Inquiry in Science and Education
1a: Inquiry in the disciplines

- What does it mean to inquire, and in particular what does this mean in science?
- Activities: different methods to structure student inquiry
  A. To support explanation
  B. To support the formation of categories
- Further discussion: Form a deeper understanding of the methods and the contents of science.

1a: Inquiry in the disciplines

Inquiry for us and for our students

Scientific inquiry refers to the diverse ways in which **scientists** study the natural world and propose explanations based on the evidence derived from their work.

Inquiry also refers to the activities of **students** in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.

National Science Education Standards

1a: Inquiry in the disciplines

Claims and evidence in the penny lab (1)

1a: Inquiry in the disciplines

Claims and evidence in the penny lab (2)

1a: Inquiry in the disciplines

What are the "parts" of science and math that can be done, studied, and learned?

- ***Content:*** Students are users of what knowledge? And to what extent do they need an awareness of the source(s) of knowledge?
- ***Process:*** What is the goal of science education: thinking with the tools of science or thinking about the tools of science?
- ***Premise*:** Are students participants or spectators in the epistemic claims of science?

"Connections between Pedagogical and Epistemological Constructivism: Questions for Teaching and Research in Chemistry," by Donald J. Wink, *Foundations of Chemistry*, DOI: 10.1007/s10698-006-9008-8.

1a: Inquiry in the disciplines

What are the "parts" of science and math that can be done, studied, and learned?

Two trends in inquiry:

- **Disciplinary end…**"focusing on cognitive goals similar to those in the established scientific disciplines—the development of explanations or models that account for some particular phenomena…"
- **Engineering end…** "technologically oriented projects and activities…involve the manipulation of structures or the fabrication of artifacts to accomplish some preset goal—goals that are primarily material rather than intellectual."

Rudolph, J. L. (2005), "Inquiry, Instrumentalism, and the Public Understanding of Science," *Sci. Ed.*, *89*, 803-821.

1a: Inquiry in the disciplines

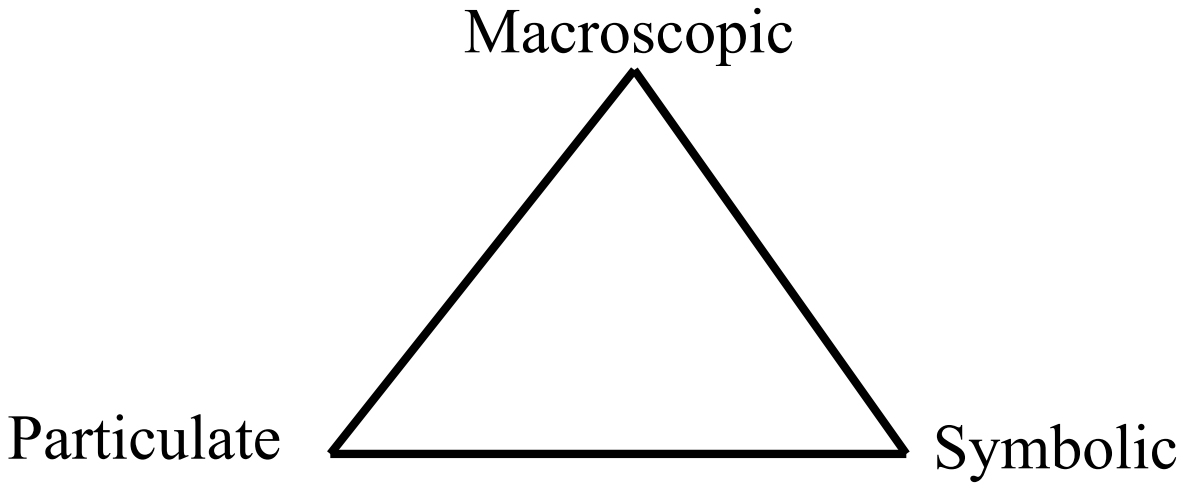
Kuhn: Disciplines shape content and process

"Effective research scarcely begins before a scientific community thinks it has acquired firm answers to questions like the following: What are the fundamental entities of which the universe is composed? How do these interact with each other and with the senses? What questions may legitimately be asked about such entities and what techniques may be employed in seeking solutions?"

