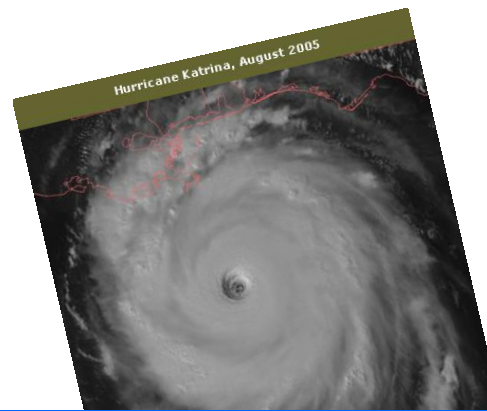
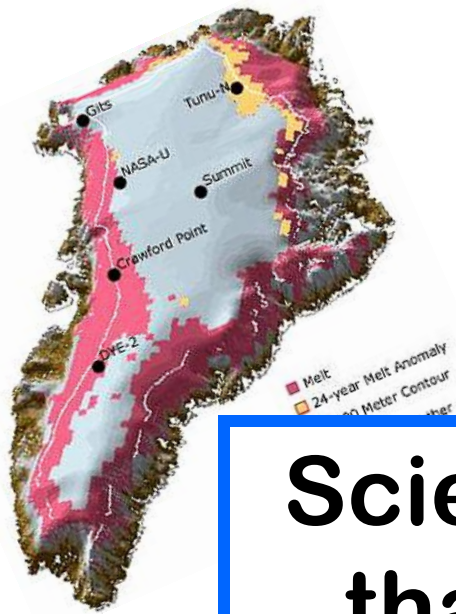
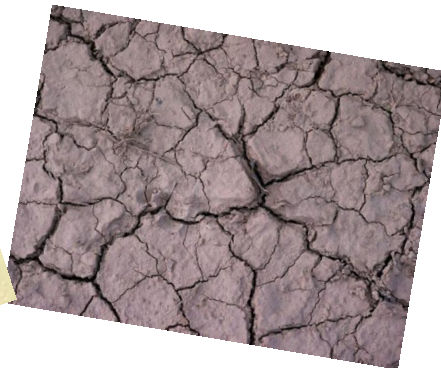


