TRAINER SCIENCE

4/25-26/09

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IS SCIENCE LIKE LOVE—

We can't define it,
but we know it when we see it?

OBJECTIVES

- Presenters will provide scientific models for exercise
  - Advice: Memorize the vocabulary
  - The models will come
- This part provides the supermodel for science
  - Like an operating system for apps
  - The context for exercise science
  - Self-referential scientific method
  - Memorize the vocabulary

CV Highlights

- PhD systems science
- Chief Scientist for high tech P&L centers
  - Quality of engineering
  - Led Internal Research & Development
    - Engineering & basic science projects
    - Cross trained scientists & mathematicians vs. engineers
  - Led strategic planning for P&L center, product lines
    - Companies with a concept of how to execute plans are rare
  - Due diligence for mergers & acquisitions
- Member UCI Science Education Advisory Board
  - Training K-12 teachers in how to teach science
    - You can't teach something you can't define
    - or Is science like love? We can't define it, but we know it when we see it?
- Educator
  - UCLA Short Courses - generalized transform theory
    - Vocabulary is the base of the pyramid
  - Hughes Technical Education Program - probability, detection & estimation
  - QualComm CDMA Trainer - propagation, coding
  - Lecturer, UCI Summer Science Institute - science in daily life, high tech, curricula
- Consultant
  - UCI Engineering, transitioning research into industry
  - Hi Tech & paralegal, patents to pensions
  - Satellite failure forensics
    - Solar panels, thrusters, contamination, SEM analysis, radiation, data reduction

GETTING HERE

- Teach the meaning of closure in R&D
  - Design programs & science projects for efficiency
  - Cross-train engineers and scientists in method
- UCI Science Education Advisory Board
  - Problem: incoming freshman have abysmal science literacy
  - Solution: Train K-12 teachers in science & math, don't touch curricula
  - Training axiom: You can't teach what you can't define.
    - "Science is like love: We can't define it, but we know it when we see it."
    - "Scientific Method is passé." LACoMuseum Science Curator; Feyerabend: *Farewell to Reason, Against Method*
  - Role of Discovery in Science, consultant for Discovery Museum
  - Roles of Peer Review & falsification in Science
  - Scientific Method

NATURE SEEN FROM THE MAGIC FLYING CARPET TRIP

✘ NO COORDINATE SYSTEMS	✘ NO DIMENSIONS (*l, m, t,* °, ε^1, μ^2)
✘ NO NUMBERS	✘ NEITHER INFINITY NOR THE INFINITESIMAL
✘ NO RATIOS, NO RATES	✘ NO SETS, CATEGORIES, TAXONOMIES
✘ NO PARAMETERS	✘ NO MODELS, NO CAUSE & EFFECT
✘ NO VALUES, NO STANDARDS	✘ NO WEIGHTS, NO MEASURES
✘ NO SCALES	✘ NO THERMOMETERS
✘ NO UNITS	✘ NO CLOCKS, NO CALENDARS
✘ NO EQUATIONS, NO MATH	✘ NO UNCERTAINTY
✘ NO GRAPHS	✘ NO LOGIC

[1]Dielectric constant [2]Permeability constant

& NATURE MAKES NO PREDICTIONS.

ALL ARE MAN'S CREATIONS!

A WORD ABOUT WORDS

- Science demands precise definitions
  - Is science the last bastion? Ambiguity everywhere
    - Major issues of the day -- economy, climate, war, fitness
    - Journalism, Media, Law, Education, History
- Through the Looking Glass:
  - 'When I use a word,' Humpty Dumpty said in rather a scornful tone, 'it means just what I choose it to mean -- neither more nor less.'
  - 'The question is,' said Alice, 'whether you CAN make words mean so many different things.'
  - 'The question is,' said Humpty Dumpty, 'which is to be master - - that's all.'
- How to be branded pedantic

SCIENCE

Practical

Laboratories
Hospitals
Libraries

Knowledge
Objective

Subjective

Explain
Describe
Belief

Basic Science	Technology
Validation	Closure

Quality Control

Carefulness
Confidence
Credentials
Falsification
Peer review
Repetition
Weight
of evidence

SCIENTIFIC METHOD

I. FOUNDATIONS
Natural language
Logic
Mathematics

II. DISCOVERY
Observation
Measurement
Fact

III. CREATIVITY
Model
Cause & Effect/Relation
Prediction
Design of Experiments

IV. VALIDATION
Experiment
Validation/Closure

GOAL:
Skepticism

MODEL QUALITY

Conjecture Hypothesis Theory Law

Familiar Terms, Selected & Organized

MODELS

- A conceptual arrangement of Real World objects and events showing Cause & Effect or Relationship + prediction or inheritance
- Examples & counterexamples
  - Atoms
    - Not Tinkertoy models
    - A Bohr atom, a Schrödinger, a QM model
  - Not a scale model; neither a mock-up nor a prototype
  - Periodic Table, Tree Graph
  - Your concept of a mother-in-law, your mother-in-law
  - Your concept of a superior sports team
  - The accumulation of experience; crucible of generalization
- Models are the containers of science

GRAVITY & THE EYE

- Creation Science 1A: a mystery of the Kabbalah & the Unseen Hand. 10th C. BC
- The bigger they are, the faster they fall. Aristotle, 4th C. BC.
- Constant acceleration for any weight. Philoponus, 6th C; Galileo, 1590.
- Mass, momentum, force, force at a distance, mass product, inverse distance squared. Newton, 1686.
- Mass curves space. Einstein, General Theory of Relativity, 1916.

LOGICAL ARGUMENT

- Sentence (S): Hypothesis (H) implies Conclusion (C)
  - S: H → C
  - Basis for logical inference. If S is true
    - Modus ponens: If H is true, so is C
    - Modus tolens: If C is false, so is H
- Quantifiers
  - Existential: ∃x(·) “For some x …”
  - Universal: ∀x(·) “For all x …”
  - Quantification rules
    - Universal Instantiation (UI)
    - Existential Generalization (EG)
    - Existential Instantiation (EI)

