"It doesn't matter what temperature the room is, it's always room temperature.“

"I bought some dehydrated water, but I don't know what to add to it.“

"I once put instant coffee in a microwave and went back in time."

Steven Wright

http://www.contrib.andrew.cmu.edu/~norm/SteveQuotes.html

The Nature of Science:

Jim Guido

Methodological Naturalism

- **Naturalism** is divided into two philosophical stances:
- **Methodological naturalism** (or **scientific naturalism**) which focuses on epistemology: This stance is concerned with knowledge: what are methods for gaining trustworthy knowledge of the natural world? It is an epistemological view that is specifically concerned with practical methods for acquiring knowledge, irrespective of one's metaphysical or religious views. It requires that hypotheses be explained and tested only by reference to natural causes and events.[1] Explanations of observable effects are considered to be practical and useful only when they hypothesize natural causes (i.e., specific mechanisms, not indeterminate miracles). Methodological naturalism is the principle underlying all of modern science. This idea extends to philosophy as well, in various degrees, such that science and philosophy are said to form a continuum, according to this view. W.V. Quine, George Santayana, and other philosophers have advocated this view.
- **Metaphysical naturalism**, (or **ontological naturalism** or **philosophical naturalism**) which focuses on ontology: This stance is concerned with existence: what does exist and what does not exist?

http://en.wikipedia.org/wiki/Naturalism_%28philosophy%29

Why study Nature of Science?

NSTA Position Statement

Preamble

All those involved with science teaching and learning should have a common, **accurate view of the nature of science**. Science is characterized by the systematic gathering of information through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. The principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts

http://www.nsta.org/about/positions/natureofscience.aspx

NGSS

- **Appendices to the NGSS:**
  - Conceptual Shifts
  - Responses to May Public Feedback
  - **College and Career Readiness** (Coming Soon)
  - **All Standards, All Students** (Coming Soon)
  - Disciplinary Core Idea Progressions
  - Science and Engineering Practices
  - Crosscutting Concepts
  - **Nature of Science** (Coming Soon)
  - Engineering Design in the NGSS
  - Science, Technology, Society, and the Environment
  - **Model Course Mapping in Middle and High School** (Coming Soon)
  - **Connections to CCSS-Mathematics** (Coming Soon)
  - **Connections to CCSS-ELA Literacy** (Coming Soon)

The New York Times

Public Health Risk Seen as Parents Reject Vaccines

In 1991, less than 1 percent of children in the states with personal-belief exemptions went without vaccines based on the exemption; **by 2004**, the most recent year for which data are available, the percentage had **increased to 2.54 percent**, said Saad B. Omer, an assistant scientist at the Johns Hopkins Bloomberg School of Public Health.

While nationwide over 90 percent of children old enough to receive vaccines get them, the number of exemptions worries many health officials and experts. They say that vaccines have saved countless lives, and that personal-belief exemptions are potentially dangerous and bad public policy because they are not based on sound science.

"If you have clusters of exemptions, you increase the risk of exposing everyone in the community," said Dr. Omer, who has extensively studied disease outbreaks and vaccines.

It is the absence, or close to it, of some illnesses in the United States that keep some parents from opting for the shots. Worldwide, 242,000 children a year die from measles, but it used to be near one million. The deaths have dropped because of vaccination, a 68 percent decrease from 2000 to 2006.

Investigation of Neurologic Symptoms among Le Roy Jr/Sr High School Students, October 2011 – January 2012

Interim Report

January 31, 2012

Summary

This report summarizes an on-going investigation (as of January 31, 2012) of neurologic tic symptoms in 12 female students at Le Roy Jr/Sr High School in Le Roy, New York (Genesee County) during October 2011 to January 2012. Tics are repeated involuntary twitches, movements, or sounds. Isolated and transient tics are common among children, affecting up to 20%of the school-age population. A collaborative investigation by New York State Department of Health (NYSDOH), New York State Office of Mental Health (NYSOMH), Genesee County Health Department (GCHD), Le Roy Central School District (LRCSD), and its medical contractor, Work Fit Medical (WFM), found no infectious or environmental etiologies.