**Topic #2:  
ON GLOBAL  
CHANGE SCIENCE  
&  
BEING A SCIENTIST**



**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 always been changing in:

**Atmosphere** (gases – composition, abundance, vertical structure)

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

**Hydrosphere** (liquid, gaseous, solid)

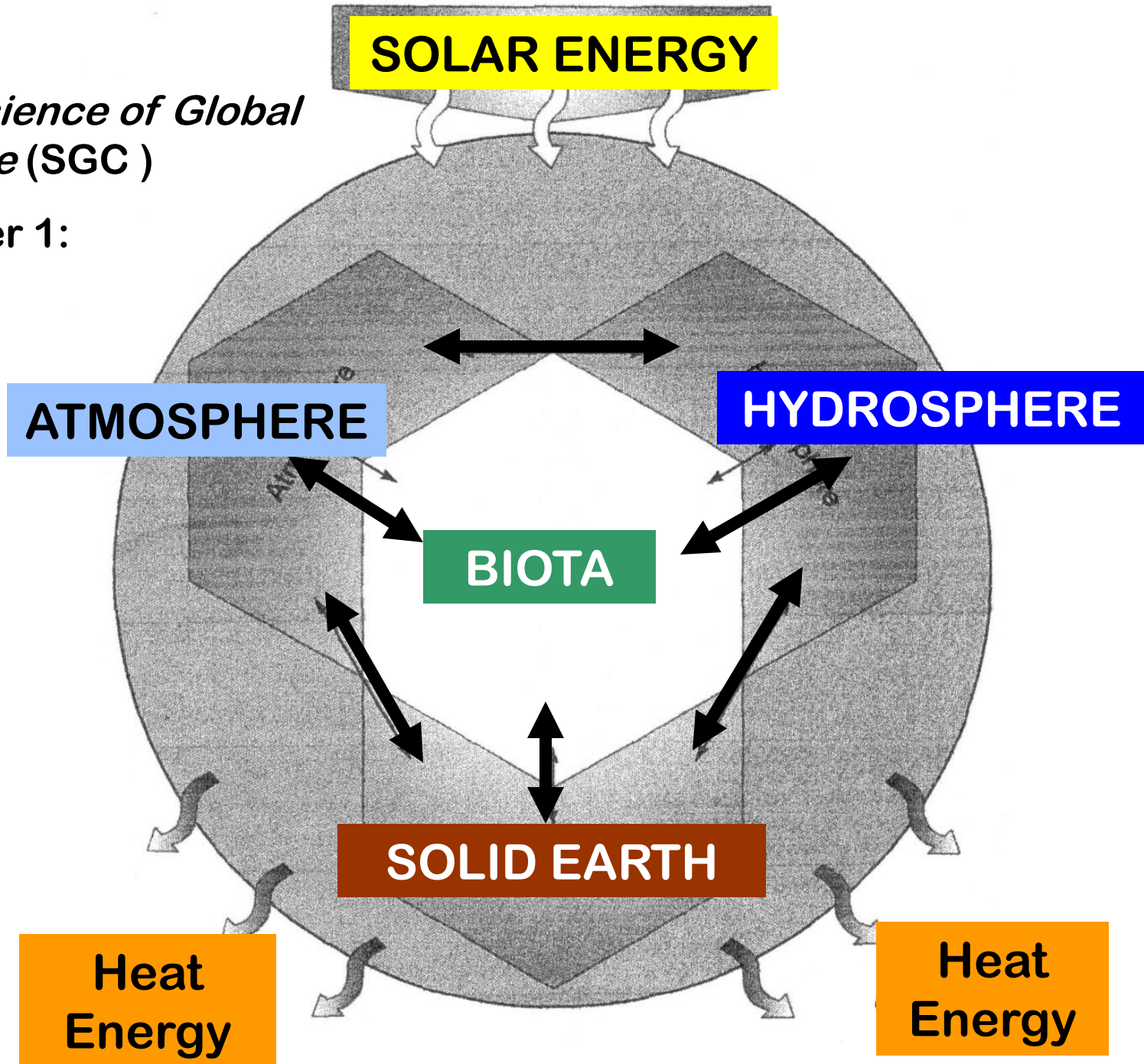
**Biota** (biosphere) (animal & plant life)

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

From:

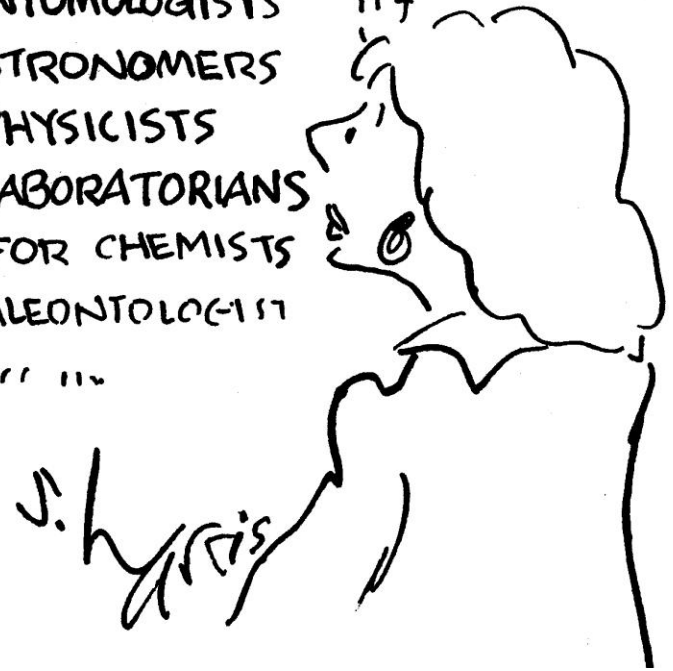
*The Science of Global Change (SGC)*

Chapter 1:



# INTERDISCIPLINARY STUDIES

	ROOM
CHEMISTRY FOR GEOLOGISTS	127
MATH FOR ARCHEOLOGISTS	214
PHYSICS FOR PSYCHOLOGISTS	206
BIOLOGY FOR MATHEMATICIANS	319
GEOLOGY FOR ENTOMOLOGISTS	114
BOTANY FOR ASTRONOMERS	
ANATOMY FOR PHYSICISTS	
PSYCHOLOGY FOR LABORATORIANS	
ANTHROPOLOGY FOR CHEMISTS	
TOPOLOGY FOR PALEONTOLOGISTS	
NUCLEAR PHYSICS III	



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](http://www.environment.arizona.edu)

&

The University of AZ's  
Global Change Faculty

GRADUATE INTERDISCIPLINARY PROGRAM IN



GLOBAL  
CHANGE



Institute of the  
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Environmental

Enter Keywords

search



art, science, environment

## News

### Meeting a Mountain Lion: Do's and Don'ts

August 15, 2013 | UA*News*

UA wild cat expert Lisa Haynes shares pointers on what to do and what not to do if you ever find yourself face-to-face with a mountain lion. First and foremost, she says, do not run. Rather you should stand your ground, maintain eye contact with the cat and try to appear as large as possible.



