

# The Many Reasons we Teach Science and What Everyone Should Know about How it Works

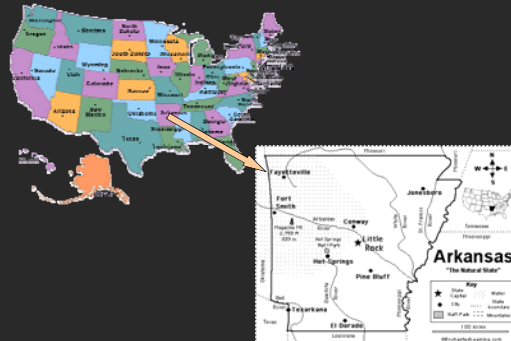
ESTABLISH and SMEC 2012  
Dublin City University 7-9 June, 2012

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# So, Where is Arkansas?



# How Many Times have we Heard? "Why do I have to Study Science?"



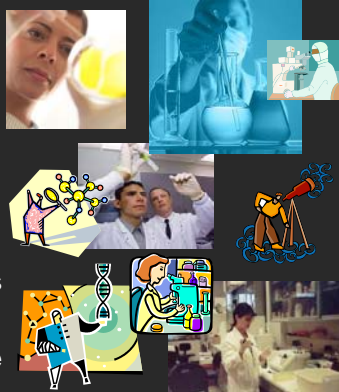
# Fortunately, there are many good answers to this question!

- Try to think of three reasons why we teach science.
- Can you think of a few more?
- This talk will focus on several important rationales for the teaching of science.
- Many of these rationales are linked so targeting one can target others.



# Science Learners Today may become Creators of Science Tomorrow

- Science classes should prepare all students to consider careers in science and technology
- Of course, this is the classic rationale for teaching science



# Science Learners Today may become Creators of Science Tomorrow

- This means that science classes must offer authentic inquiry experiences similar to those in real-world science
- Students should be able to think like scientists!



### Science Learners Today must become *Critics* of Science Tomorrow

- Students must be able to use the tools and methods of science to evaluate claims made in the name of science
- They must separate science from non-science (nonsense)
- Science class must foster the development and use of a scientific world view in students

### What Americans Believe

#### We Have a Problem

	1976	1998	Change
<b>Spiritualism</b>	12%	52%	+40
<b>Faith Healing</b>	10%	45%	+35
<b>Astrology</b>	17%	37%	+20
<b>UFOs</b>	24%	30%	+6
<b>Fortune Telling</b>	4%	14%	+10

Yankelovich Monitor Survey (USA Today April 20, 1998)

### What Americans Believe

#### It seems that we still have a problem

	2005	2007	Change
<b>Ghosts</b>	40%	41%	+1
<b>UFOs</b>	34%	35%	+1
<b>Astrology</b>	25%	29%	+4
<b>Witches</b>	28%	31%	+3

Harris Poll N = 2303

### The High Cost of Not Knowing How Science Functions

#### The Case of Breast Implants

- Legal cases were filed because of a suspected link between silicone breast implants and auto-immune diseases such as lupus
- One “expert” believed he could find an antigen-antibody effect with exposure to silicone
- The “science” was not valid but juries ruled on emotion and companies (and stockholders) unfairly lost millions of dollars!

MONDAY, MARCH 14, 2011 THE FORUM 9A

### How to help scientists and the public see eye-to-eye

By Barry Glassner

Science has a public persuasion problem. If that weren't already clear, we now have something close to final confirmation, courtesy of polls finding that huge swaths of the American public are confused, unconvinced about global warming.

High levels of disconnection between scientists and the public are also evident around issues such as vaccination safety, organic food, evolution, and other areas where science intersects with politics, religion, values and faddism.

It's not about data

Campus-based efforts have begun, as well. Stony Brook University...

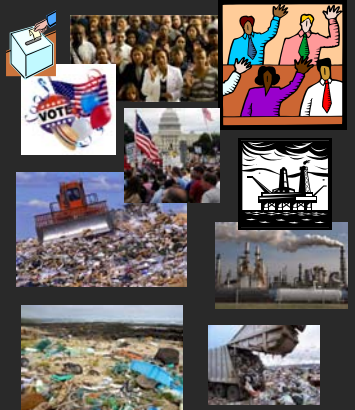
High levels of disconnection between scientists and the public . . .