http://www.whec.com/whecimages/repository/cs/files/Investigation_letter.pdf

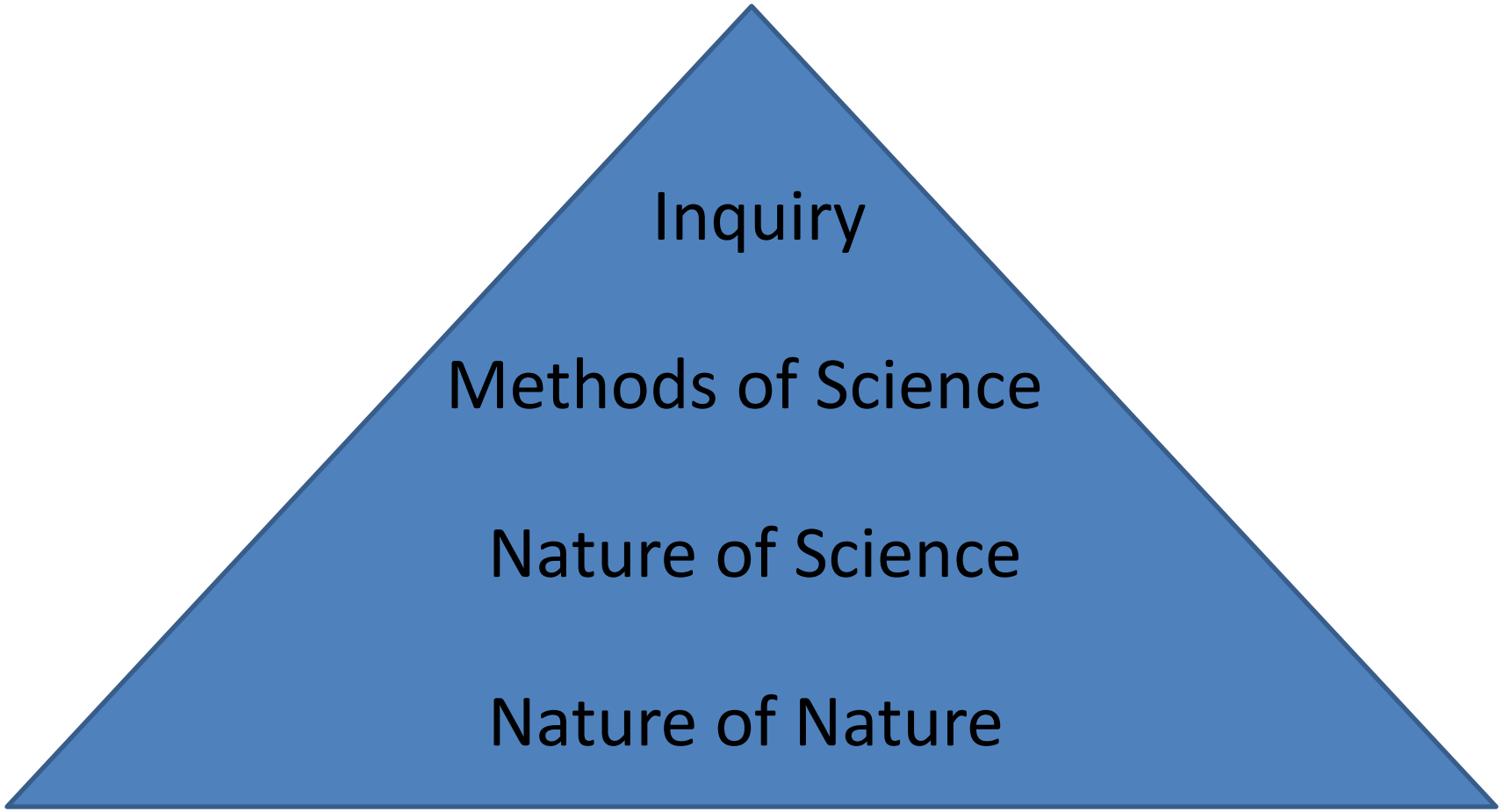
Physics

"physics is concerned with those aspects of nature which can be understood in a fundamental way in terms of elementary principles and laws."

McGraw-Hill Encyclopedia of Science and Technology

Why study Nature of Science?

Actually as I worked my way through this topic I realized we need to study the Nature of Science as part of the total paradigm of how we know what we know about nature, which includes the characteristics of nature, the nature of science, and the methods of science all of which are the underpinnings of inquiry .


