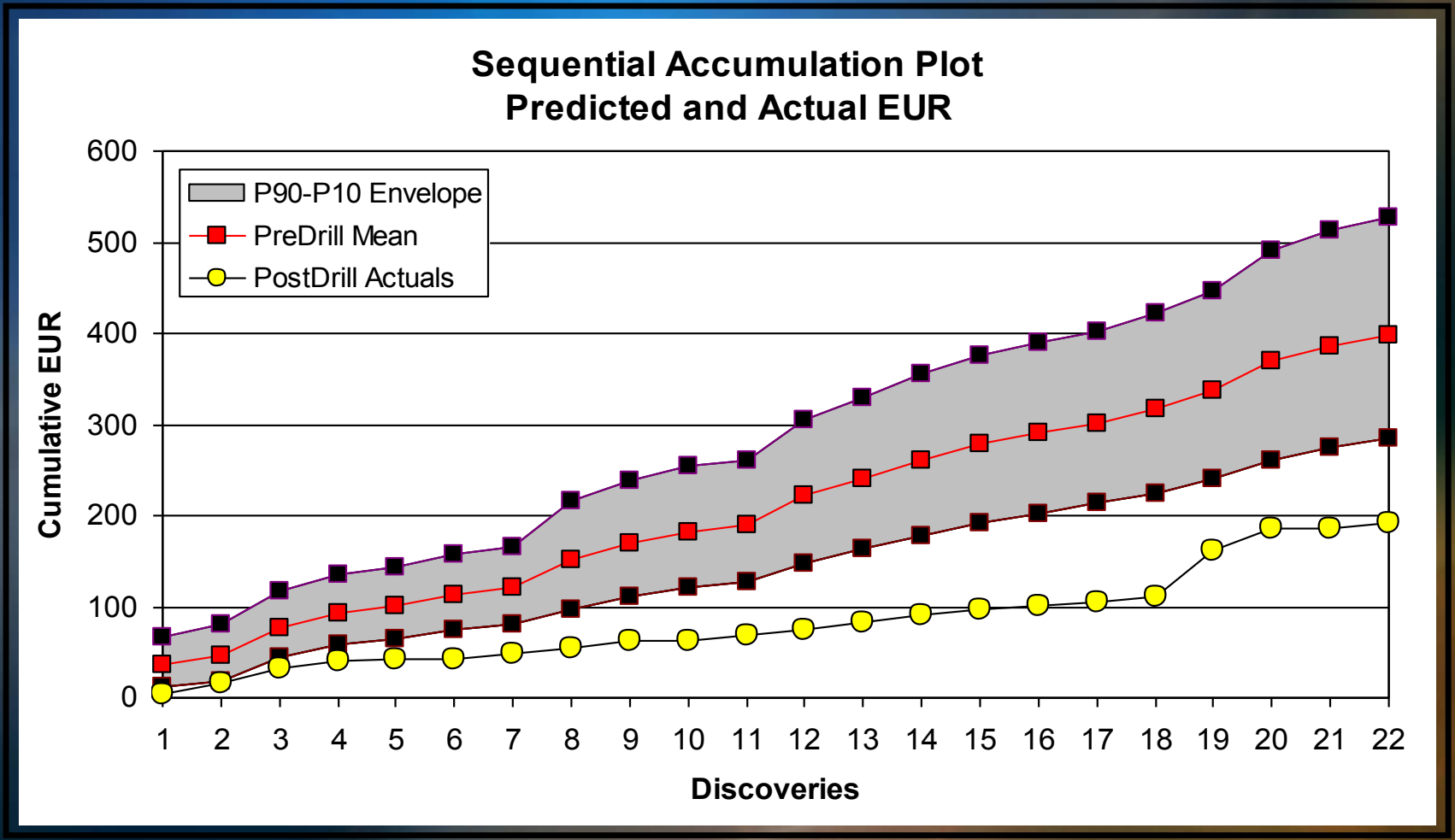
LAND & OCEAN DATA UNDERPINNING "PAUSE-BUSTER" KARL REPORT (NOAA, 2015) UNDER REVISION

- **Retired ex-NOAA whistleblower John Bates, Ph. D. (Climatology).**
- **Report was "rushed through" in time for UN Paris Climate Conference.**
- **Basic Message: Claimed to debunk 1998-2015 global temperature "Pause".**
- **NOAA now concedes underpinning land & sea temperature data are flawed, being revised.**
- **SCIENCE considering possible Retraction of Karl et al. (2015) paper.**