### Science Learners Today will become Consumers of Science Tomorrow

- All of our students live in a world of science & technology
- Students must understand the pros, cons, roles and impacts of both
- School science should provide opportunities to explore these issues

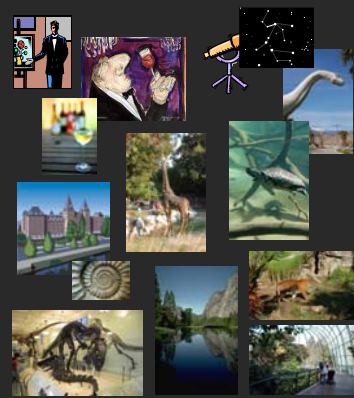
**Science Learners Today will become engaged and informed Citizens of Science Tomorrow**

- Science classes must give students opportunities to see the connections between science, technology and society and
- Take appropriate action



**Science Learners Today should become Connoisseurs of Science Tomorrow**

- Enhancing connoisseurship is an exciting reason to teach science.
- Science is everywhere; in museums, the media, books, zoos, parks and hobbies



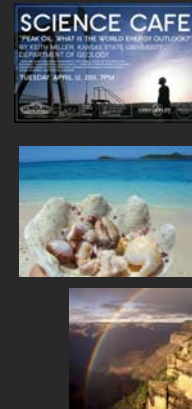
**Science Learners Today should become Connoisseurs of Science Tomorrow**

- Appreciation and enjoyment of science can enhance the quality of life for everyone – even non-scientists!



**Science Learners Today should become Connoisseurs of Science Tomorrow**

- School science should encourage an amateur interest in science
- Perhaps it is time to return to a “nature study” orientation for science teaching



**Science Learners should move from basic Cognition to Caring**

- Our present focus is to have student learn facts about science (within the cognitive domain)
- We should also encourage caring about science and its products (this is part of the affective domain)
- “Caring” must come through understanding, not blind allegiance to science



**Science Learners should become Science Connectors Tomorrow**

- Students must be able to see how science connects with and relates to the rest of the human experience
- Students must also see how the science disciplines connect to each other



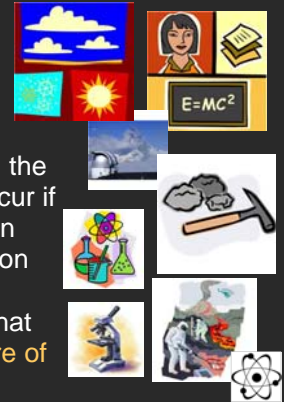
**Science Learners should become Science *Connectors* Tomorrow**

- Understanding of the connections between science and the real world can only occur if students are given an opportunity to apply what they have learned
- This includes process and product (knowledge)



**Science Learners should become Science *Connectors* Tomorrow**

- Understanding the connections between the sciences can only occur if science is taught in an interdisciplinary fashion and includes a cross discipline focus like that provided by the **nature of science!**



## So, What is Science?

*Science is real hard. Harder than reading. We aren't allowed to have it in kindergarten.*

*Antonio (Kindergarten)*

*The weatherman is science. He chooses the weather each day and writes it on the wall.*

*Mary Beth (Kindergarten)*

*Science is the same old stuff. I've seen the same DVD on earthquakes four years in a row.*

*Joshua (Grade 4)*

## What is Science, Really?

***Science is an endeavor designed to explore and address questions about the natural world leading to valid and reliable generalizations and explanations, using methods of investigation and producing evidence open to review by all.***

*McComas*

## Examining Science

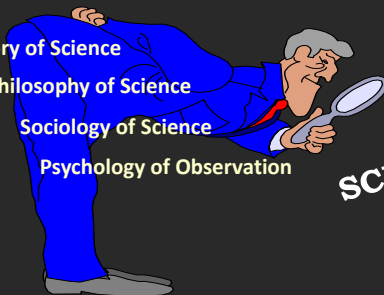
*So we know what to teach about its' nature*