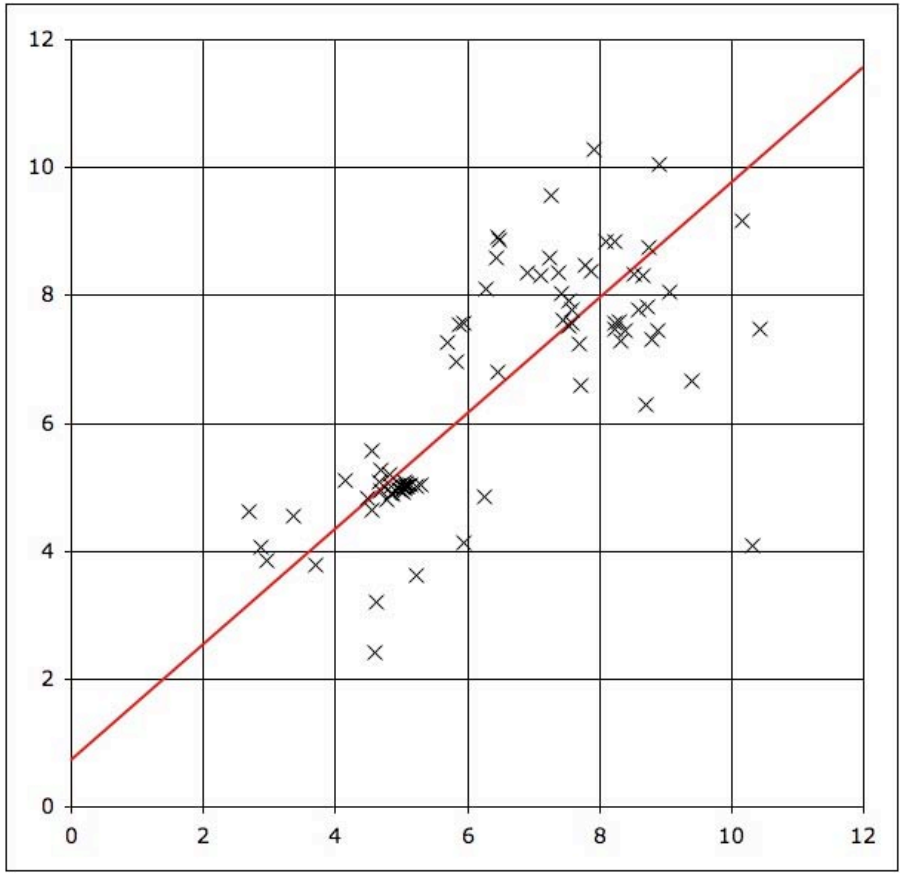
SCIENTIFIC MODELS

- Statement of Cause & Effect or Relationship

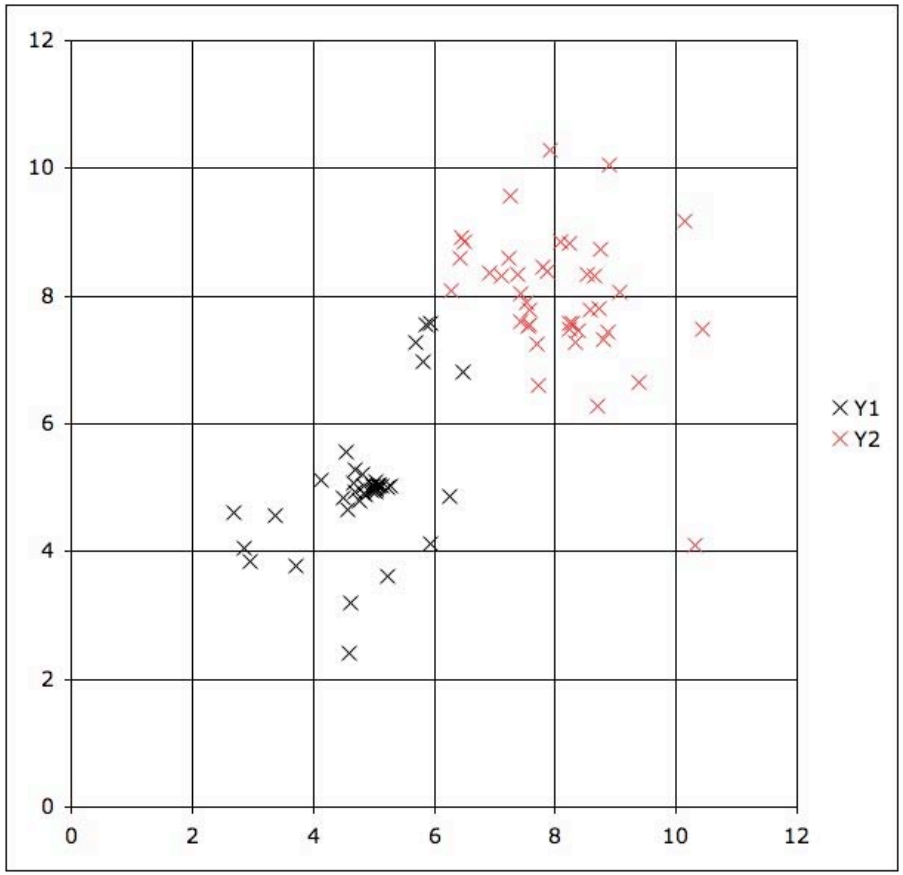
$$C \rightarrow E$$

- C is the problem setup, the Cause
  - Includes the set of initial & boundary conditions
  - Presumably true and valid
  - Faithful to the Scientific Method
  - Induction from facts
    - Generalization
    - E.g., discriminant analysis …
- E is the prediction, the Effect
  - By deduction
  - Subject to validation or closure

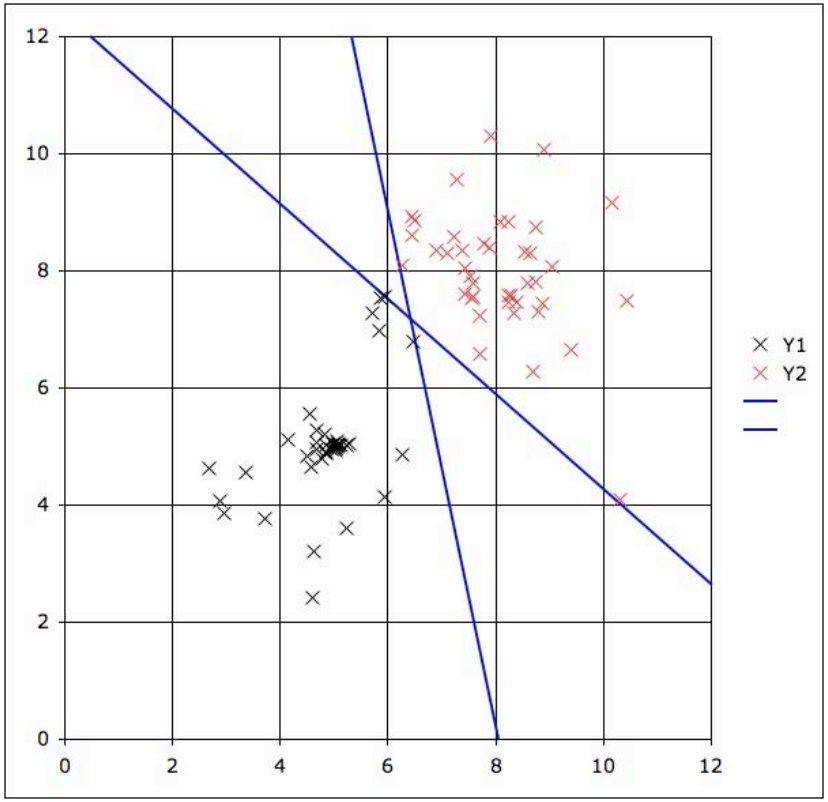
DISCRIMINANT ANALYSIS
Step 1: The Data & a Fit



DISCRIMINANT ANALYSIS
Step 2: … but wait!



DISCRIMINANT ANALYSIS
Objective Discriminating Criteria



POPPER'S ERRONEOUS MODEL

- 20th C's most influential science philosopher
- Popper's concept of a scientific model

$$\forall x(F(x) \rightarrow G(x))$$

  - For all x, if x is a member of F then it is of G
  - "All Fs are G"
  - "Universal Generalization"
  - All Ravens are black: Hempel (1965)
- Popper assumed science practiced an inductive proof …

Popper's Error (Cont)

- Popper's confirmations:

$$F(x_1) \wedge G(x_1)$$
$$F(x_2) \wedge G(x_2)$$
$$\vdots$$

- This would be erroneous logic. It does not establish proof by induction.
- Scientists are not as illogical as all that, & this is not they do.