Inquiry
Methods of Science
Nature of Science
Nature of Nature

Nature of Nature

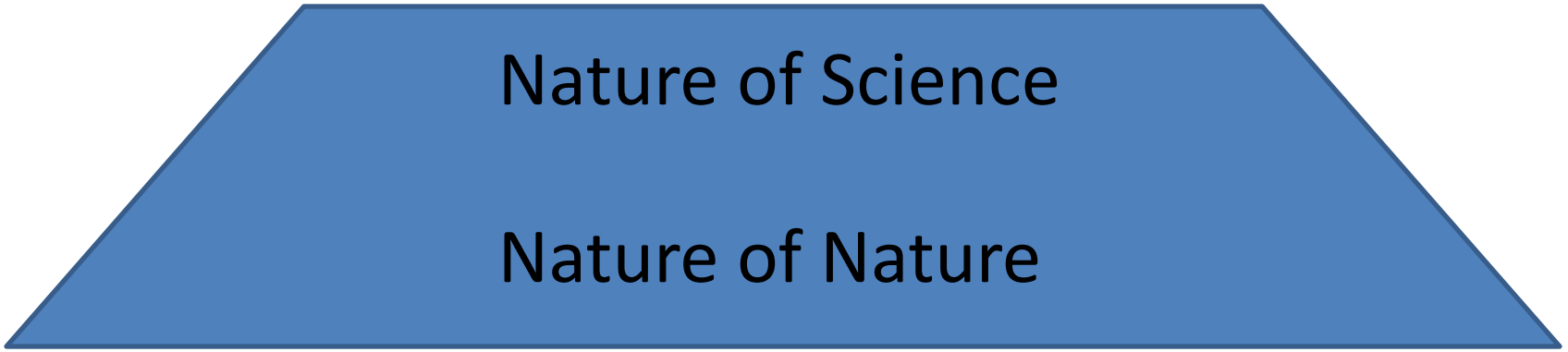
Nature of Nature

Causal

Reproducible

(not capricious)

Predictable


Nature of Science
Nature of Nature

The Nature of Science

Science Is a Process

- Scientific ideas are developed through reasoning.
- Scientific claims are based on testing explanations against observations of the natural world and rejecting the ones that fail the test.
- Scientific claims are subject to peer review and replication.
- In the marketplace of ideas, the simplest explanation has the advantage. This principle is referred to as parsimony.
- There is no such thing as "*THE* Scientific Method."

  But there are Methods of Science!!!!!!!!!!!!!

- Theories are central to scientific thinking.

The Nature of Science

Characteristics of Science

- Conclusions of science are reliable, though tentative.
- Science is not democratic.
- Science is non-dogmatic.
- Science cannot make moral or aesthetic decisions.

The Nature of Science

Science Exists in a Cultural Context

- Science is not always a direct ascent toward the truth.
- Science corrects itself.
- Science is a human endeavor.

http://evolution.berkeley.edu/evosite/nature/IIcontext3.shtml

The Nature of Science

hypotheses: Hypotheses are proposed explanations for a fairly narrow set of phenomena.

theories: Theories are broad explanations for a wide range of phenomena.

l**aw:** In science, the term *law* usually refers to a generalization about data and is a compact way of describing what we'd expect to happen in a particular situation. Scientific laws may have exceptions, and like other scientific knowledge, may be modified or rejected based on new evidence and perspectives.

http://undsci.berkeley.edu/glossary/glossary.php

Nature of Science
Characteristics of Physical Laws

Several general properties of physical laws have been identified [see Davies (1992) and Feynm(1965)as noted], although each of the characterizations are not necessarily original to them).

Physical laws are:

True, at least within their regime of validity. By definition, there have never been repeatable contradicting observations.

Universal. They appear to apply everywhere in the universe. (Davies, 1992:82)

Simple. They are typically expressed in terms of a single mathematical equation. (Davies)

Absolute. Nothing in the universe appears to affect them. (Davies, 1992:82)

Stable. Unchanged since first discovered (although they may have been shown to be approximations of more accurate laws—see "Laws as approximations" below),

Omnipotent. Everything in the universe apparently must comply with them (according to observations). (Davies, 1992:83)

Generally conservative of quantity. (Feynman, 1965:59)

Often expressions of existing homogeneities **(symmetries) of space and time.** (Feynman)

Typically theoretically reversible in time (if non-quantum), although time itself is irreversible. (Feynman)

http://en.wikipedia.org/wiki/Physical_law

Laws of Nature

- 1. are factual truths, not logical ones; “The boiling point of sulfur is 444.6° Celsius” expresses a factual truth. “Every number has a double” expresses a logical truth.

- 2. are true for every time and every place in the universe; There are no laws of nature that hold just for the planet earth (or the Andromeda Galaxy, for that matter), nor are there any that hold just for the Eighteenth Century or just for the Mesozoic Era.

- 3. contain no proper names; Laws of nature may contain general concepts, such as “mass”, “color”, “aptitude”, “capital”, “diabetes”, “return on investments”, etc.; but may not contain such terms as “the Fraser River”, “the planet Earth”, “$59.22″, “June 18, 1935″, “IBM”, etc.