### Warming Climate Pushes Plants up the Mountain

August 14, 2013 | UA*News*

Comparing plant communities today with a survey taken 50 years ago, a UA-led research team is providing the first on-the-ground evidence for Southwestern plants being pushed to higher elevations by an increasingly warmer and drier climate.



### One Tree's Architecture Reveals Secrets of a Forest, Study Finds

August 5, 2013 | UA*News*

Trees share remarkably similar architecture based on fundamental principles, UA ecologists have discovered.



## 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

The screenshot shows the homepage of the UA Environment & Sustainability Portal. At the top left is the University of Arizona logo. The main header reads "ENVIRONMENT AND SUSTAINABILITY PORTAL" with the tagline "Your gateway to environmental research, education and sustainability at the University of Arizona". A navigation bar includes links for HOME, ACADEMICS, RESEARCH, CAMPUS SUSTAINABILITY, OUTREACH, and STUDENTS, along with a search box. The main content area features a large image of three students in a dorm room looking at a tablet. Below this image is a section titled "ENVIRONMENT IN THE NEWS". To the right is a featured article titled "What's Your 'Carbon PawPrint?'" which discusses the launch of EcoPower software. The bottom of the page has a news ticker with three items: "UA Recognized for Sustainability Leadership by Natural Resources Defense Council", "Southwest Climate Podcast", and "August Southwest Climate Outlook Released".

**THE UNIVERSITY OF ARIZONA.** ENVIRONMENT AND SUSTAINABILITY PORTAL  
Your gateway to environmental research, education and sustainability at the University of Arizona

HOME ACADEMICS RESEARCH CAMPUS SUSTAINABILITY OUTREACH STUDENTS SEARCH

**ENVIRONMENT IN THE NEWS**

**What's Your 'Carbon PawPrint'?**

University of Arizona Residence Life has launched EcoPower, a "virtual room" software application designed to educate students and employees about the impact of their energy usage.

Previous Next [Read more](#)  
More Features

08.27.2013 | UANews  
**UA Recognized for Sustainability Leadership by Natural Resources Defense Council**

**Southwest Climate Podcast**

08.26.2013 | CLIMAS  
**August Southwest Climate Podcast: Monsoon Report**

08.22.2013 | CLIMAS  
**August Southwest Climate Outlook Released**

[www.portal.environment.arizona.edu](http://www.portal.environment.arizona.edu)

# Campus Sustainability Campus Climate Action Plan

[www.portal.environment.arizona.edu/campus-sustainability/climate-action](http://www.portal.environment.arizona.edu/campus-sustainability/climate-action)

Climate Action Plan

## Treading Lightly

Steps Toward Reducing Our Carbon Footprint

PDF FULL REPORT

The University of Arizona has been committed to sustainability since our beginning in 1885. There was no LEED certification then but our first building, Old Main, which is 120 years old and still is used today, was constructed with local materials and designed for climate control using common-sense principals. In 2012, we are proud to continue this tradition as a signatory of the American College and University President's Climate Commitment.

### CAMPUS SUSTAINABILITY

- University-Wide Leadership
- Operations, Planning, and Campus Design
- Student Clubs and Groups
- Climate Action Plan**
- UA Recycling

## ASUA Students for Sustainability

ARIZONA

STUDENTS FOR SUSTAINABILITY

Event Calendar | SFS Gardens | Earth Day | Grassroots | Waste Reduction | Water Harvesting | Food for All | Marketing | Compost Cats | Sitemap

