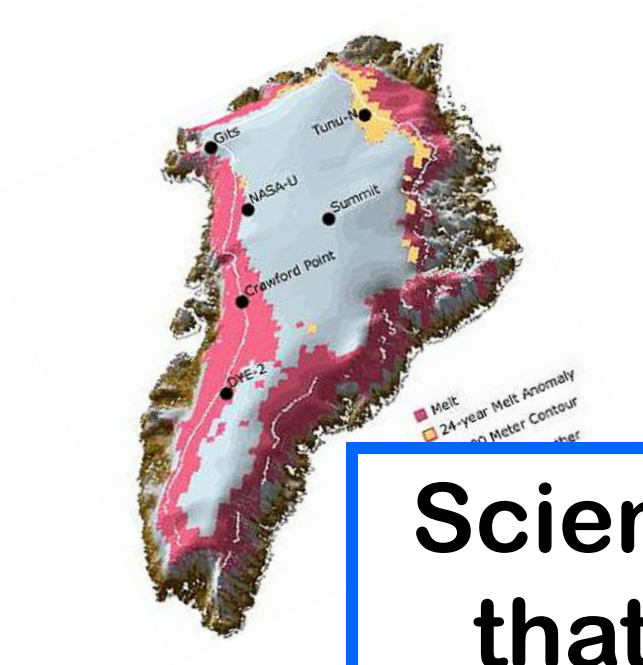
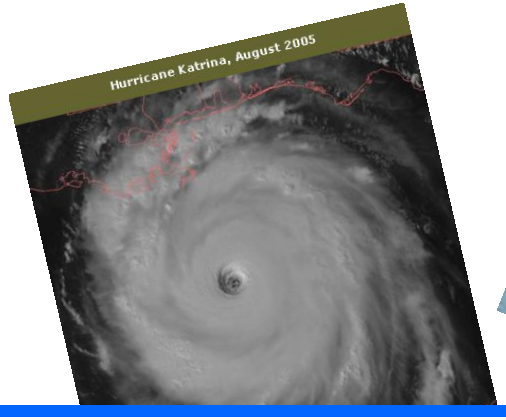
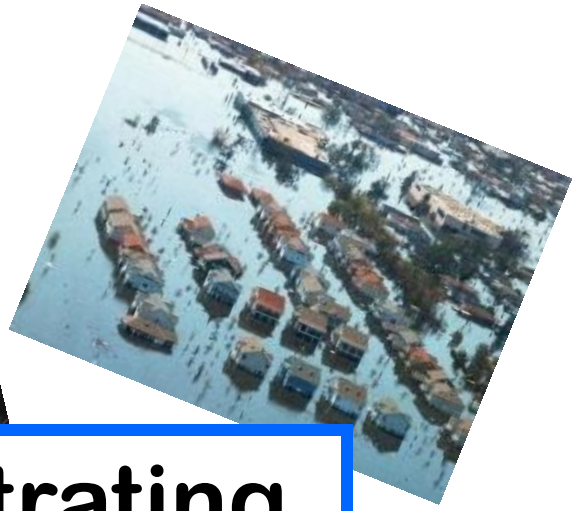
Topic #2:
ON GLOBAL CHANGE SCIENCE
&
BEING A SCIENTIST

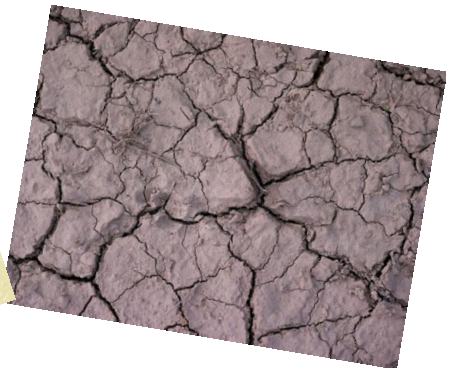






Science is demonstrating that this planet is more vulnerable than had previously been thought.

~ Richard Benedick



OBJECTIVES FOR TODAY'S CLASS:

- Gain an understanding of the huge scope of
  Global Change scientific research:
  at UA, nationally, and internationally

- Review "the" formal scientific method

- Learn how science "in practice" involves a wide variety of approaches – especially for Global Change science

- Hear how scientists themselves describe their science

- Understand that science advances through a constant critique of its own findings and methods

- Have fun with quotes and cartoons about science!