Popper's Error (Cont´)

- Popper asserted correctly that to prove

$$\forall x(F(x) \rightarrow G(x))$$

  - one must assume

$$\exists x(F(x) \wedge \sim G(x))$$

  - something has the property F but is not a G
  - and show that this leads to a contradiction.
- This was Popper's falsification, and he asserted that it was always necessary in the scientific method.
- Popper thus asserted all science models are of the form of a universal generalization

Popper's Error (Cont´´)

- More likely, no scientific model is a universal generalization.
  - Validation appears impossible
- Math and logic, not science, contain proofs.
- Science is about predictions that are better than chance.
- *Confidence* in science is inductive, & subjective.

Popper's Error (Cont´´´)

- All ravens are black!
  - True by definition
  - A raven is defined as a songbird with a certain physical description that is lustrous black.
  - Regardless of the utility of such a definition, considering albinos or other accidents, it precludes the existence of a non-black raven
  - If one asked an ornithologist whether a specimen non-black bird was a raven, he would have to rely on a different definition, e.g., a DNA test, to establish parentage
- Popper couldn't have contradicted the alleged paradox — he held that "definitions do not matter":
  - "Our 'scientific knowledge'... remains entirely unaffected if we eliminate all definitions"
- Science begins with definitions.

FALSIFICATION

- Didn’t penetrate science
- Karl Raimund Popper, philosopher economist
- Counter examples, contradictions always demote models
- But models don’t have Falsification clauses
- Acid-test: validation of a novel, significant prediction
- Validation, closure replace falsifiable notion

PEER REVIEW

- PEER REVIEW CAN'T DEFINE SCIENCE
  - Astrology, Creationism, Economics, Stock market analysis , Parapsychology
  - Climatology
- TRANSCENDED BY *CLOSURE* & *VALIDATION*
- COMMUNICATING SHOWS OBJECTIVITY
  - Repeatable, not repeated
  - No such thing as a private basic science
  - Incestuous science is tainted science
    - Closed groups
    - Jargon
  - Public access is the essence
    - Ethics

PREDICTION

- Unmaterialized Effect
  - Predicting a particle chamber trace
  - Shard carbon dating (retrodiction)
  - Calling the time and place of a Richter 9
  - Calculating stimulus inflation
- Better than chance

FACT

- Perfectly good free word
- Definition:

A fact is a measurement compared to a standard

THEORY

- Weak, common usage: “Only a theory”
  - esp. as in Evolution Theory
  - Usage rejected as synonymous immature model
- Strong, narrow meaning in science
  - E.g., Probability theory
- Theory: A hypothesis in which a nontrivial prediction has been validated.

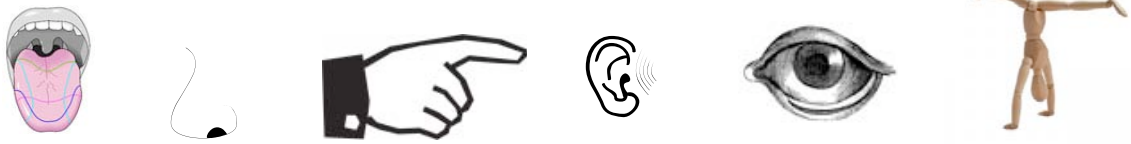
NATURAL LAW vs MAN'S LAW

- "Science is discovery of natural law"
  - filtering model, a sieve of facts
  - repeatability criterion
- If natural law exists, it is not in any language man speaks
- Modern man takes as natural man's inventions: momentum, force, inertia
- Science discovers facts, not models

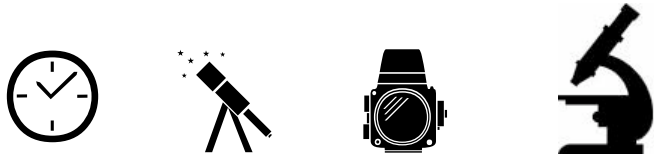
Real World

NATURAL WORLD

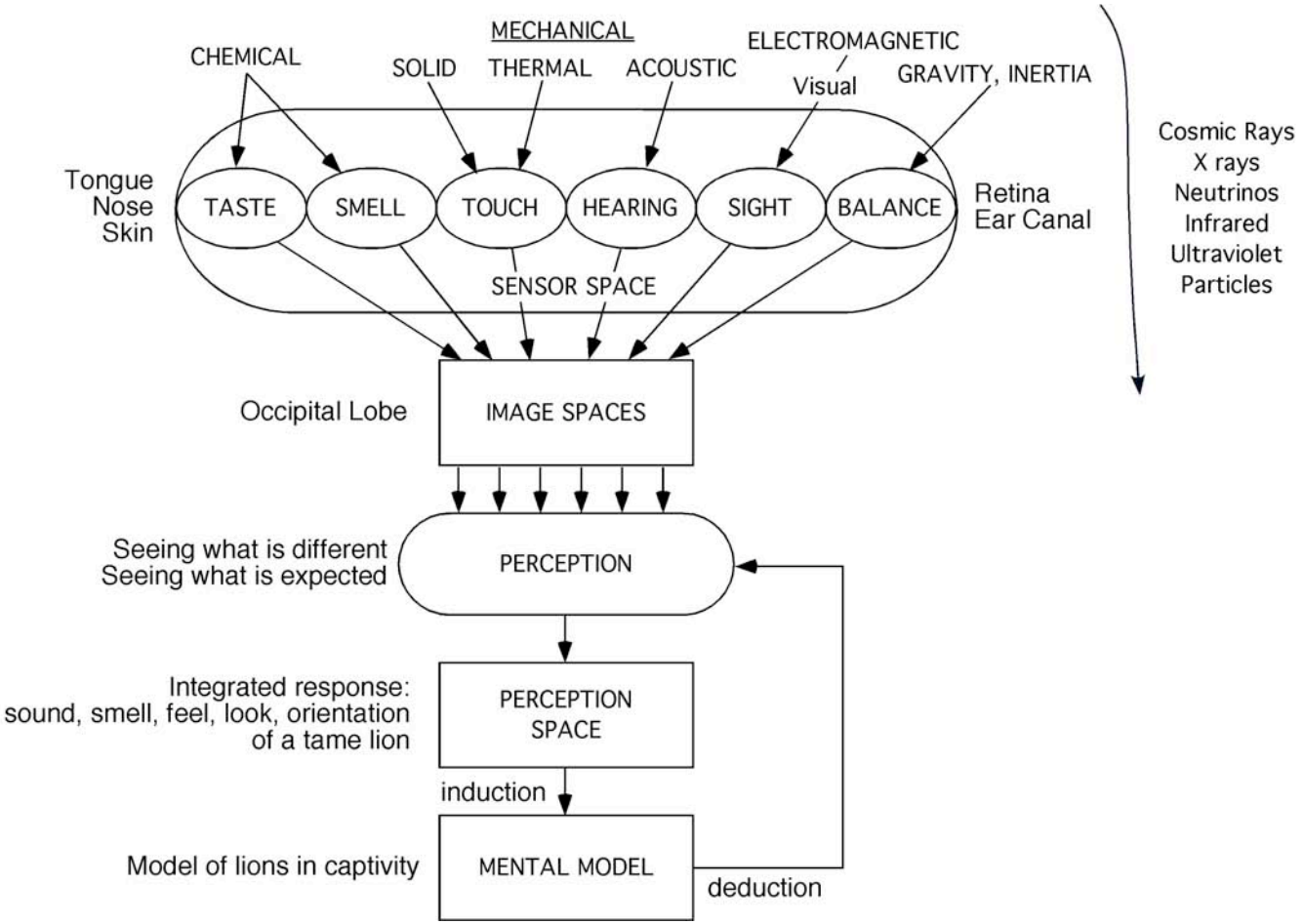
PROJECTED ON OUR SENSES



& ON OUR INSTRUMENTS



REAL WORLD



PERCEPTION & MODELS

KNOWLEDGE

- MODELS REPRESENT REALITY
  - *We only think we deal with reality*
- SCIENCE IS KNOWLEDGE
  - *Not white coats, smelly labs, nerds, hackers & techies*
- THE POWER IN SCIENCE IS VALID PRECICTION
- ANYTHING PRETENDING OBJECTIVITY IS THE STUFF OF
  - *Charlatans, demagogues, fakers, quacks, scam artists, …*