<http://sustainability.asua.arizona.edu>

# GLOBAL CHANGE SCIENCE IN ACTION

... at U of A

... **Nationally** ←

... Internationally

# U.S. GLOBAL CHANGE RESEARCH PROGRAM



globalchange.gov  
U.S. Global Change Research Program



Thirteen Agencies, One Vision: Empower the Nation with Global Change Science

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About

What We Do

News

Resources

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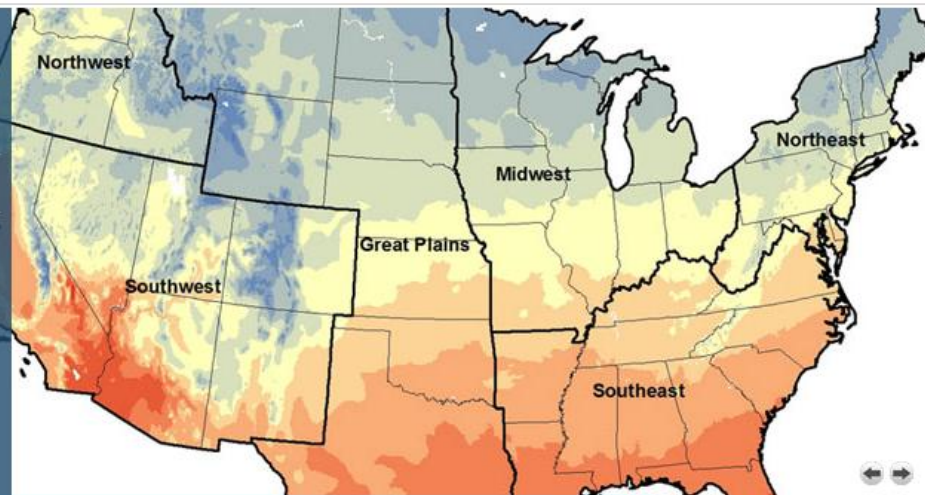
search...

## How Will Climate Change Impact Your Region?

Scenarios for Climate Assessment & Adaptation

New reports explore how a shifting climate may impact eight U.S. regions.

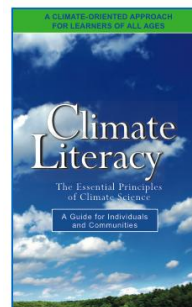
[More...](#)



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 Nobel Foundation

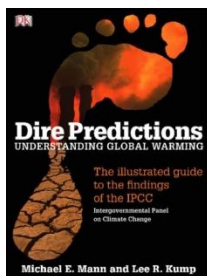
IPCC honoured with the 2007 Nobel Peace Prize

**The  
2007  
Report**  
4<sup>th</sup> Assessment  
Report  
(AR4)



**The 5<sup>th</sup>  
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.

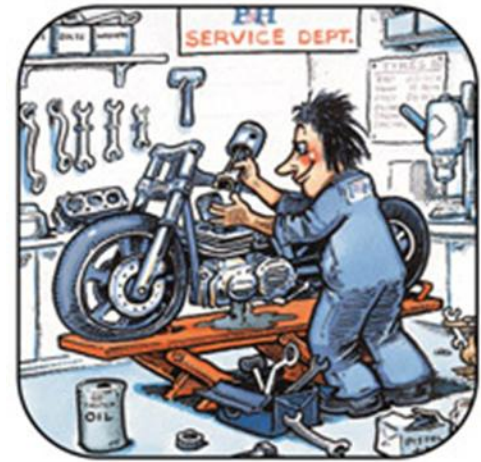
## When does a Theory become a “Law of nature?”

- 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:**

**IN**dividual 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?**



the  
symphony of science

[www.symphonyofscience.com/videos.html](http://www.symphonyofscience.com/videos.html)

**THE SCIENTIFIC  
PROCESS  
IN ACTION**

Remember this??????

## **INDUCTION:**

**IN**dividual 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 prejudice’  
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 disproved 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**