THE SCOPE OF GLOBAL CHANGE SCIENCE

GLOBAL CHANGE SCIENCE

"The one universal ever-operating law throughout has been the law of change . . ." ***~ Laurence M. Gould***

Earth has <u>always</u> been changing in:

Atmosphere (gases – composition, abundance, vertical structure

Solid Earth (core, mantle, crust, plate tectonics, volcanism, surface processes)

Hydrosphere (liquid, gaseous, solid)

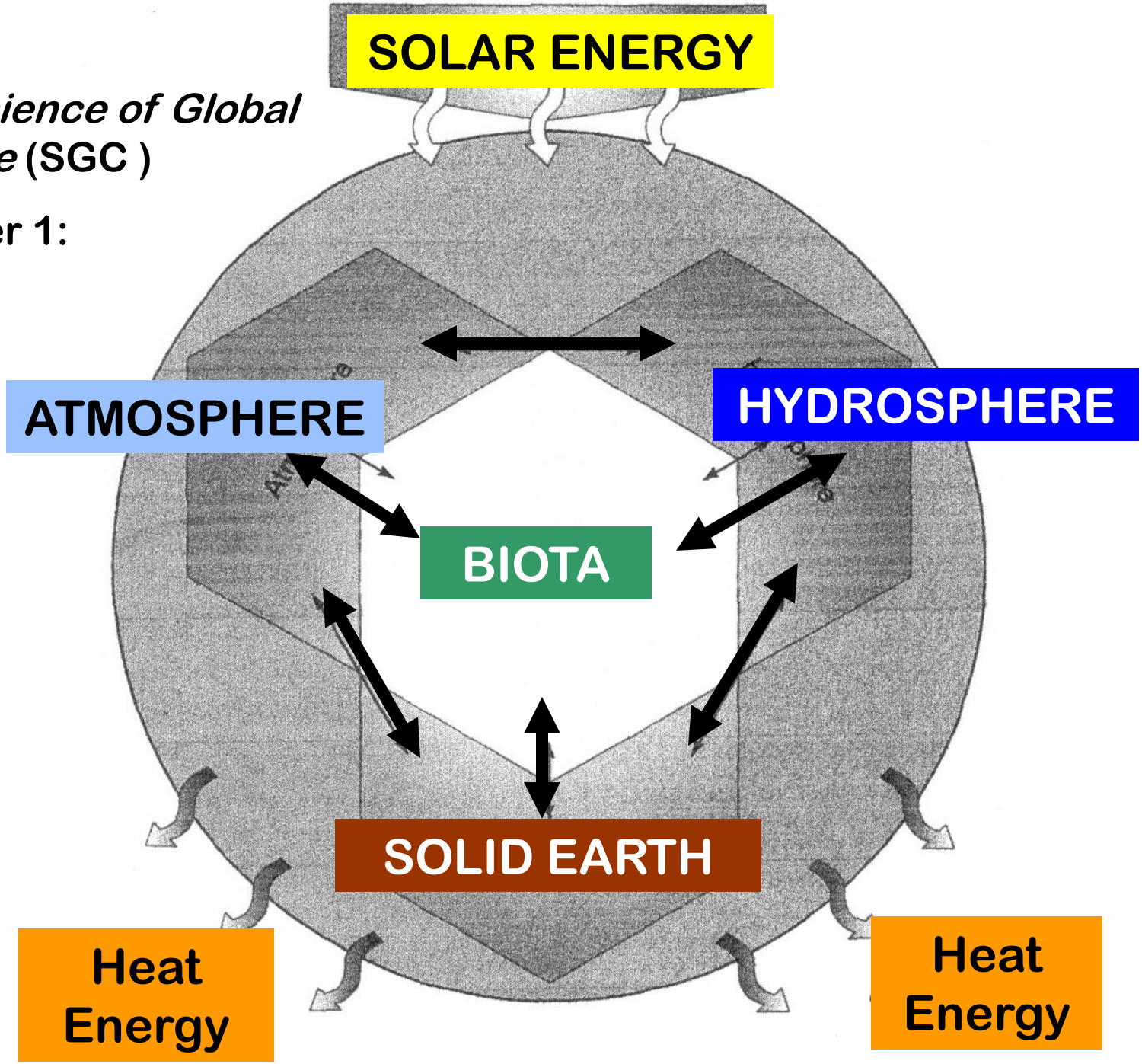
Biota (biosphere) (animal & plant life)