SCIENTIFIC METHOD

- “Scientific method” is in common, ambiguous use and misuse. What is published on the method is chaos.
- Some philosophers, Stove’s four “irrationalists”, urge variously that a scientific method does not exist (Feyerabend, Popper), and that it must include falsification (Popper). These views carry no weight in the modern practice of science.
- Academics routinely include peer-reviewed publication in their definition. Industrial science, which in some fields outpaces academic science by an order of magnitude, regularly rejects publication, and only internally undergoes peer review.
- An operational definition of Scientific Method arises out of the meaning of science. It distinguishes science from non-science, and provides a method to grade scientific achievement.

SCIENCE IS A BRANCH OF KNOWLEDGE

- The Objective Branch
  - Encompasses all things objective
  - if and only if
  - Economics
    - Over-all a human endeavor and not science
    - However, what is measurable is subject to science
- Objectivity vs. Subjectivity …

SUBJECTIVE vs. OBJECTIVE

- Subjective:
  - Resides in the brain
  - “To Explain” & “To Describe” are error
  - So is “Most Scientists believe …”
- Objective:
  - Shared or sharable
  - Measurable
  - To Predict
    - ‘Right here I have a magic black box. …’
    - Earthquakes, the market, Roulette, …

ATTRIBUTES OF SCIENCE

1. Science is a branch of **knowledge**.
2. Science is the **objective** branch of knowledge.
3. Science is ultimately **shared** (public) knowledge.
4. Scientific models account for all relevant **facts** in their domain.
5. Scientific models **predict** new phenomena or relationships.
6. Predictions of qualitatively new results must be **validated**.
7. **Basic science** is the branch of Science
   in the domain of the natural world.
8. **Technology** is the branch of Science
   in the domain of manmade objects and processes,
   that serves man by extending his senses &
   his span of control.
9. Science is the application of the **Scientific Method**.

DEFINING SCIENCE

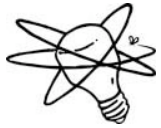
ELEMENTS OF SCIENCE

1. DEFINITIONS

2. OBSERVATIONS

3. MEASUREMENTS

4. MODELS



5. PREDICTIONS

6. EXPERIMENTS

7. VALIDATION

SCIENTIFIC METHOD
FROM ESSENTIAL ELEMENTS

Essential Elements	SCIENTIFIC METHOD
1. Definitions	**1. FOUNDATIONS**
	a. Language
	b. Logic
	c. Mathematics
	2. DISCOVERY
2. Observations	a. Observing
3. Measurements	b. Measuring
	3. CREATIVITY
4. Models	a. Modeling
5. Predictions	b. Predicting
6a. Experiments	c. Designing Experiments
	4. VALIDATION
6b. Experiments	a. Experimenting
7. Validation	b. Confirming