## CARTOON B



"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

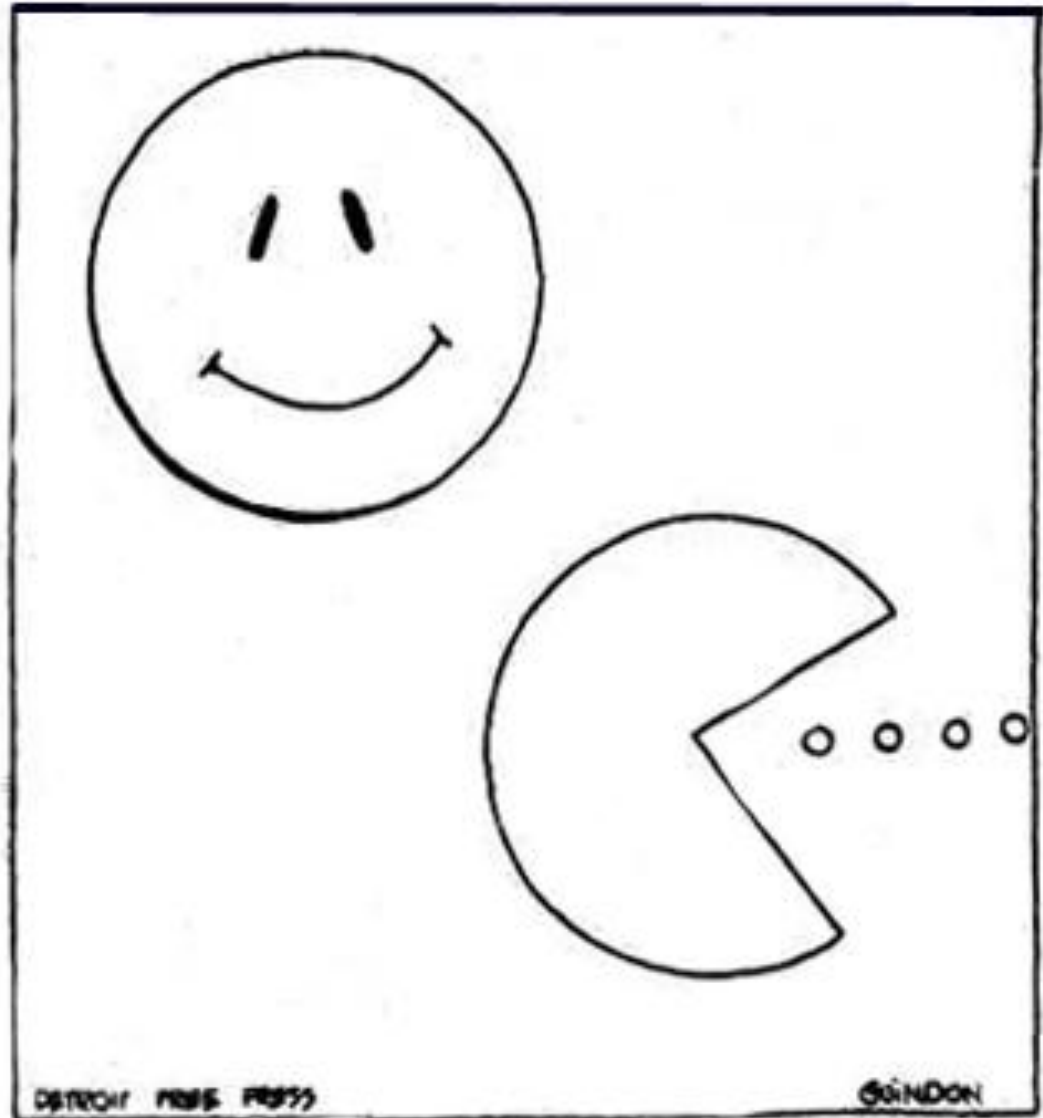


**CARTOON D**





## 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**



# CARTOON G



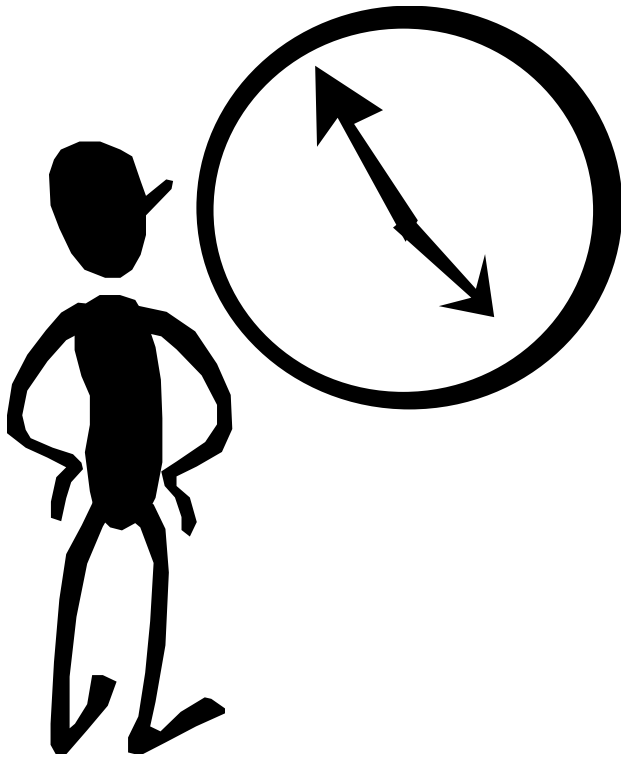
"IT STARTED WITH A SIMPLE CASE OF  
PEER-REVIEW."