. . . .and in patterns and distribution of the above

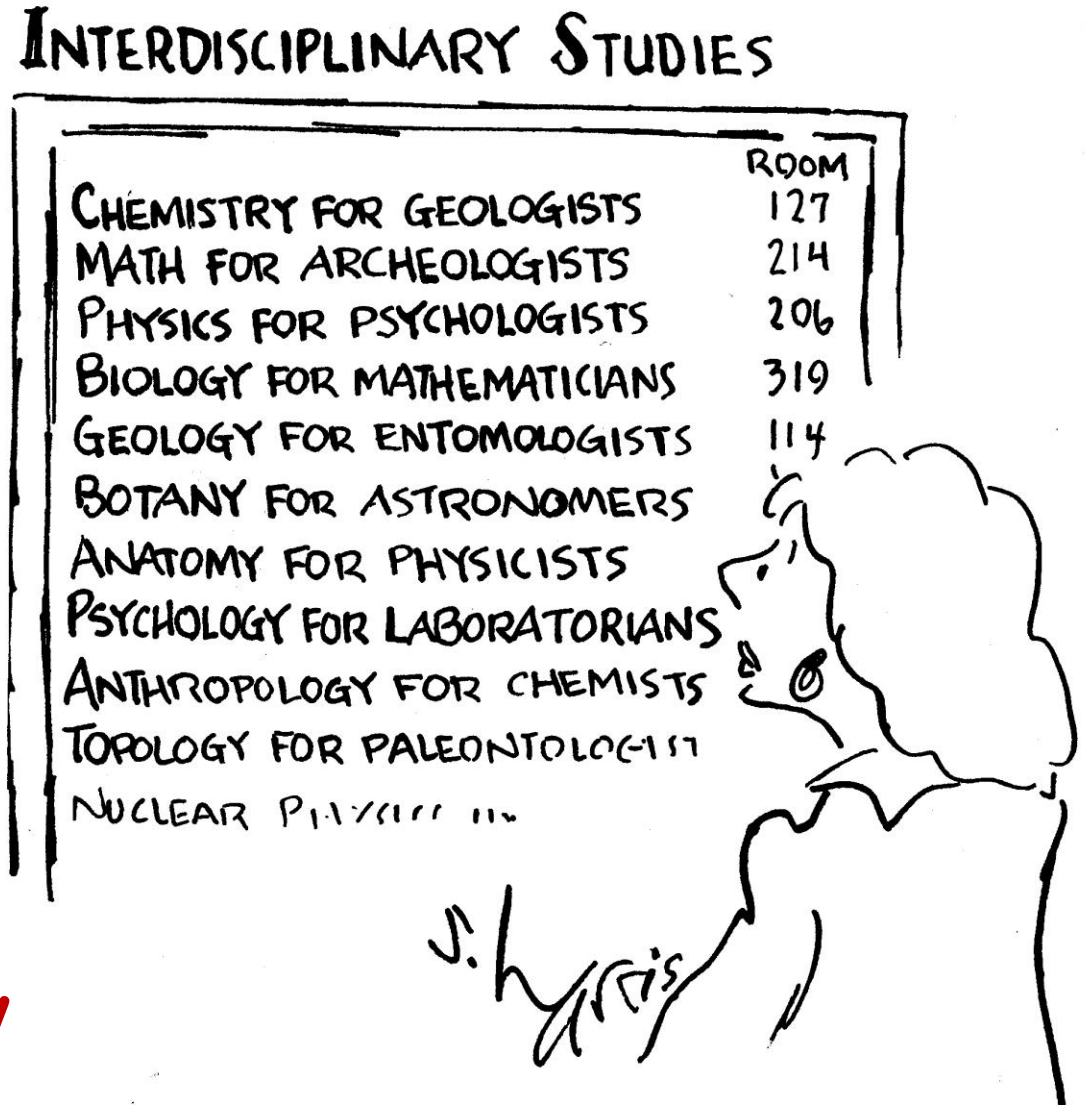
From:

The Science of Global Change (SGC)

Chapter 1:



Hence studying global change requires an interdisciplinary approach



GLOBAL CHANGE SCIENCE IN ACTION

. . . at U of A ←

. . . Nationally

. . . Internationally

How Global Change Science is done:

Many disciplines involved, e.g., at U of A . . .

Geosciences
Hydrology & Water Resources
Atmospheric Sciences
Laboratory of Tree-Ring Research
School of Geography & Development
Arid Lands Resource Sciences
Global Change PhD Minor
Remote Sensing Minor
School of Natural Resources & Environment
Udall Center for Studies in Public Policy
Soil, Water & Environmental Science
Electrical / Environmental / Computer Engineering
Ecology & Evolutionary Biology
Anthropology
Economics & Agricultural Economics . . . etc. etc.

Institute of the Environment

Institute of the Environment (IE)

www.environment.arizona.edu

&

The University of AZ's Global Change Faculty

GRADUATE INTERDISCIPLINARY PROGRAM IN GLOBAL CHANGE

Our Mission

The Institute of the Environment collaborates across The University of Arizona campus to understand, communicate, and solve the environmental challenges facing our world, nation, and state, as well as to help the people of Arizona seize opportunities created by these challenges.

