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Elementary Statistical Concepts and the Logic of the Scientific Method

Module 1: Knowledge Generation

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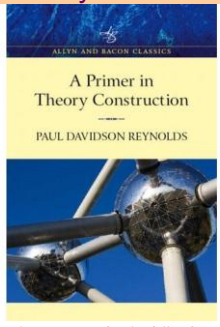
Elementary Statistical Concepts and the Logic of the Scientific Method
On-line Modules

- **Module 1: Knowledge Generation**
- Module 2: The Scientific Method
  - Part 1: Logic and Reasoning
  - Part 2: The Scientific Method; Marrying logic and empiricism
- Module 3: Elementary Statistics & Research Design
- Module 4: Describing Your Data
- Module 5: Inferential Statistics & Research Design
- Module 6: Selecting Statistics by Design
- Module 7: Research Design and Statistics: Examples and Practice

Just a suggestion….

- Please open and/or print the handout associated with this presentation
- Following along with the handout allows you to add notes as the presentation goes along
- You can always pause the presentation

If you read only one book on the topic of theory construction….

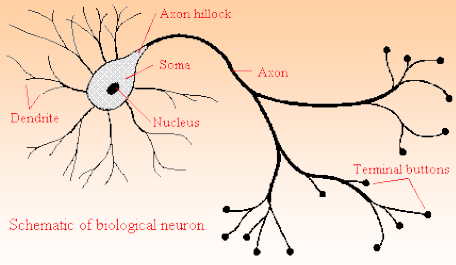


(See the "Activities and Resources" for the full reference to this book.)

What is a Body of Knowledge?

- An organized system of concepts, rules and processes
- Helps us decide what to believe.
- What we "believe" (i.e., know) informs our decisions of how to act

Example 1: The Neuron….



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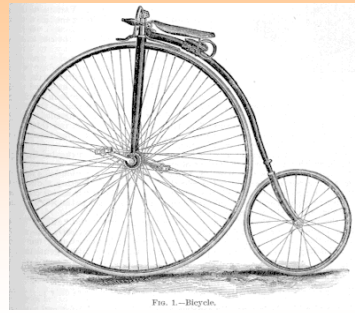
Example 1:

The Neuron

- *Concepts:* A neuron. A typical neuron is a cell that possesses a cell body, dendrites, and axons.
- *Rules / Processes:* Neurons are electrically excitable cells that process and transmit information via electrical and chemical signaling.

Example 2: The Bicycle….



Example 2:

The Bicycle

- *Concept:* Bicycle. also known as a bike, pushbike or cycle, is a pedal-driven, human-powered, single-track vehicle, having two wheels attached to a frame, one behind the other
- *Rules / Processes:* Pedaling a bicycle spins one wheel, propelling the bicycle.

Two Types of Knowledge Systems: What's the Difference?

Natural Systems	Man-made Systems
• Understanding - Theory-building	• Invented With a Purpose or Goal
• Evolving	• Static With Intended Revisions
• "Best guess" - Describing what exists or occurs in the world	• Specified and defined
• Scientific Method – Discovery	• Acquire or learn – Acquisition

Examples of Knowledge Systems

Natural	**Man-made**
• Cell	• Bicycle
• Neuron	• Airplane
• Tree	• Pipette
• Coniferous	• Camera
• Fish	• Patch clamp
• Oxygen	• Thermometer
• Aerodynamics	• Celsius
• Temperature	

Creating a Body of Knowledge

Many sources of knowledge:

- Authority - religious or political;
- Tradition;
- Invention;
- Expert opinion;
- **The scientific method (Module 2)**

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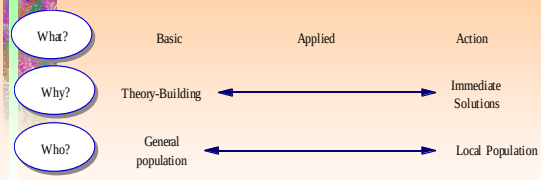
How Do We Build Knowledge: Three Types of Research

- **Basic:** Understanding Natural Knowledge Systems via Theory Building and Discovery
- **Applied:** Building Theory and Solving Real-World Problems (often using Man-made Knowledge Systems)
- **Action:** Solving Real-World Problems

How Do We Build Knowledge: Three Types of Research



How Do We Build Knowledge: Basic Research

Small Water Fleas Help Ecologists Understand Population Dynamics

A study of populations of tiny water fleas is helping ecologists to understand population dynamics, which may lead to predictions about the ecological consequences of environmental change.

Edward McCauley, E., Nelson, W. A. & Nisbet, R. M. Small-amplitude cycles emerge from stage-structured interactions in Daphnia–algal systems. *Nature* **455**, 1240-1243 (2008)

See http://www.biology-online.org/

How Do We Build Knowledge: Basic Research Informing Applied Research

Agrochemicals increase trematode infections in a declining amphibian species

Global amphibian declines have often been attributed to disease, but ignorance of the relative importance and mode of action of potential drivers of infection has made it difficult to develop effective remediation. In a field study, here we show that the widely used herbicide, atrazine, was the best predictor (out of more than 240 plausible candidates) of the abundance of larval trematodes (parasitic flatworms) in the declining northern leopard frog *Rana pipiens*.

Rohr, J. R. et al, *Nature* **455**, 1235-1239 (2008)

How Do We Build Knowledge: Applied Research

Evaluating handwashing technique

Though standards for handwashing have been defined, little effort has been made to assess the quality of handwashing in clinical settings. This paper describes tests of reliability and validity of tools to evaluate two aspects of handwashing — appropriateness and technique. Based on these tests, methods to evaluate handwashing are recommended.

Larson E. & Lusk E. (2006) *Journal of Advanced Nursing* 53(1), 46–53

How Do We Build Knowledge: Action Research

(see also "experimental development")

Action research is a process of deep inquiry into one's practices in service of moving towards an envisioned future, aligned with values. Action research is the systematic, reflective study of one's actions, and the effects of these actions, in a workplace context.

(http://cadres.pepperdine.edu/ccar/define.html)

See another example, **Action research in a primary care setting,** in the "Activities and Resources" area of this module

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Just for FUN! Basic, Applied, or Action???

Engines of Our Ingenuity….

http://www.uh.edu/engines/

Three Types of Research: Why Does This Matter?

- When Reading/Critiquing or Designing Research, Typology Matters
- Methodology is Critical and Dependent on Type of Research
- Understanding "Research" Means Understanding the Connection Between Goals, Methods, Results

Three Types of Research: Why Does This Matter?

- Goals, Purposes, and Questions Drive Research Type and Design
- Research Design Involves:
  - Articulate Your Questions
  - Stakeholders, participants
  - Choose Methods
  - Select Statistics
  - Complete Your Analysis
  - Describe and Discuss Your Results

Module 2 Preview: Part 2 – What is Knowledge and What is the Scientific Method?

- Building a Body of Knowledge: The Marriage of Logic and Empiricism
- The Scientific Method
- Operationalizing Concepts: NOIR
- Deconstructing a Basic Research Article

Module 2 Preview: Part 1 – Logic and Reasoning

- The Syllogism
- Deduction and Induction
- Evaluating Reasoning