History of Science

Philosophy of Science

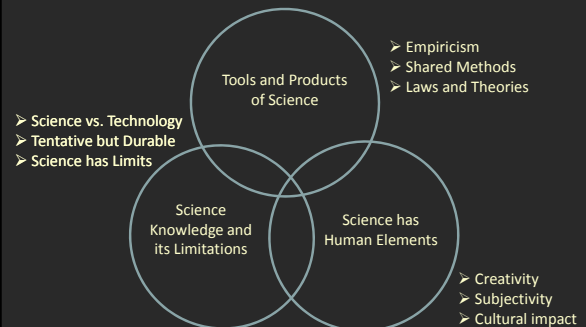
Sociology of Science

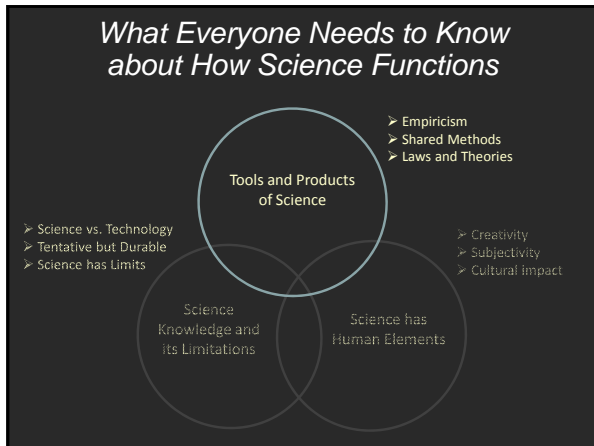
Psychology of Observation



**SCIENCE**

## What Everyone Needs to Know about How Science Functions



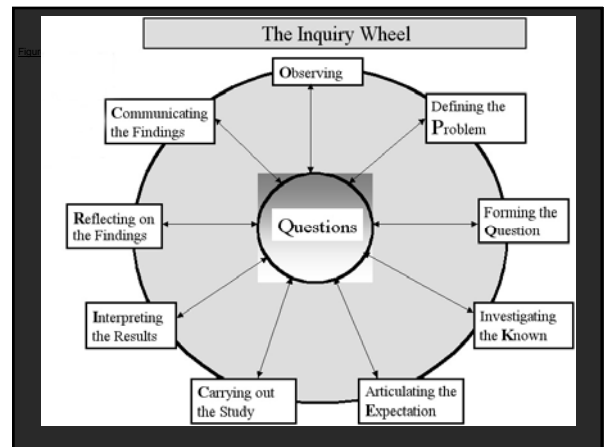
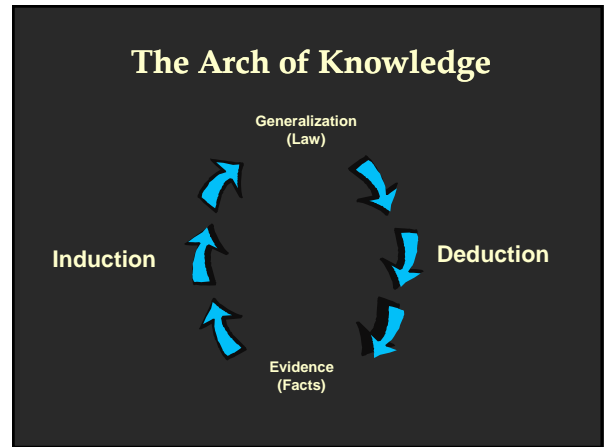


### Tools and Products of Science Science is Empirical

- Every discovery and conclusion in science is based on data (evidence) that may be viewed and evaluated by others

### Tools and Products of Science Science has Shared Methods

- Scientists all use careful and appropriate methods, they record and report all data, apply inference, etc.
- Induction and deduction (logic) are the primary routes to knowledge in science
  - Induction is often used to discover new laws and form new theories and
  - Deduction (hypothetico-deductivism) is frequently used to test those ideas



## Tools and Products of Science

Science Produces Laws and Theories but . . .

- Laws are generalizations or patterns in nature
- The law of gravity is the relationship between distance, mass and gravitational attraction
- Knowledge of the law of gravity can be used to plan space travel (even without a good theory of gravity)



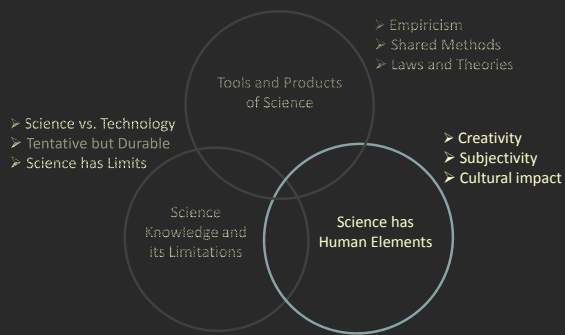
## Tools and Products of Science

Science Produces Laws and Theories but . . .



- Theories are explanations for why laws work in the way that they do
- Darwin gave us the “theory of evolution by natural selection” to explain how evolution occurs
- Laws and theories are distinct and equally useful kinds of knowledge
- But, theories do NOT become laws!

## What Everyone Needs to Know about How Science Functions

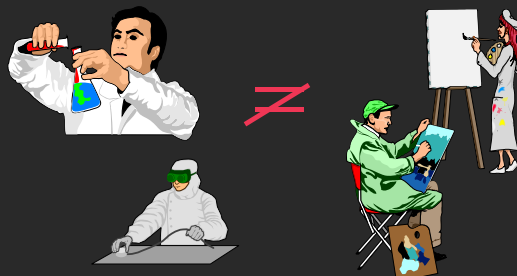


## The Human Elements of Science

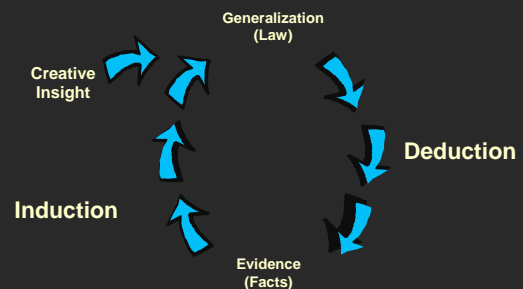
Science has Creative Components

- There is creativity all throughout science including in the selection of problems and in the
- Selection and application of methods of investigation
- School science rarely features the creative aspects of science but scientists themselves know how much creative thought is involved