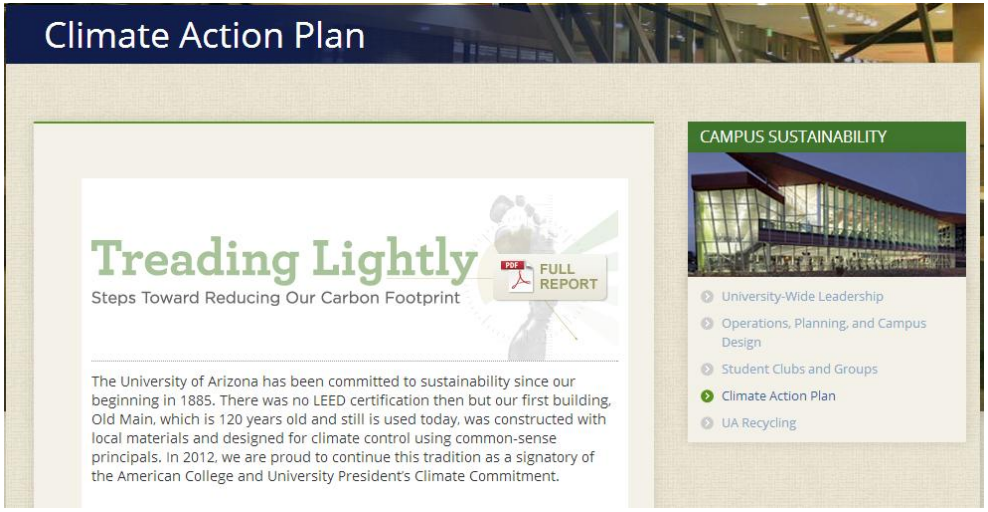
UA Environment & Sustainability Portal

www.portal.environment.arizona.edu

Campus Sustainability

Campus Climate Action Plan

www.portal.environment.arizona.edu/campus-sustainability/climate-action



ASUA Students for Sustainability

http://sustainability.asua.arizona.edu

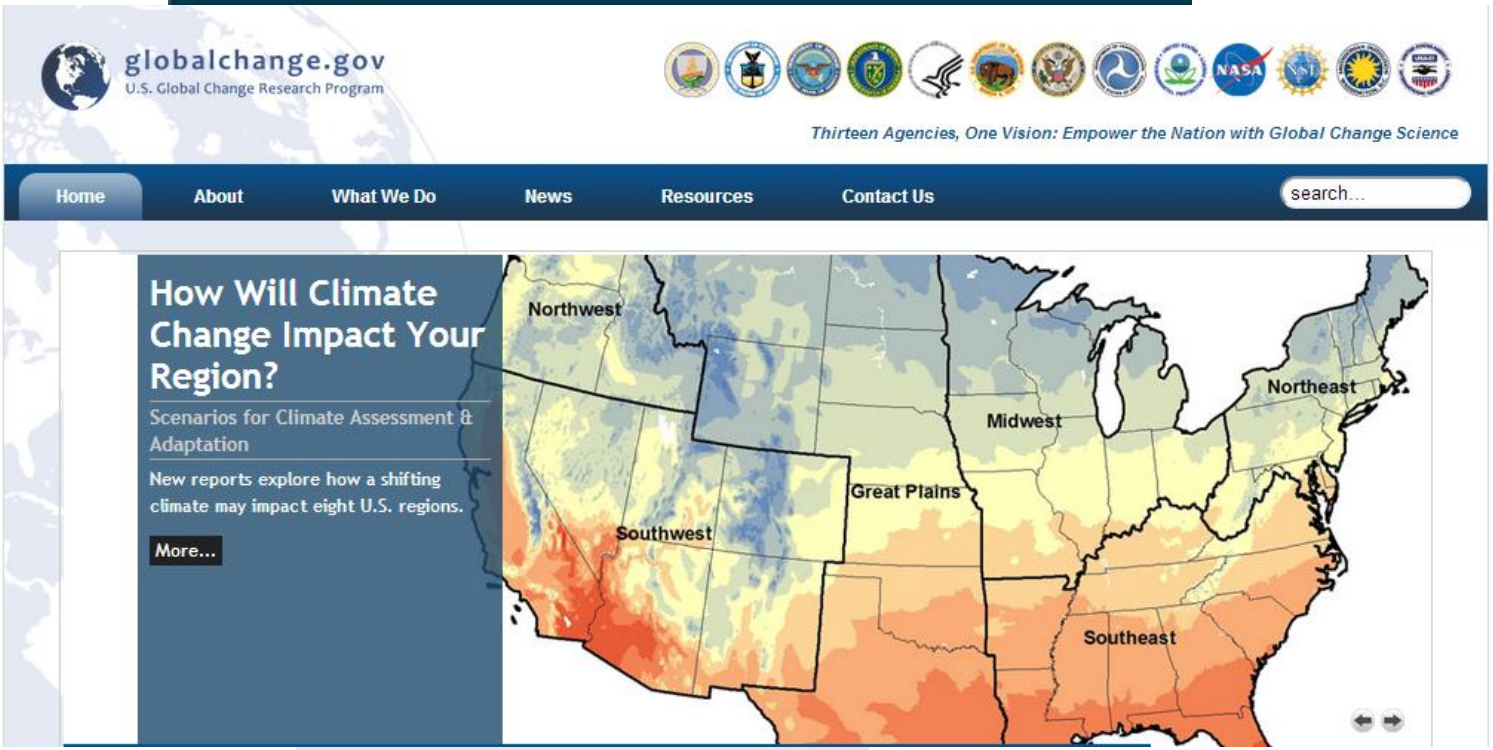
GLOBAL CHANGE SCIENCE IN ACTION

. . . at U of A

. . . **Nationally** ←

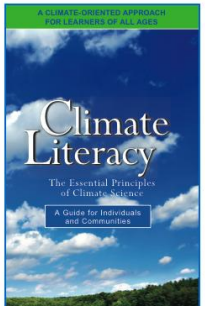
. . . Internationally

U.S. GLOBAL CHANGE RESEARCH PROGRAM



Reports and Assessments

Annual Reporting to Congress



GLOBAL CHANGE SCIENCE IN ACTION

. . . at U of A

. . . Nationally

. . . **Internationally** ←

Intergovernmental Panel on Climate Change (IPCC)

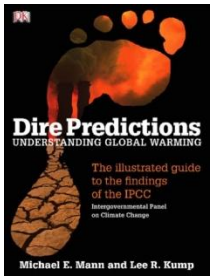
http://www.ipcc.ch/

The 2007 Report

4th Assessment Report (AR4)

The 5th Assessment Report

SOON!