Thomas Kuhn
Structure of Scientific Revolutions, 3rd Ed.

1a: Inquiry in the disciplines

An example of disciplinary content: Johnstone's Three Levels of Chemistry



Johnstone, A. H. (1991) "Why Is Science Difficult to Learn? Things Are Seldom What They Seem", *Journal of Computer Assisted Learning*, *7*, 75.

Gabel, D. (1999). "Improving Teaching and Learning through Chemistry Education Research: A Look to the Future," *Journal of Chemical Education*, *76*, 548.

1a: Inquiry in the disciplines

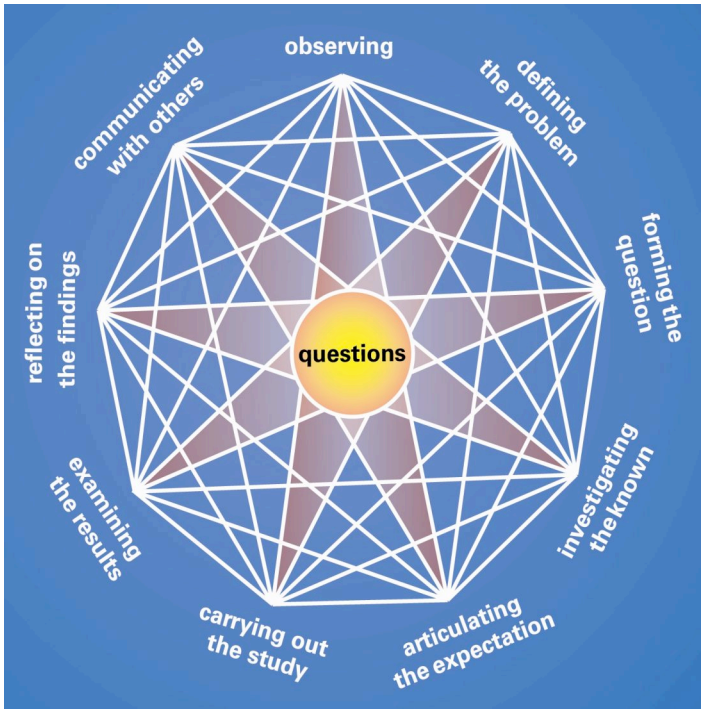
Disciplinary content:
Johnstone's Three Levels of Chemistry

"In physics, there are three similar levels: the macro, the invisible (e.g., forces, reactions electrons) and the symbolic (maths, formulae, etc.) Biology has its three levels: the macro (plant or animal), the micro (cells), the biochemical (DNA etc.). *It is little wonder science is hard to learn."*

1a: Inquiry in the disciplines

Disciplinary Processes: Harwood's Activity Model

A model of *how science is done:* "In the activity model, there is no set of steps that defines 'good science.' Rather, the following 10 activities must be done (and often done more than once) to develop and carry out inquiry."



Acknowledgement: W. S. Harwood and C. Miller

W. S. Harwood, "A New Model for Inquiry. Is the Scientific Method Dead?," *Journal of College Science Teaching*, **2004**, *33(7)*.

1a: Inquiry in the disciplines

Disciplinary Processes: Harwood's Activity Model

- Questions
- Defining the problem
- Forming the question
- Investigating the known
- Expectation
- Carry out the study
- Examine results
- Reflect on findings
- Communication
- Observation

1a: Inquiry in the disciplines

Inquiry and the NSES

Inquiry for scientists:

- Makes observations.
- Exhibits curiosity, defines questions, from knowledge background.
- Gathers evidence using technology and mathematics.
- Uses previous research.
- Propose a possible explanation.
- Publishes explanation based on evidence.
- Considers new evidence.
- Adds to explanation.
- Explanation informs public policy.

Inquiry and the National Science Education Standards, Ch. 1

1a: Inquiry in the disciplines

Inquiry and the NSES

Inquiry for students:

- Exhibits curiosity, defines questions, from knowledge background.
- Propose preliminary explanations or hypotheses.
- Plan and conduct simple investigation.
- Gathers evidence from observation.
- Explain based on evidence.
- Considers other explanations.
- Communicate explanation.
- Test explanation

Inquiry and the National Science Education Standards, Ch. 1