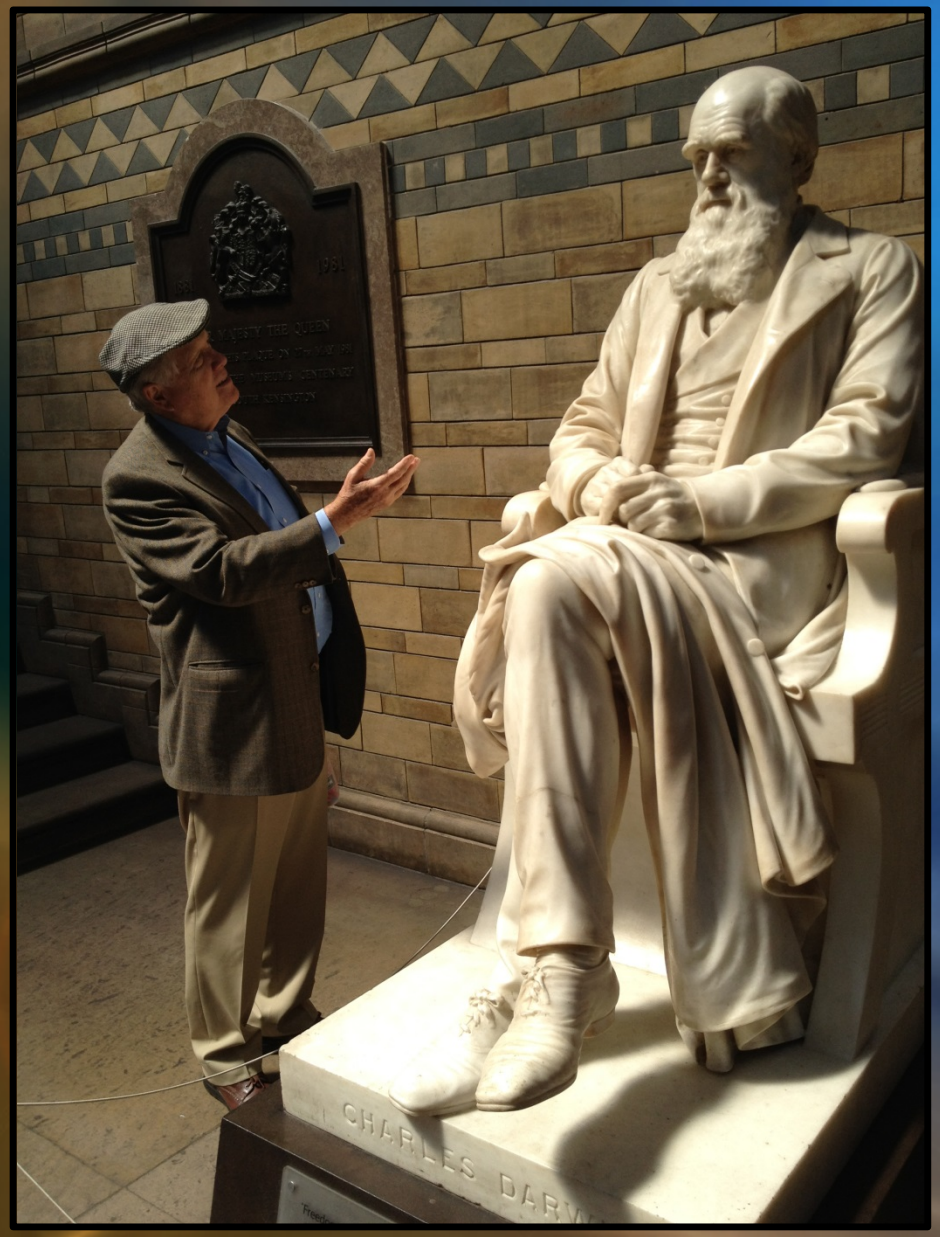
Model Forecasts of Future Global Warming Exceed Actual Results, 1975 - 2012



Sequential Accumulation Plots Help Track Program Performance



After Clapp and Stibolt, 1991



Public Regard for Objectivity of Science

Proper role of Advocacy for Scientists?

. . . BACK TO E&P GEOSCIENCE . . .

BECAUSE EXPLORATION IS DOMINATED BY

- SUBJECTIVITY
- UNCERTAINTY

… it invites the Exercise of Intuition!

. . . so Explorers Tend to Overvalue their Prospects!

PROFESSIONAL RESPONSIBILITIES OF PETROLEUM GEOSCIENTISTS

- **Find profitable oil and gas accumulations**

Fun Part!

- **Measure opportunities consistently w/o bias**

Business Part!

DETACHMENT IS REQUIRED TO MEASURE YOUR OWN PROSPECTS!

- Professionalism
- Project Teams

BASIC MESSAGE:

Q: How to reduce Cognitive Bias in Science?

A: Renewed commitment to the Rigor of the Scientific Method.

REMEMBER RICHARD FEYNMAN!

COGNITIVE BIAS, THE "ELEPHANT IN THE LIVING ROOM" OF SCIENCE AND PROFESSIONALISM

Peter R. Rose, Ph. D
Rose & Associates, LLP

AAPG Distinguished Lecturer, 2015-17

ESSENTIAL READING ON COGNITIVE BIAS:

- Daniel Kahneman (2011) *Thinking, Fast & Slow.*
- Massimo Piatelli-Palmarini (1994) *Inevitable Illusions: How mistakes of reason rule our minds.*
- Jonathan Haidt (2013) *The Righteous Mind: Why Good People are Divided by Politics & Religion.*
- Dan Ariely (2012) The (*Honest) Truth about Dishonesty: How we lie to everyone – especially ourselves.*
- Rolf Dobelli (2013) *The Art of Thinking Clearly.*
- Roger Pielke, Jr. (2007) *The Honest Broker.*
- Robert Merton (1957) *Reward System of Science.*
- Thos. Sowell (1996 ed.) *Knowledge & Decisions.*
- Consortium for Science, Policy & Outcomes (2016) *Science on the Verge.*