Your Dire Prediction text is based on AR 4:

"The illustrated guide to the findings of the IPCC"

POP QUIZ
ON THE SYLLABUS & FAQ !!!

Q1: What should you do if you miss class?

Q2: When can you use a laptop during class?

Q3: What should you do if you need Dr H to sign a grade report for your coach, tutor, sorority, fraternity, etc.?

Topic #2 (cont.)
ON BEING A SCIENTIST

"The real purpose of scientific method is to make sure Nature hasn't misled you into thinking you know something you don't actually know."

~ Robert Pirsig
Zen and the Art of Motorcycle Maintenance

WHITE HANDOUT

ON SCIENTIFIC METHOD (s?) & the Nature of Scientific Research

. . . About the essay:

Robert Pirsig's essay from
Zen and the Art of Motorcycle Maintenance
outlines a 6-part "Formal Scientific Method":

1. **statement of problem**
2. **hypotheses about the cause of the problem**
3. **experiments designed to test each hypothesis**
4. **predicted results of experiments**
5. **observed results of experiments**
6. **conclusions from the results of experiments**

Read it tonight if you haven't read it yet!

Is there “a” single scientific method?

Many scientists regard such blanket descriptions of what they do with suspicion.

Rather than following a single scientific method, scientists use a *body of methods* particular to their work.

But first a review of the traditional outline of "the" scientific method:

a. **OBSERVATION**

b. **HYPOTHESIS**

c. **PREDICTION**

d. **TESTING**

OBSERVATION (vs. Experiment):

Observation -- observe nature without manipulating it

Experiments -- manipulate some aspect of nature and observe the outcome

Then identify **patterns** and **regularities** in one's observational and experimental results.

What scientific methods do Global Change scientists use??

Experiments?

- **The ever-changing Earth is one unrepeatable "experiment" -- We are living it!**
- **We can run controlled experiments on isolated parts of system, but can ALL the components of the system be part of an experiment?**
- **Computer models are the closest we come to running global change experiments . . .**

Observations?

- How can the whole Earth be observed?
  - collecting & monitoring LOTS of data
  - plus remote sensing from satellites

- How can change over long periods of time be observed?

– paleoclimatic indicators, "natural archives" (tree rings, etc.)

- Combine the above with computer models of past, present and future environments based on input from local, regional, and global observations

HYPOTHESIS

Form a **HYPOTHESIS**

-- a “tentative guess” about how the world works

-- must be able to be evaluated with available data

-- often several hypotheses are formed at once
"multiple working hypotheses"
(scientists want to avoid "ruling hypothesis")

THEORY -- refers to a description of the world that covers relatively large numbers of phenomena and has met extensive observational and experimental tests.

(it is not “just” a theory or an unfounded guess)

PREDICTION AND TESTING

-- **Test** hypotheses and theories by using them to **make predictions** about how a particular system will behave . . .

-- Then we **observe** nature to see if the system behaves as predicted.

When does a Theory become a "Law of nature?"

-- when a theory or group of related theories has been tested extensively and seems to apply everywhere in the universe

-- when we have had enough experience with it and have a lot of confidence that it is true

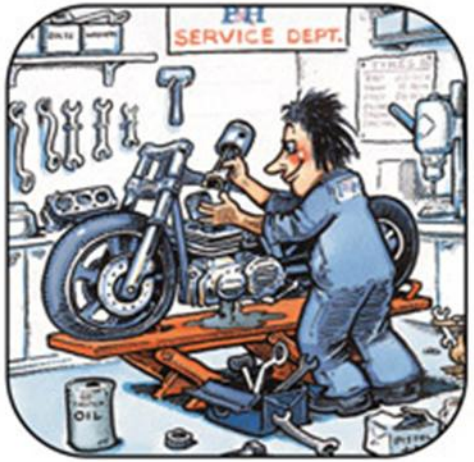
-- we elevate the theory to a new status & call it a law of nature

-- an overarching statement of how the universe works.

Q. Can you give an example of a LAW OF NATURE?

e.g. GRAVITY

Pirsig's essay also describes two types of reasoning processes that go into observations, hypotheses, and predictions:



Induction (inductive reasoning) = generalizing from individual observations . . . . . .to general conclusions

Deduction (deductive reasoning) = start with general knowledge (first principles or established theory) . . . . . and predict a specific observation.

INDUCTION:

INdividual observations ➔

General conclusion

DEDUCTION:

DE (“the”) big picture (theory) ➔

conclusion / prediction about a specific observation

Pirsig suggests:

“. . . in actual science, problem solving takes place by long strings of mixed inductive and deductive inferences that weave back and forth between observations and theory . . . “

Interconnectivity of methodological steps!