- 4. are universal or statistical claims; and “(All pure) copper conducts electricity” expresses a law of nature. But “Stars exist” (although true) does not express a law of nature: it is neither a universal nor a statistical claim.

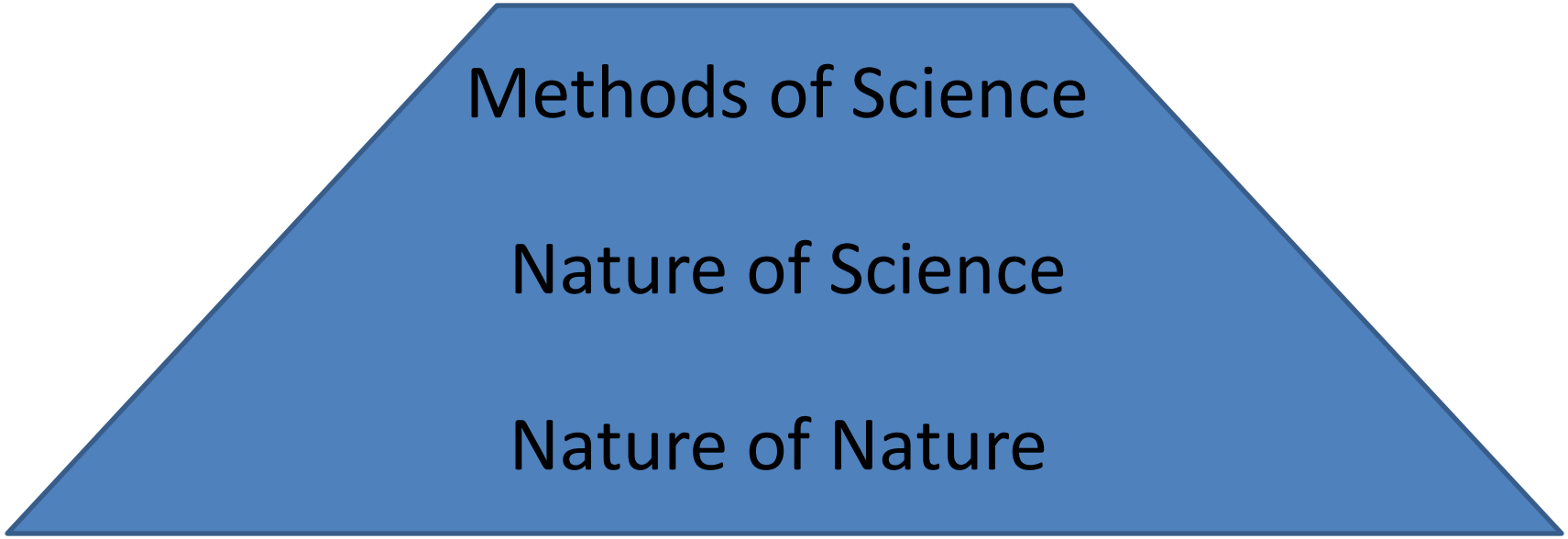
- 5. are conditional claims

http://www.iep.utm.edu/lawofnat/

What should a theory have?

1. Explanatory power
2. Predictive success-predicts novel and unexpected phenomena
3. Control-practical consequences
4. Testability, verifiability
5. Suggest research programs