SCIENTIFIC METHOD

1. FOUNDATIONS

a. Language

b. Logic

c. Mathematics

2. DISCOVERY

a. Observing

b. Measuring

3. CREATIVITY

a. Modeling

b. Predicting

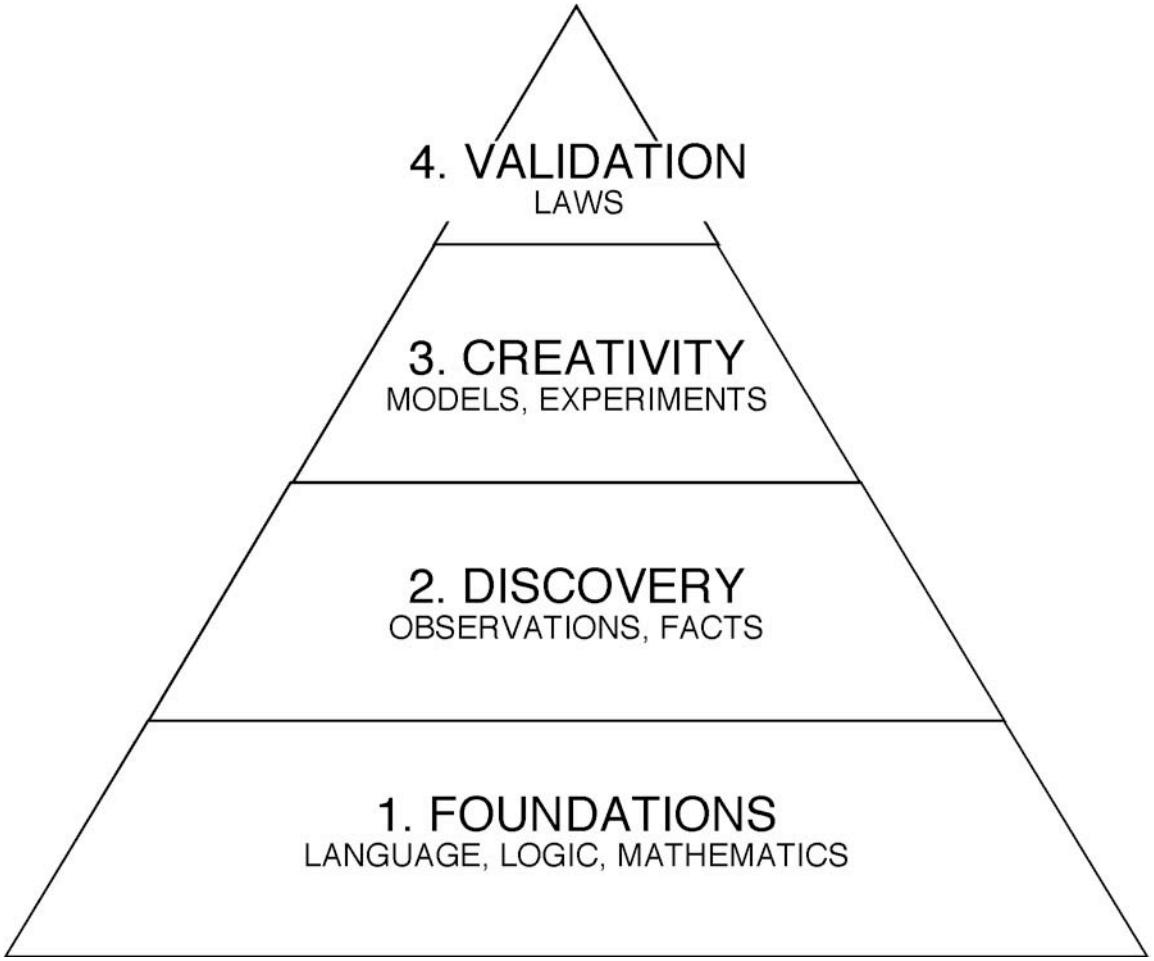
c. Designing Experiments

4. VALIDATION

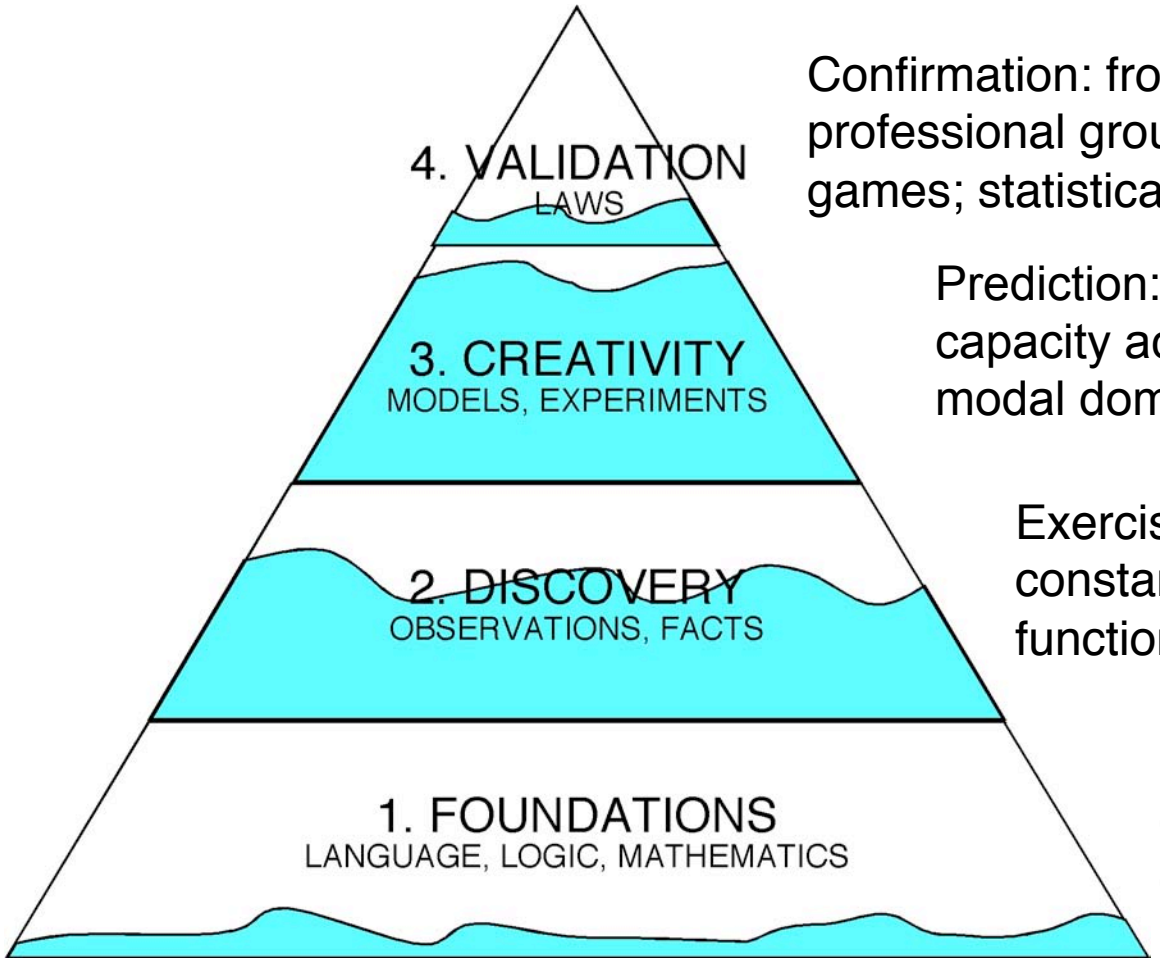
a. Experimenting

b. Confirming

SCIENTIFIC METHOD PYRAMID



CROSSFIT SCIENCE PYRAMID



Confirmation: from individuals, professional groups, contests, games; statistical accumulations

Prediction: increased work capacity across broad time and modal domains

Exercise: Measured, intense, constantly varied or randomized functional movements

Library of exercises; definitions of work, energy; definition of fitness

QUALITY OF MODELS

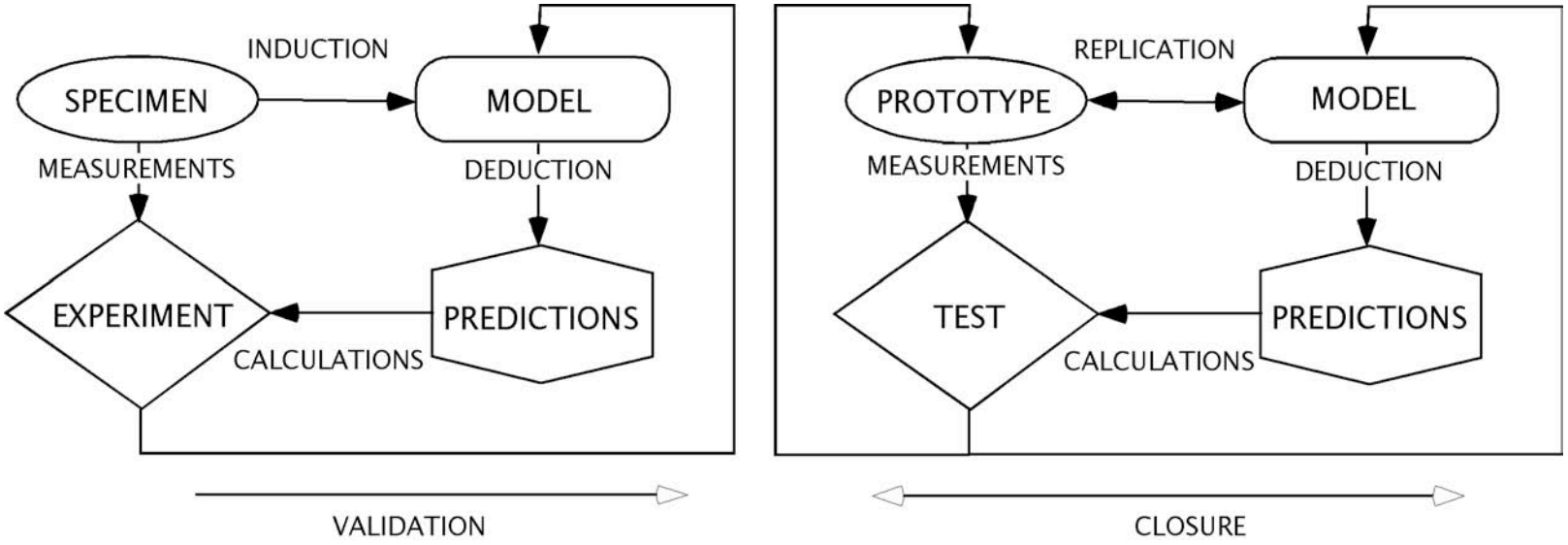
- Jello first came in six delicious flavors
- Scientific Models come in just 4
  - »CONJECTURES
  - »HYPOTHESES
  - »THEORIES
  - »LAWS

MODEL RATING CONCEPT

		Science			
Method Attribute	Non-science	Conjecture	Hypothesis	Theory	Law
Definitions	**O**	✚	✚	✚	✚
Observations	Possible	Possible	✚	✚	✚
Measurements	Possible	**O**[1]	✚	✚	✚
Cause & Effect	Possible	✚	✚	✚	✚
Predictions	Possible	Possible	✚	✚	✚
Experiments	Possible	**O**	**O**	✓	✚
Validation[2]	Impossible	**O**	**O**	✓	✚
Comments	Without definitions, no sharable fact, model, prediction or experiment is possible.	Lacking full set of measurements in domain, model lacks confirmation[2].	Model fits all data in domain. Testable, non-trivial prediction.	Non-trivial prediction validated.	No sensible validation of consequences remains other than to improve accuracy.
	✚ = Complete; ✓ = Non-trivial, but incomplete; **O** = Missing				

- [1] If in a domain objective but unmeasurable observations can exist, give the theory credit for the measurement.
- [2] A *confirming* datum is a *fact* supporting the foundation of a model. It is neither falsifying of the model nor a *fact* validating a prediction.