There is no “right” place to enter the cycle of steps.

How do SCIENTISTS talk about their science? . . .

On the list of quotes in today's
Topic #2 WHITE HANDOUT
and the quotes on the PINK HANDOUT . . .

WHICH QUOTE DO YOU LIKE BEST?

WHICH QUOTE INTRIGUES YOU MOST?

www.symphonyofscience.com/videos.html

THE SCIENTIFIC PROCESS IN ACTION

Remember this??????

INDUCTION:

INdividual observations ➔

General conclusion

DEDUCTION:

DE (“the”) big picture (theory) ➔

conclusion / prediction about a specific observation

Some critiques of scientific methodologies:

- **Inductive method cannot establish "certain" knowledge because the NEXT observation might change things!**

- **Deductive method might lead to FACTS and OBSERVATIONS becoming "Theory-laden":**

i.e., We may observe *what we want to observe,* based on personally held beliefs in certain theories . . .

. . .Or there may be certain deeply held values underlying motivation for research.

Scientists often say: "I believe such and such is happening . . . ." But what do they really mean by that??

Is it a mere "opinion?"

Belief without evidence?

Belief or confidence IN in the evidence?

When scientists say they **"believe"** in their results, this is based on

compelling scientific reasons:

(e.g., consistent observations, converging evidence, etc.)

"Science replaces 'private predjudice' with publicly verifiable evidence."

- Richard Dawkins, biologist

More things to be aware of about the scientific process:

- **Observations might be ignored because they don't conform with theory!**
- **Risk of self-deception**
- **Methodologies have their limits**
- **Theories can never be positively proven to be true, but some can be <u>disproved</u> by "falsifying" them** **(Karl Popper, philosopher of science)**

Being able to FALSIFY some theories is an important step in the advancement of scientific knowledge!

(WHY? We can eliminate incorrect theories & get closer to truth)

HOW DOES SCIENCE OPERATE & PROGRESS?

- **Driven by curiosity**
- **Dedicated & persistent research sparked by moments of intuition & exciting discovery**
- **Communal review of scientific results (i.e. PEER REVIEW)**
- **Scientists build on previous results; it is a cumulative process or enterprise**

- **Open but skeptical mind; theories may be falsified but never verified**
- **Human error, plagiarism, and fraud will get weeded out over time**
- **Conflicts of interest, (e.g. who's funding the research?), ethics, & human values play an important role in "objective" science (self-awareness needed!)**
- **Collaborative efforts (Team work!) essential as body of knowledge gets more complex**

- **Wonder, awe, joy & mystery are at the source of scientists' love for their work**

IN-CLASS ACTIVITY

"Think-Pair-Share" Exercise on:

CARTOONS & QUOTES ABOUT & BY SCIENTISTS

Form a "MINI-Team" of 2 – 3 people & INTRODUCE YOURSELF while the green handout is being distributed . . . . (one for every team)

WE RE-USE & RECYCLE – PLEASE DO NOT WRITE ON THIS HANDOUT SO WE CAN COLLECT IT AND RE-USE IT AGAIN

We'll do PART A first (on today's WHITE HANDOUT)

You MAY WRITE ON THE WHITE HANDOUT!.