Steven L. Goodman PhD Lehigh University


Methods of Science
Nature of Science
Nature of Nature

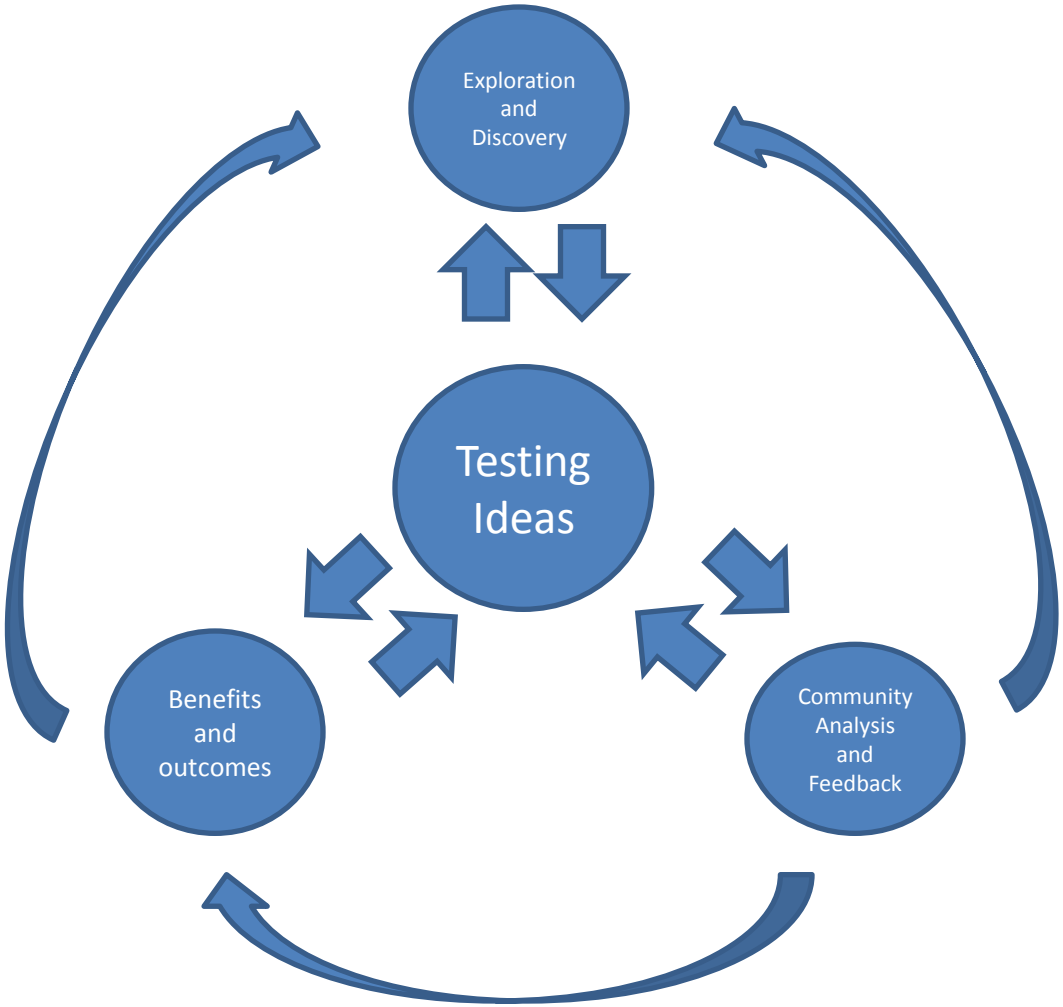
A Note on Methods of Science

Although no single universal step-by-step scientific method captures the complexity of doing science, a number of shared values and perspectives characterize a scientific approach to understanding nature. Among these are a demand for naturalistic explanations supported by empirical evidence that are, at least in principle, testable against the natural world. Other shared elements include observations, rational argument, inference, skepticism, peer review and replicability of work.