# 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.

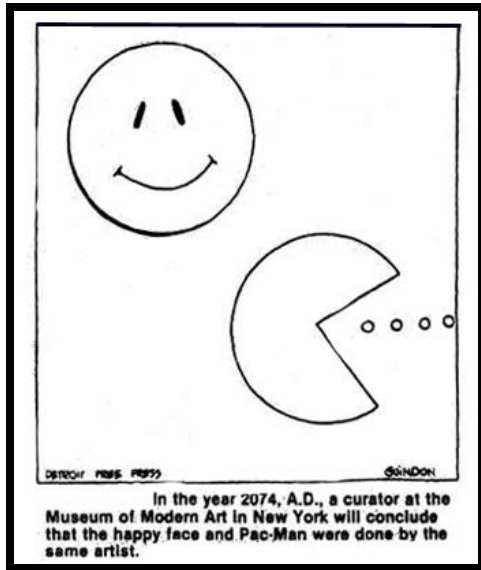
**See how well can you do !!!**

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.**



# 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!

**INTRODUCTION TO GLOBAL CHANGE**

Instructor: Dr. Katie Hirschboeck

**ENTER D2L  
HERE**  
D2L Tip Sheet

**COURSE  
FAQ**

**TEACHING  
TEAM**



**SYLLABUS**

**QUICK LINKS**

**GLOBAL  
CHANGE  
LINKS**

**CLASS  
SUPPORT  
LINKS**

**CLASS  
FOLLOW UP**





# 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?

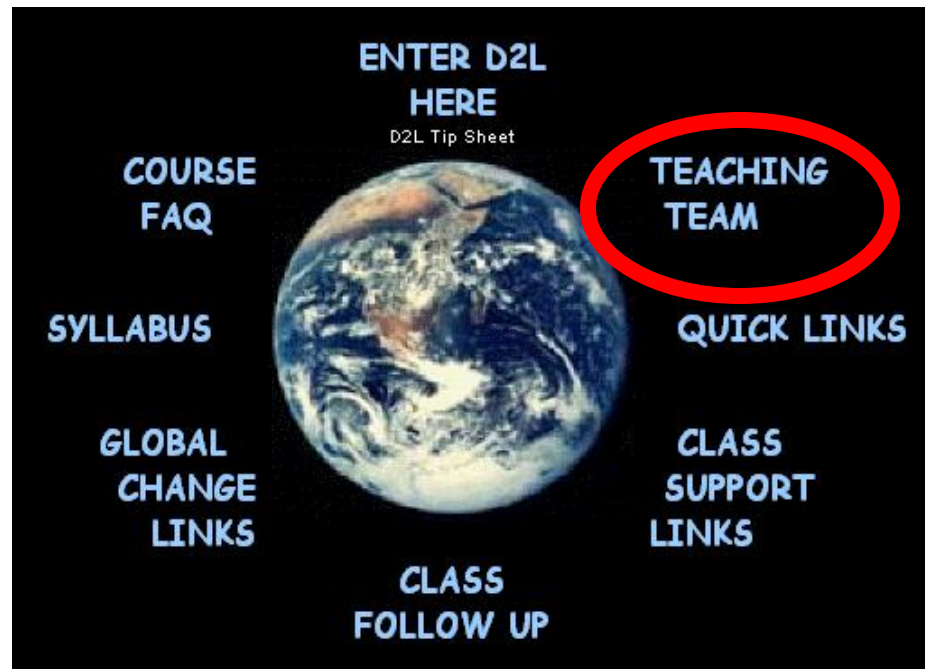
**Preceptors receive 3 units academic credit by enrolling in one of the following courses:**

**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/](http://www.ltrr.arizona.edu/kkh/natsgc/)