CARTOON A


MADE POSSIBLE BY A GRANT FROM INC.
FUNDED BY J-J
BROUGHT TO YOU BY

CARTOON B

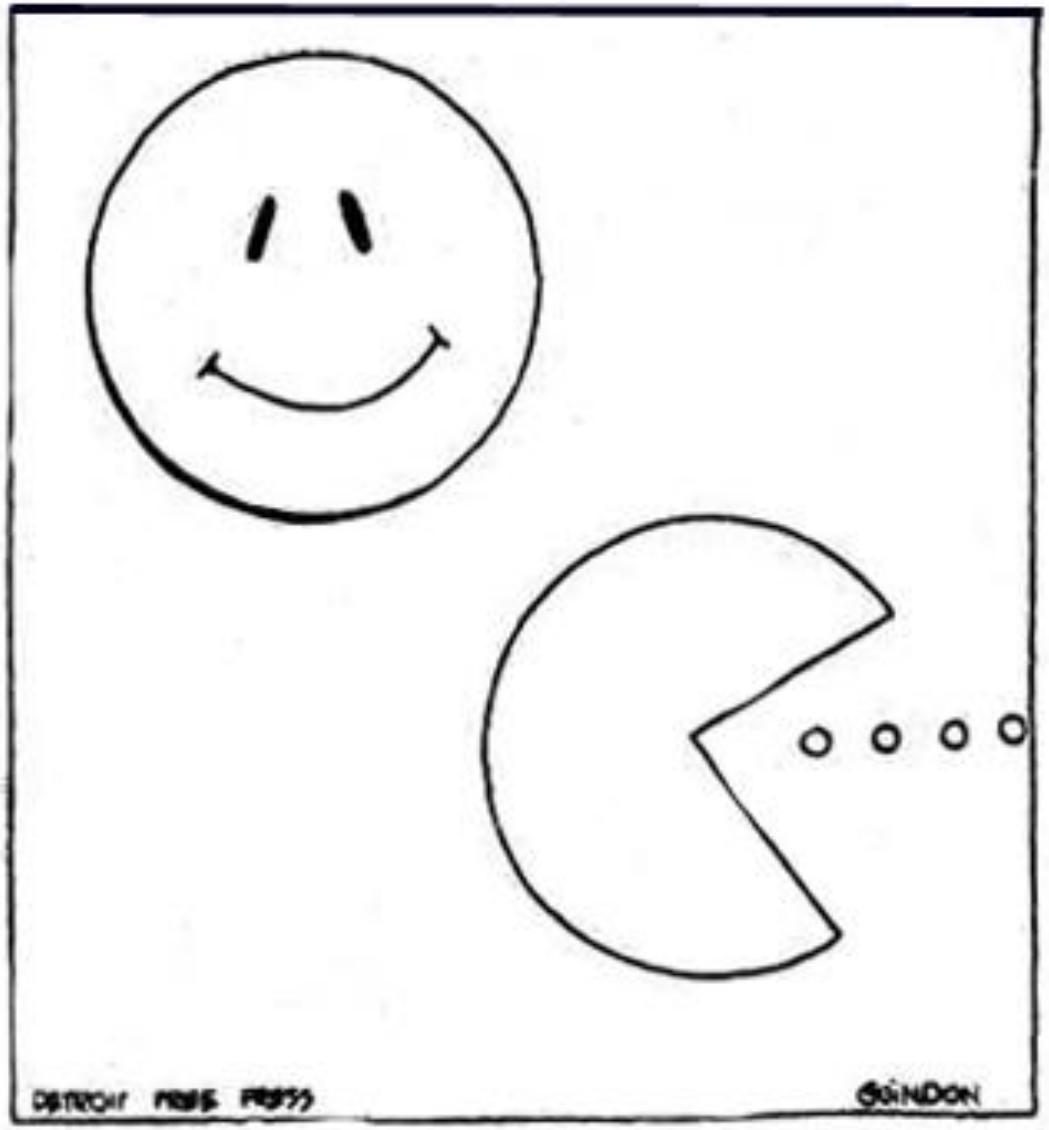

THINK TANK
"IT'S OUR NEW ASSEMBLY LINE. WHEN THE PERSON AT THE END OF THE LINE HAS AN IDEA, HE PUTS IT ON THE CONVEYOR BELT, AND AS IT PASSES EACH OF US, WE MULL IT OVER AND TRY TO ADD TO IT."

CARTOON C


Ah, ha – just as I expected.
Ah, ha – just as I expected.
Ah, ha – just as I...
S. Harris

CARTOON D

CARTOON E



In the year 2074, A.D., a curator at the Museum of Modern Art in New York will conclude that the happy face and Pac-Man were done by the same artist.

CARTOON F


I'VE DONE IT– I'VE FOUND THE MOST BASIC PARTICLE!
I'VE FOUND THE PARTICLE THAT MAKES UP THAT BASIC PARTICLE!
I'VE FOUND THE PARTICLES THAT MAKE UP THE PARTICLES...

CARTOON G

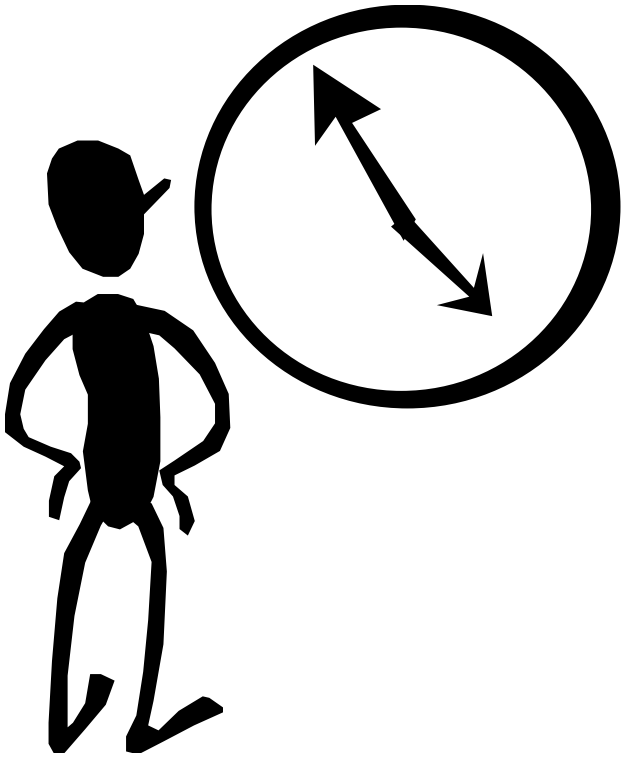
"IT STARTED WITH A SIMPLE CASE OF PEER-REVIEW."