## Science has Many Creative Aspects



## The Arch of Knowledge



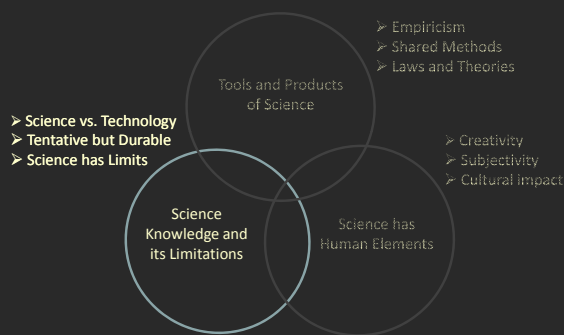
## The Human Elements of Science Science has a Subjective Component

- We all observe the world with our own prior conceptions
  - This is called a “theory-laden” observation
- Scientists make observations the same way
- Much of the time this bias is an advantage because it helps scientists sift through useless data (observations)
- However, sometimes prior conceptions block the ability to “see” something interesting

## The Human Elements of Science Science has Social, Cultural & Political Dimensions

- The work in science in a particular nation is likely related to the interests and priorities of that nation (and the available funding)
  - Consider the stem cell debate
- Funding and national (cultural) priorities play large roles in the direction taken in scientific research
- Science itself is a highly social endeavor
- Science is done in groups and final knowledge is negotiated in groups

## What Everyone Needs to Know about How Science Functions



## Science Knowledge and its Limits Science and Technology



- Pure science generates new knowledge for the sake of knowledge alone
- Technology makes use of scientific knowledge to achieve a specific purpose
- Of course, science and technology interact, but they are not the same!

## Scientific Knowledge and its Limits

### Scientific Knowledge is Durable but Tentative

The methods of science along with the checks and balances insure that science knowledge is as accurate as humanly possible

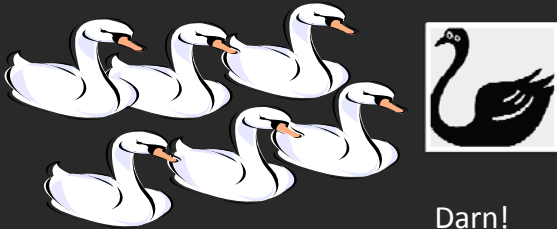
## Scientific Knowledge and its Limits

### Scientific Knowledge is Durable but Tentative

However, it is not possible to prove anything in science so science must remain tentative – it could change!

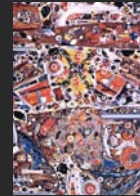
## The Problems of Induction

- It is always possible that some new fact may kill a promising idea!

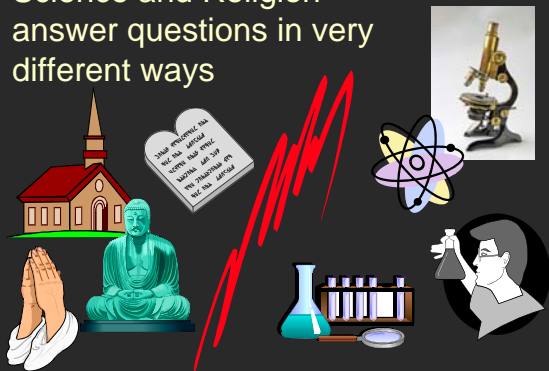


## Science Knowledge and its Limits Science Can't Answer all Questions

Questions of aesthetics, morality, ethics, and religion cannot be addressed by science



## Science and Religion answer questions in very different ways



## Science and Religion can Co-Exist if we remember to ask our questions of the right authority

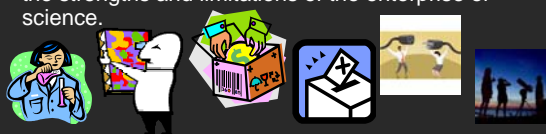
In the 1600's Cesare Cardinal Baronio remarked that "*the Bible is a book about how to go to heaven - not how heaven goes.*"

Quoted in Sobel, D. (1999). *Galileo's Daughter*. P. 65 New York: Walker & Company.

## Finally . . .

- The philosophy of science is one of the most important elements in any science course
- Only by understanding how science works will it be possible to be informed *creators, critics, consumers, citizens, connectors* or *connoisseurs!*

And, move students from just knowing about science (cognition) to caring and understanding of the strengths and limitations of the enterprise of science.



## The Many Reasons we Teach Science and What Everyone Should Know about How it Works

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