TWO BRANCHES OF SCIENCE



BASIC SCIENCE TECHNOLOGY

SCIENCE

- is anything faithful
to the
Scientific Method.
- Scientific Method is a checklist, not a recipe.

SCIENCE

Is anything
that makes better-than-chance
PREDICTIONS.

AXIOMS OF SCIENCE

0	*Rational Domain*	The domain of discourse lies in rational thought*
I	*Curiosity*	Man must answer all question; he craves reasons & knowledge of the future and the unobservable, & control of his destiny: thus the Mission for Science
II	*Real World*	∃ an all encompassing 𝔑𝔢𝔞𝔩 𝔚𝔬𝔯𝔩𝔡 beyond knowledge
III	*Cause & Effect*	∀ Effects observed in the 𝔑𝔢𝔞𝔩 𝔚𝔬𝔯𝔩𝔡, ∃ a discoverable Cause in the 𝔑𝔢𝔞𝔩 𝔚𝔬𝔯𝔩𝔡
IV	*Measurability*	∀ objective observations, ∃ an unambiguous standard
V	*Uncertainty*	∀ measurements, ∃ an error
VI	*Master Clock*	∃ A master clock — universal, uniform, & unidirectional
VII	*Least Work*	Systems that adapt evolve to conserve energy
VIII	*Logic Rules & Axioms*	Science is based on logical discourse, using a set of rules & axioms. The set is not unique.

* re the "irrationalists", e.g. Popper, Feyerabend's *Farewell to Reason* & *Against Method*

SCIENCE GLOSSARY (I)

basic science	Science in a domain of the natural world
belief	Subjective acceptance of a model, hence external to science
conjecture	A consistent Cause & Effect or relationship, such as ranking or heritage, direct or by analogy to another domain.
confirmation	A measurement within the uncertainty range of its prediction, or a set of such measurements consistent with the predicted probability distribution
creativity	Part 3 of 4 of the Scientific Method, the design of models and experiments
describe	To appreciate subjectively that a model depicts a part of the Real World, hence external to science
discovery	Part 2 of 4 of the Scientific Method, encompassing observations and measurements of Real World objects and processes, and the quantification of patterns in the measurements
explain	To accept subjectively that a model accounts for Real World processes, hence external to science
fact	A measurement relative to a standard
foundations	Part 1 of 4 of the Scientific Method, encompassing language, logic and mathematics by which models are expressed
hypothesis	A conjecture based on all existing data in its domain & making a non-trivial prediction .
language	Natural verbal communications, such as English, ASL
law	A theory for which all explicit and implicit predictions have been validated

SCIENCE GLOSSARY (II)

logic	The abstract, formal structure of argument as characterized in language, including truth and falsity, rules of inference, deduction, mathematical induction, quantification, negation, adjunction, conjunction, and implication.
mathematics	Symbolic representation and treatment of relationships between entities characterized by numbers, shapes, sets, or patterns
measurement	Capture of Real World observations on a standard scale
model	A representation of a Real World Cause & Effect or relationship, expressed in natural language, logic, or mathematics
observation	A registration of the Real World on a sense or sensing instrument
prediction	A forecast of a measurement
scientific method	A process of objective investigation of the Real World comprising the four parts of Foundations, Discovery, Creativity, and Validation
sense	Seeing, hearing, smelling, tasting, touching, or balancing.
standard	A basis of comparison
technology	Science in the domain of the manmade world
theory	A hypothesis containing a significant, validated prediction.
validation	Part 4 of 4 of the Scientific Method, encompassing empirical evidence of and statistics for predictions.

Backup Slides

Wikipedia
ELEMENTS OF SCIENCE

- The essential elements[11][12][13] of a scientific method[14] are iterations,[15][16] recursions,[17] interleavings, and orderings of the following:
- Characterizations (observations,[18] definitions, and measurements of the subject of inquiry)
- Hypotheses[19][20] (theoretical, hypothetical explanations of observations and measurements of the subject)[21]
- Predictions (reasoning including logical deduction[22] from the hypothesis or theory)
- Experiments[23] (tests of all of the above). Wikipedia, *Scientific method*, 2/24/09

Wikipedia: Iterations, Recursions, Interleavings & Orderings

1. **Iteration** in computing is the repetition of a process … .
2. Recursion in linguistics enables 'discrete infinity' by embedding phrases within phrases of the same type in a hierarchical structure. … **Recursion** is the process a procedure goes through when one of the steps of the procedure involves rerunning the procedure.
3. **Interleaving** … is a way to arrange data in a non-contiguous way in order to increase performance.
4. [A] **partially ordered set** … formalizes … an ordering, sequencing, or arrangement of the elements of a set. Wikipedia, 2/24/09

Wikipedia: OPERATIONAL MODEL of a scientific method

- The essential elements of a scientific method are operations, observations, models, and a utility function for evaluating models.[citation needed]
- Operation - Some action done to the system being investigated
- Observation - What happens when the operation is done to the system
- Model - A fact, hypothesis, theory, or the phenomenon itself at a certain moment
- Utility Function - A measure of the usefulness of the model to explain, predict, and control, and of the cost of use of it. One of the elements of any scientific utility function is the refutability of the model. Another is its simplicity, on the Principle of Parsimony also known as Occam's Razor.

Wikipedia: linearized, pragmatic [essential elements] … guideline for proceeding[26]

1. Define the question
2. Gather information and resources (observe)
3. Form hypothesis ◄
4. Perform experiment and collect data
5. Analyze data
6. Interpret data and draw conclusions that serve as a starting point for new hypothesis ──┘
7. Publish results
8. Retest (frequently done by other scientists). Wikipedia, 2/24/09

[26]Crawford S, Stucki L (1990), "Peer review and the changing research record", "J Am Soc Info Science", vol. 41, pp 223–228. Susan Crawford & Loretta Stucki are Medical School librarians, U. Washington at St. Louis.

Wikipedia: On guideline

- While this schema outlines a typical hypothesis/testing method,[27] it should also be noted that a number of philosophers, historians and sociologists of science (perhaps most notably Paul Feyerabend) claim that such descriptions of scientific method have little relation to the ways science is actually practiced.

On the Real World & Perception – I

I shall consider that the sky, the air, the earth,
colours, shapes, sounds, and
everything which we see in the external world
are nothing but illusions and tricks
which He employs to gull my credulity.

– Descartes, *Discourse on the Method*, 1637

KNOWLEDGE & CERTAINTY

On the Real World & Perception - II

When we pass from the works of nature,
in which all the delineations are perfectly accurate
and appear to be otherwise
only from the imperfections of the eye which surveys them,
to the institutions of man,
in which the obscurity arises as well from the object itself
as from the organ by which it is contemplated,
we must perceive the necessity
of moderating still further our expectations and hopes
from the efforts of human sagacity.