http://www.nsta.org/about/positions/natureofscience.aspx

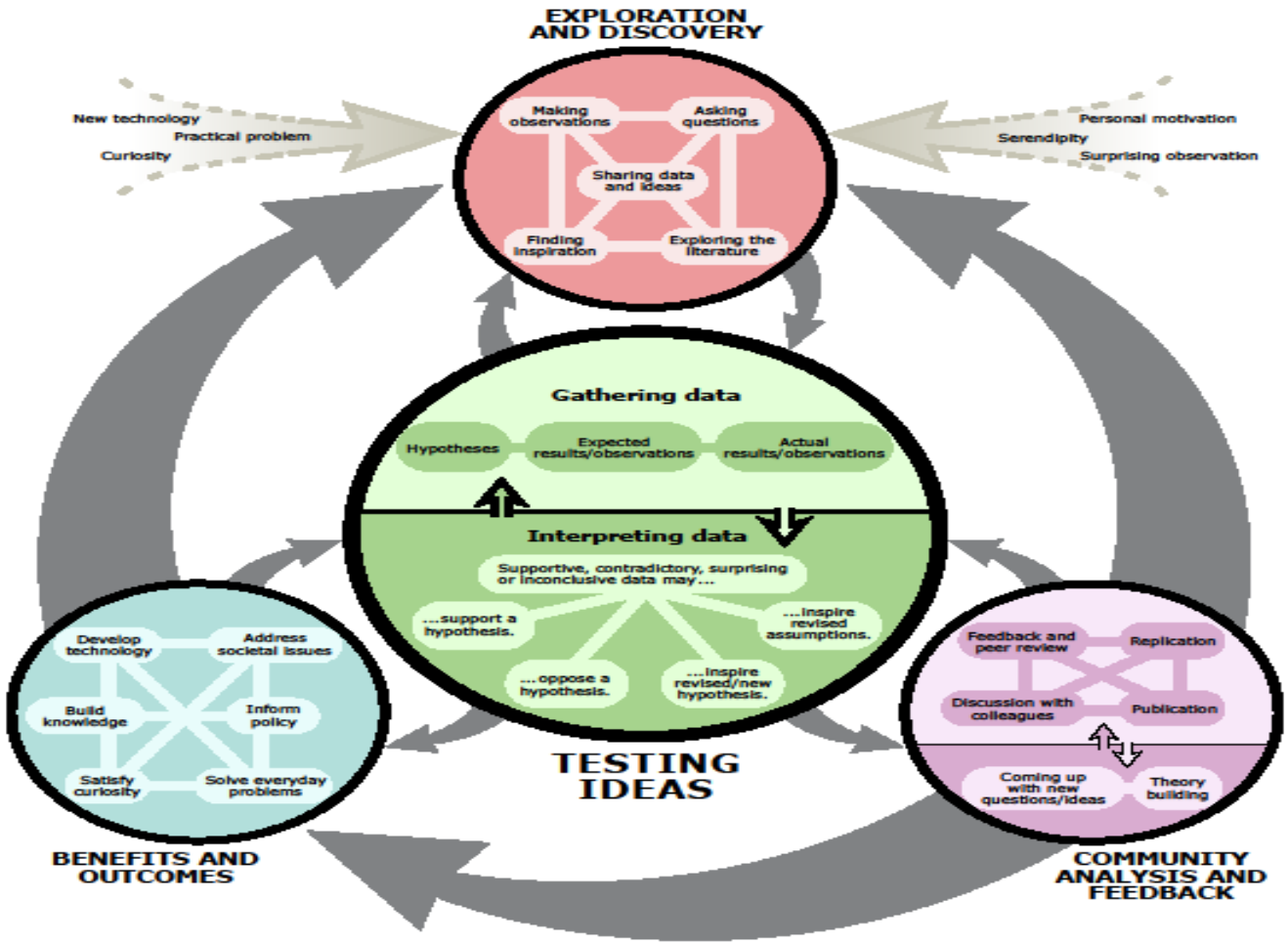
Methods of Science

How science works: The flowchart



http://undsci.berkeley.edu/article/0_0_0/howscienceworks_02

How science works



www.understandingscience.org

Methods of Science

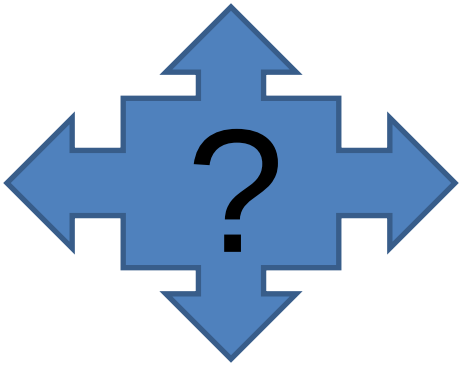
The following model is a problem solving/inquiry model that I believe will give you a framework from which you can structure your work in building a problem solving approach you can use.

Understanding the problem

A. Determine what you are trying to find.
(What is the unknown?)
B. What are the conditions of the problem?

Carry out the plan

If part of your plan includes experimental procedures to collect data on your variables you would use several “experimental” skills.



Devising a plan

A. Find the connection between the data and the unknown.
B. Solve any intermediate steps that will lead you to the connection between the data and the unknown.
C. Create a plan that will lead to the solution.

Looking Back

A. What happened?
B. Can you check the result?
C. Can you check the plan you used?
D. Does your answer seem reasonable?

The eight practices of science and engineering, the Framework identifies as essential for all students to learn, and describes in detail, are listed below:

1. Asking questions (for science) and defining problems (for engineering)

2. Developing and using models

3. Planning and carrying out investigations

4. Analyzing and interpreting data

5. Using mathematics and computational thinking

6. Constructing explanations (for science) and designing solutions (for engineering)

7. Engaging in argument from evidence

8. Obtaining, evaluating, and communicating information

http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20_0.pdf

Methods of Science: Skills

- **Applying mathematics**
- **Classifying**
- **Communicating**
- **Creating models**
- **Creativity**
- **Formulating hypotheses**
- **Generalizing**
- **Identifying variables**
- **Identifying/Selecting courses of action**
- **Inferring**
- **Interpreting data**
- **Manipulating materials**
- **Measuring**
- **Observing**
- **Predicting**
- **Recording data**
- **Spatial Thinking**
- **Verifying**

Adapted from: How to Solve It, Princeton University Press, George Polya, 1945 and 1989 N.Y. State Regents Physics Syllabus

IN ADDITION
AT THE HIGHEST LEVELS OF RESEARCH THE SKILLS NEEDED TO "DO" SCIENCE PROBABLY INCLUDE:

Inspiration

Insight

Genius

and often

LUCK

The eight practices of science and engineering, the Framework identifies as essential for all students to learn, and describes in detail, are listed below:

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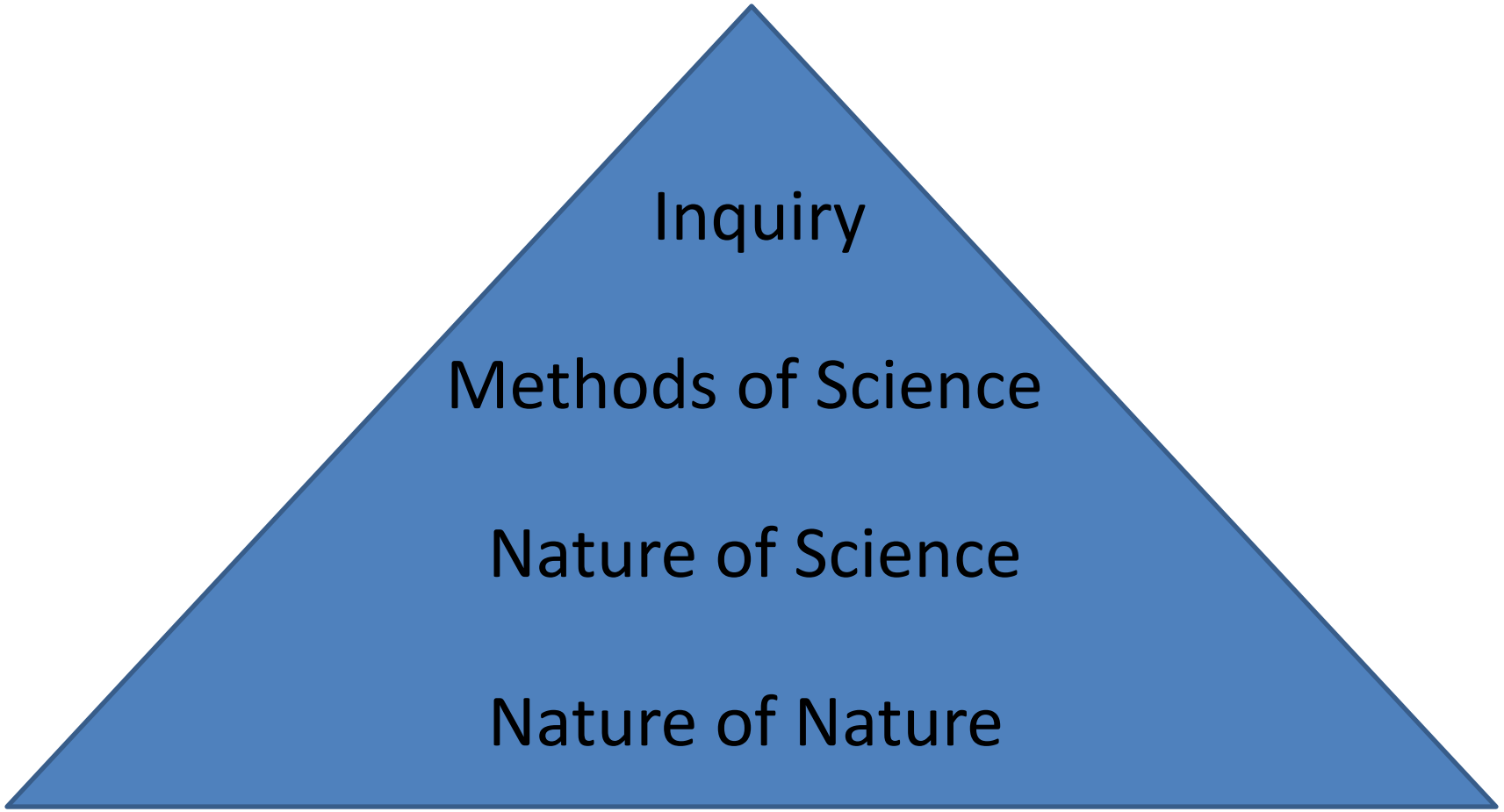
http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20_0.pdf

22 logic faults

Because it deals in probabilities rather than certainties, informal reason is susceptible to a host of weaknesses that can derail an argument before it gets from the premises to a logical conclusion. These weaknesses are called fallacies or, more commonly, logic faults.

The presence of a logic fault, it should be remembered, doesn't mean an argument isn't true -- it just means it hasn't been proven. If an opinion has a logic fault, it is a weaker argument. The more logic faults a piece has, the weaker it is. And if your argument hinges on a point that contains a fault, it is doomed.