DIRECTIONS FOR CLASS ACTIVITY – PART A:

1. **THINK: PART A** First, look over the cartoons and decide on the one phrase on the WHITE HANDOUT PART A # 1- #7 that best expresses an aspect of SCIENCE that the cartoon is "spoofing".
2. **PAIR:** Pair up with your Mini-Team.
3. **SHARE:** Share & discuss your ideas & answers with each other and discuss your reasoning.
4. Come to a consensus and **WRITE YOUR ANSWERS ON YOUR OWN WHITE HANDOUT** (NOT the green handout!) The correct answers will be revealed in several minutes.

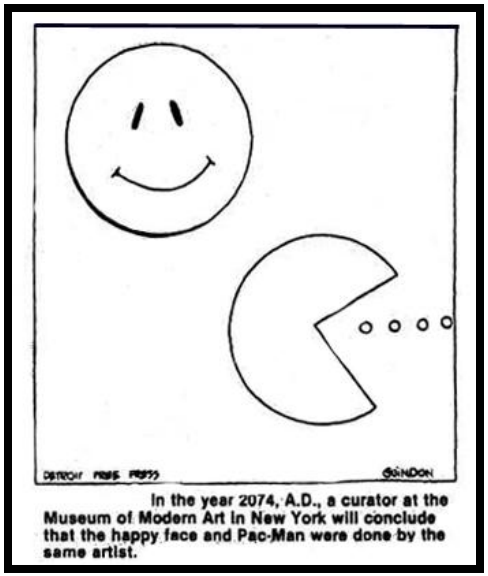
   See how well can you do !!!

   When you finish Part A, continue with Part B until other teams finish . . . .



IT'S TIME TO END YOUR DISCUSSION . . .

PLEASE WRAP IT UP AND QUIET DOWN.



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E

1. INDUCTIVE REASONING

D 2. DEDUCTIVE REASONING

F

3. EVER-CHANGING NATURE OF SCIENTIFIC KNOWLEDGE

C 4. PREDICTION & TESTING

A

5. CONFLICT OF INTEREST

G 6. REVIEW OF SCIENTIFIC RESULTS BY COLLEAGUES

and the last cartoon . . . . .

B

7. SCIENCE IS A CUMULATIVE ENTERPRISE (i.e. process)

PART B: PHRASES ABOUT SCIENCE FOR MATCHING:

__5___ A. Curiosity & self-discovery tend to motivate scientists
("Ask questions! . . " Paul Ehrenfest)

__4__ B. Dedicated & persistent research yields benefits
("No, it's a great life . . ." Steven Weinberg)

__2__ C. Scientists are attracted by the wonder, awe, & joy found in their research *("The joy of insight . . ." Victor Weisskopf)*

__1__ D. Inspiration emerges from a well-informed mind
("Newton's . . act of the prepared imagination" John Tyndall)

__7__ E. Theories cannot be verified, but they can be falsified
("No amount . . . can prove me right . . ." Albert Einstein)

__3__ F. Self-deception can color an observation
(" ...art to be learned -- not to see what is not." Maria Mitchell)

__6__ G. Knowledge is ever-changing
("law of change ...Nature never stands still ..." Laurence Gould)

Recap: OBJECTIVES FOR TODAY'S CLASS:

- Gain an understanding of the huge scope of Global Change scientific research: at UA, nationally, and internationally

- Review "the" formal scientific method

- Learn how science "in practice" involves a wide variety of approaches – especially for Global Change science

- Hear how scientists themselves describe their science

- Understand that science advances through a constant critique of its own findings and methods

- Have fun with quotes and cartoons about science!

ASSIGNMENTS FOR NEXT WEEK

(1) Check off completed tasks in the D2L CHECKLIST TOOL

(2) Register your Clicker

(3) Access the E-Text – Complete reading of Chapter 1

(4) Take the 2 practice SELF TESTS & Readiness Quizzes (RQ's)

(5) When you've done all of the above, read the LAST chapter in the SGC E-Text titled : ATOMS: THE NATURE OF THINGS
Your first GRADED RQ will be on this chapter and due next THURSDAY.

CONSIDER BEING A PRECEPTOR!

About the Teaching Team Program & becoming a Preceptor

(see Syllabus & GC 170A website for additional details on being a Preceptor in this class)

Teaching Teams Program

Putting People Back Into Education

What is a Preceptor?

- Motivated and responsible student
- Facilitator
- Peer Tutor
- Classroom leader

Why should I Become a Preceptor?

- Personal involvement with your course – YOU can help make it a better course through your input
- Learn new professional and leadership skills
- Learn the material better by helping others learn
- Opportunity to excel in the course !!
- Get to know your professor & TA's as mentors and future references for applications, jobs, etc.
- It's FUN!!!!

Do Preceptor's get any academic credit?

Preceptors receive 3 units academic credit by enrolling in one of the following courses:

LASC 197a: Preceptor Training Course

OR if in the Honors Program, preceptors can receive HONORS CREDIT in GC170A.

How do I find out more?

See the PRECEPTOR SECTION
under TEACHING TEAM
on our GC 170A WEBPAGE:

www.ltrr.arizona.edu/kkh/natsgc/