–Madison, *Federalist Paper No. 37,* 1788

KNOWLEDGE & CERTAINTY

On the Real World & Perception - III

The belief in an external world
independent of the perceiving subject
is the basis of all natural science.

Since, however, sense perception
only gives information of this external world
or of "physical reality" indirectly,
we can only grasp the latter
by speculative means.

– Einstein, *The World as I See It,* 1931

KNOWLEDGE & CERTAINTY

On the Real World & Perception - IV

The implication is that it is much more
custom and example
than any certain knowledge
which persuades us.

Yet the voice of a majority carried no weight as a proof
where the truths are a little difficult to discover,
since it is more likely that one man on this own
rather than an entire people
has found them.

– Descartes, *Discourse on the Method,* 1637

KNOWLEDGE & CERTAINTY

On the Real World & Perception - V

The power of judging well and of distinguishing
the true from the false
– which properly speaking is what we mean by
good sense or reason –
is naturally equal in all men.
I was attracted above all by mathematics,
because of the certitude and the evidence of the arguments there.
But I did not yet appreciate its true application,
thinking that it was of use only to the mechanical arts.
I was astonished by the fact that
when foundations are so firm and solid
no one should have built anything taller on top.

– Descartes, *Discourse on the Method,* 1637

KNOWLEDGE & CERTAINTY

On the Real World & Perception - VI

XLVI. For in and out, above, about, below,
'Tis nothing but a Magic Shadow-show,
Play'd in a Box whose Candle is the Sun,
Round which we Phantom Figures come and go.

LXVIII. We are no other than a moving row
Of Magic Shadow-shapes that come and go
Round with the Sun-illumin'd Lantern held
In Midnight by the Master of the Show.

– *Rubaiyyat of Omar Khayyam*

KNOWLEDGE & CERTAINTY

ADAPTATION

- Adaptation is a necessary characteristic of Life, implemented by robustness of the species and evolution. It is biophysics. It is Gaia-like, meaning a reference to the collection of all life, the objective being to emphasize that adaptation is a characteristic of the specimen to be activated by the environment and training, and not to be inserted thereby;

EQUILIBRIUM

- Equilibrium is too important to be used imprecisely, as demonstrated by IPCC work. Equilibrium arises with reversible processes, but reversibility does not imply equilibrium. It is a state in which all exchanges of work have ceased.
- A system is in an equilibrium state when it is isolated and all parameters are constant.

$$A + B \underset{K_0}{\overset{K_1}{\rightleftharpoons}} C + D$$

$$K_1 = \frac{[C][D]}{[A][B]} = \frac{1}{K_0}$$

DATA SELECTION

- Data Selection, e.g., outlier removal, leads to model demotion.

LINEARITY

- Linearity, a property exclusively of models. Climate is either linear or not. Non-linearity is the absence of linearity, and has no range. “Very nonlinear” is meaningless.

$$f(Ax_1 + Bx_2) = Af(x_1) + Bf(x_2)$$

A NEW PERSPECTIVE ON SCIENCE LEADING TO AN OPERATIVE DEFINITION

– FOR TEACHING

– FOR PLANNING PROJECTS

– FOR JUDGING “THEORIES”

– FOR ASSESSING RISK

– FOR INCREASING KNOWLEDGE

A MISSION FOR SCIENCE EDUCATION

- MAKE CITIZENS LESS VULNERABLE TO SCAMS
- HELP PEOPLE DEAL WITH RISK
- DISTINGUISH SCIENCE FROM ARTS, RELIGION
- PRAGMATIC

#1 GENERAL CITIZENSHIP, PARENTING

#2 JOB TRAINING

#3 INDUSTRIAL COMPETITIVENESS

#4 NOT PHD PREP, BUT A RESOURCE POOL FOR COLLEGE

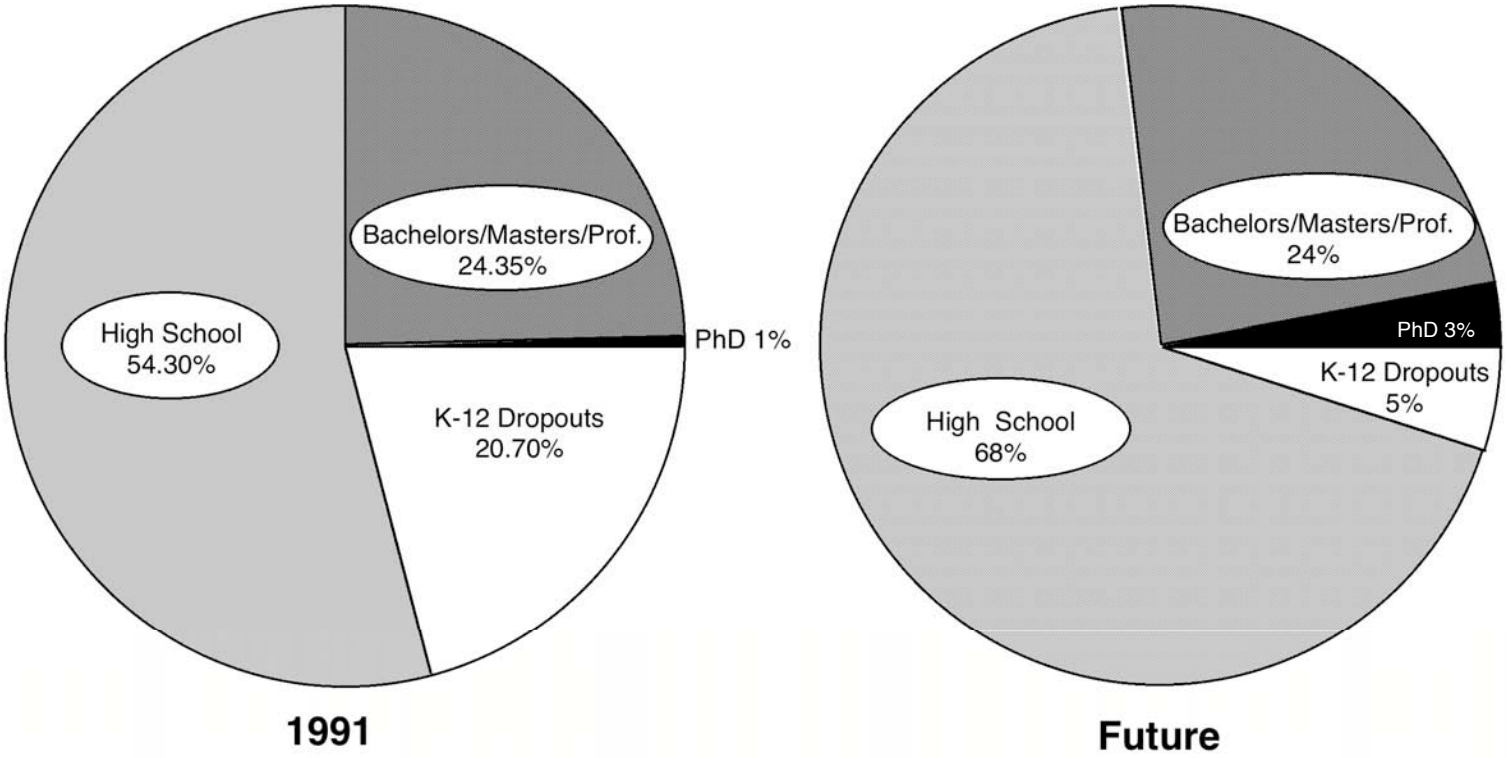
FOSTER SKEPTICISM

- WHEN IS A SCIENTIST BEING A TRUE SCIENTIST?
- WHICH THEORY IS CORRECT?
- WHAT DOES “CORRECT” MEAN?