- http://www.news-sentinel.com/


Inquiry
Methods of Science
Nature of Science
Nature of Nature

in·qui·ry

Function: *noun*
Inflected Form(s): *plural* **-ries**

1 : examination into facts or principles **:**
2 : a request for information
3 : a systematic investigation often of a matter of public interest

www.merriam-webster.com

Definition of Inquiry

Inquiry is the science, art and spirit of imagination. It can be defined as the scientific process of active exploration by which we use critical, logical and creative-thinking skills to raise and engage in questions of personal interests. Driven by our curiosity and wonder of observed phenomena, inquiry investigations usually involve

Generating a question or problem to be solved

Choosing a course of action and carrying out the procedures of the investigation

Gathering and recording the data through observation and instrumentation to draw appropriate conclusions

http://sd54.org/science/inquiry/

Current Version of the Benchmarks Statements

By the end of the 2nd grade, students should know that:

- When a science investigation is done the way it was done before, we expect to get a very similar result.
- When a science investigation is done again in a different place, we expect to get a very similar result.

http://www.project2061.org/publications/bsl/online/index.php?chapter=1

By the end of the 12th grade, students should know that:

- Science is based on the assumption that the universe is a vast single system in which the basic rules are everywhere the same and that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study.

- From time to time, major shifts occur in the scientific view of how things work. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Continuity and change are persistent features of science.

- No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations.

- In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to a better understanding of how things work in the world but not to absolute truth.

- In matters that can be investigated in a scientific way, evidence for the value of a scientific approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions.

http://www.project2061.org/publications/bsl/online/index.php?chapter=1

Fundamentals of Inquiry
Internet Resources

My email address:

jdguido@gmail.com

NYSUT website:

http://www.nysut.org

Methodological naturalism:

http://plato.stanford.edu/entries/naturalism/

http://en.wikipedia.org/wiki/Naturalism_%28philosophy%29

NSTA position paper:

http://www.nsta.org/about/positions/natureofscience.aspx

Project 2061:

http://www.project2061.org

Fundamentals of Inquiry
Internet Resources

Nature of Science:

http://www.project2061.org/publications/bsl/online/index.php?chapter=1

http://www.nsta.org/about/positions/natureofscience.aspx

http://www.unl.edu/rhames/courses/current/sciencegoals.htm

http://www.pantaneto.co.uk/issue25/clough.htm

http://www.quackwatch.org/01QuackeryRelatedTopics/science.html

http://evolution.berkeley.edu/evosite/nature/index.shtml

http://www.amazon.com/Nature-Science-Z-Principles-Governing/dp/0618319387

http://www.springerlink.com/content/u36855363q70r757/

Misc:

http://richarddawkins.net/

http://www.csun.edu/science/ref/language/index.html

Fundamentals of Inquiry
Internet Resources

Nature of Science:

http://undsci.berkeley.edu/teaching/allgoals.php

National Standards:

http://www.nsta.org/publications/nses.aspx

Inquiry:

http://science.education.nih.gov/supplements/nih6/Inquiry/guide/info_process-a.htm

http://www.exploratorium.edu/IFI/workshops/fundamentals/index.html

http://www.usask.ca/education/coursework/mcvittiej/methods/inquiry.html

http://www.nap.edu/catalog.php?record_id=9596

http://www.uft.org/teacher-teacher/engaging-students-scientific-inquiry

Methods of Science:

http://undsci.berkeley.edu/article/0_0_0/howscienceworks_02

http://www.indiana.edu/~educy520/sec5982/week_1/inquiry_sci_method02.pdf

http://www.scientificmethod.com/sm3_whatissm.html

Books

Miller, Kenneth R. *Only a Theory Evolution and the Battle for America's Soul.* New York: Penguin Books, 2008

Pigliucci, Massimo. *Nonsense on Stilts How to tell Science from Bunk*. Chicago: the University of Chicago Press. 2010

Bell, Randy L. *Teaching the Nature of Science through Process Skills.* Boston: Allyn and Bacon, 2008

Lindberg ,David C. *The Beginnings of Western Science.* Chicago: The University of Chicago Press, 1992

Rosenberg, Alex. *Philosophy of Science A Contemporary Introduction*. New York: Routledge. 2012

jdguido@roadrunner.com

82.7% of all statistics are made up on the spot.

Steven Wright

http://www.freemaninstitute.com/Wright.htm

What, in the way we are teaching or what we are teaching, is causing this to happen?

Interesting concept:

The asymmetry of causal determination