MENTAL BLOCKS & DEFICITS

MOST VULNERABLE	DISEASE	SYMPTOM: Inability to …
Engineers, scientists	Englishosis	use English to job standards
Degreed professionals, citizens Lawyers, juries	Determinitis	cope with randomness, risk
Clerical & blue collar workers, parents	Integeritis	handle fractions, decimals
Non-technical degreed professionals	Enumeritis	handle elementary mathematical operations
Administrators, clerical workers	Verbalosis	manipulate elementary algebraic expressions
Clerical workers, teachers, media	Graphosis	use graphs

CALIFORNIA EDUCATION ACHIEVEMENT



- A consequence, not an immediate goal
- Making attendance a goal emasculates curricula
- Achieve attendance through value delivered

PARAMETER

The name and particular properties given to any object, dimension, scale, concept or thing, or a class of such PARAMETERs, which have different values or states of being.

E.g., any algebraic variable whether symbolic or not; system state or condition of being, a characterizing element; identification of a tabular column or row, graph axis, or a space or blank slot provided for completion in a form, or anything capable of a tabular, graphical, or blank slot representation, and capable of being named and specified; name and properties given to any datum, to any physical concept capable of being observed, characterized, or measured, or to any ratio or proportion; computer storage element whether real or virtual so specified. Any identifiable variable which may be in one of only two states, such as having the value of being true or false, high or low, on or off, black or white. Any general name to which specific names or different values may occur or be assigned.

Includes any property or dimension of an object or concept specified by name and particular conditions or restrictions, including a statistic of a measurement. Distinguished from any of its values or content at any time, location, or state of being.

A PARAMETER in one context may be a value of another PARAMETER in a different context.

EXPERIENCE IN INDUSTRY

- QUALITY OF ENGINEERING
- CUSTODIAN OF INTELLECTUAL PROPERTY
- RESEARCH PROJECTS …
- DEVELOPMENT PROGRAMS …
- TRAINING PERSONNEL …
- SYSTEMS SCIENCE …
- STRATEGIC PLANNING
- PROMOTING SKEPTICISM …

PLANNING RESEARCH PROJECTS

- WHAT ARE THEY?
  MODELING PHENOMENA
- WHEN ARE WE DONE?
  VALIDATION

PLANNING DEVELOPMENT PROGRAMS

- WHAT ARE THEY?
  PROGRESSIVE RISK REDUCTION!
- WHAT IS NECESSARY & SUFFICIENT TESTING?
  CLOSURE

TRAINING PERSONNEL

- SCIENTISTS, MATHEMATICIANS, ENGINEERS
- FIELD TRAINING, CROSS TRAINING
- SPECIAL PROBLEMS:
  ENGLISH, GRAPHS, ALGEBRA, RANDOMNESS, Others
- SUPPORT PERSONNEL:
  CLERKS, ATTORNEYS/CONTRACT TYPES, BUSINESS/FINANCIAL TYPES, LIBRARIANS, TECHNICIANS
- EXECUTIVES, MANAGERS

WHAT IS SCIENCE

1	*Science is a branch of knowledge*	Science is not merely an occupation, safely ignored by anyone who might, or by the intellectually lazy.
2	*Sciences is the objective branch of knowledge*	The domain of Science is bounded only by those things man can define, record, measure, & quantify or order. Even these attributes do not assure objectivity, for groups of well-trained observers do sometimes fool themselves into thinking that the group has made a contribution. Individual senses & mental models shape perceptions of the Real World.
3	Science creates models that account for observations of the Real World.	Objective models replace private, subjective models. Prose models, mathematical models, & computer models are but mere translations, one to the other, in the several languages of Science.
4	Science models build on measurements of the observations.	Measurements (facts: comparisons of observations with standards) provide consistency in observations & permit objective sharing of experiences. With all safeguards to this point, a model that a scientist might create from facts may yet be myth. No matter how often he might repeat his measurements, they provide only improve accuracy (confirm). Science asks substantially more.

WHAT IS SCIENCE (Cont.)

5	*Scientific models require validation through demonstrated predictions of qualitatively new phenomena or relationships.*	Qualitatively new phenomena involve different parameters than confirming facts.
6	*Basic science is the branch of science in the domain of the Real World.*	
7	*Science satisfies Man's need to predict, & hence to control.*	Beyond the desire to predict the future, which Man shares with other animals, Man wants to govern his fate by controlling his environment – to close the loop. *To Explain* or *To Describe* are subjective values; the beauty in Science. *To Predict* is the ultimate in objectivity & knowledge

- Corollary: Any Endeavor that Applies the Method Is Science
  - Corollary: Any Model with Predictive Power is Scientific

STRATEGIC PLANNING OF SCIENCE EDUCATION

SCIENCE IS THE OBJECTIVE BRANCH OF MAN'S KNOWLEDGE

☆ MISSION	To Serve Man by Accounting for the Real World in a Constructive Way
☆ GOAL	To Create Useful Models of Real World Phenomena Consistently Based on Measurements
☆ OBJECTIVE	To Predict Novel Phenomena or Relationships that Validate the Models
☆ Technology	The Branch of Science that Increases Man's Physical Horizons & Gives Man Control Over His Environment.

SCIENTIFIC METHOD

- FOUR ELEMENTS
  1. Foundations
  2. Discovery
  3. Creativity
  4. Validation
- IN ANY ORDER
  - A checklist
  - Not a recipe
- This morning, the emphasis is on language
  - We'll turn the method around and apply it to science
  - Talk the talk

FORMS OF HUMAN INQUIRY

AN ACCOUNTING

	FIELD				
Scientific Method Attribute	Astrology & Religion	Environ-mentalism	UFOlogy	Para-psychology	Technical Stock Market Analysis
A. Definitions	O	✔	✔	✔	✔
B1. Observations	✔	O	✔	✔	✔
B2. Measurements	O	O	O	✔	✔
C1. Models	✔	✔	✔	O	✔
C2. Predictions	✔	✔	✔	O	✔
C3 & D1. Experiments	O	O	O	✔	O
D. Validation	O	O	O	O	O

SCIENCE LITERACY TEST

IS _____ SCIENCE?

practice, model, curriculum, report, …

IF NOT, WHY NOT?

IF SO, WHAT REMAINS TO BE DONE?

FINAL EXAM IN SCIENCE

For each endeavor or concept here, explain whether it is Science.
If it is not Science, state which criteria for Science are missing.
If it is Science, state the stage of development of the model.

ANTHROPOGENIC GLOBAL WARMING
ASTROLOGY
BALANCE OF NATURE
BALANCED DIET
CALORIES IN - CALORIES EXPENDED
COLD FUSION
CREATIONISM
DEFORESTATION
DELICATE BLUE PLANET
DESTRUCTION OF SPECIES
DIET FAD OR REGIMEN (of your choice)
ECONOMICS
EMF HAZARDS (Power lines, CRTs)
ESP
EVOLUTION
GLOBAL CLIMATE MODELS
GLYCEMIC INDEX
NUCLEAR WINTER
OZONE DEPLETION
PARAPSYCHOLOGY
SECOND HAND SMOKE HAZARD
SURVIVAL OF THE FITTEST
TECHNICAL STOCK MARKET ANALYSIS
TOBACCO CARCINOGENS
UFOs
UNIFORMITARIANISM