How We Know What We Know

by
Ellen Deehan, M.S.

The way a biologist (life scientist) explores and determines the workings of nature is different from what many young students suspect. Biologists learn new things by observing nature, rather than by reading and thinking about nature.

**Science is not the memorization of facts from books;
it is a way of gathering information about the world around us.**

How We Know What We Know[1]

People gather information about the world around them in multiple ways. Each of us uses several methods, for example:

- What color is your hair?
  How do you know? (see)
- Is ice cream sweet or salty?
  How do you know? (taste)
- Is Alaska an island?
  How do you know? (map)
- What is 12 plus 12?
  How do you know? (mathematics)
- Have you ever been aware that someone behind you was staring at you, and you turned around and saw that indeed they were staring at you?
  Before you turned around,
  how did you know? (just knew)

Table I describes four fundamental sources of knowledge for people – four fundamental ways that we know what we know about the world around us. Every person in the world uses all four of these methods, and over our lifetimes, we hone the skills necessary to become better and better at each method.

[1] The branch of philosophy that describes how we know what we know is called *epistemology. Epistemology* is a very complex discipline; therefore, please note that our discussion here is a simplification. However this simple version can be clarifying and empowering for young students.

Table I. Four fundamental sources of knowledge used by people. A simplified description of how people know what they know about the world around them (based on Royce 1964[2]; Jennings 1993 *as cited in* McKay 1997[3]). Note: every one of us uses each of these methods at different times and in different circumstances.

Human Source of Knowledge	Description	Examples
Empirical Observation (Sensing)	Personal experience through the five senses (observations and experimentation)	Using the five senses (see, hear, taste, smell, touch), physical experiments; *Data* (May involve microscope, thermometer, sensor, etc.)
Rational Analysis (Thinking)	Linear thought based on a premise (interpretation and inference)	Systematic analysis, logic, reasoning, mathematics, thought experiments, critical thinking, etc; *Data Interpretation* (May involve equations, models, statistics, etc.)
Authoritative Source (Believing)	Information from a person or group (credible source)	Map, teacher, dictionary, text book, photograph, etc; *Citations* (May involve definitions, references, etc.)
Intuitive Insight (Attuning)	Personal experience without the five senses via intuition (insight and attunement)	Sudden awareness, flash of insight, attunement to surroundings, dream, etc; *Inspiration* (Different than emotions, and different than subconscious logic)

[2] **Royce** JR (1964) *The Encapsulated Man.* D. Van Nostrand Company, Inc., Princeton, New Jersey.
[3] J**ennings** L (1993) *Research Paradigms in the Social Sciences.* Southern Cross University, Lismore, New South Wales, Australia. a*s cited in* **McKay** PR (1997) *The Development of the On-line Educational Institute. Masters Thesis.* Southern Cross University, Lismore, New South Wales, Australia. www.redbean.com.au/articles/files/masters/thesis

No human source of knowledge is foolproof!
Each method requires lots of practice
and sometimes training.

Western science is *empirical*[4] and is based on physical experiences (experiments and/or observations), which provide *data* (recorded observations). Those data are then analyzed systematically (*data interpretation*) and inferences are made[5].

***Empirical observations* with**
***rational analysis* of those observations**
form the foundation of the scientific method.

In addition to *empirical observations* and *rational analysis,* scientists also use *authoritative sources* (information from other scientists) by reading and citing each other's scientific articles. Scientists know, however, that the credibility of each scientific article depends upon the accuracy of the *empirical observations* and *rational analyses* in the article. Therefore, scientists usually look at another scientist's data before trusting that other scientist's conclusions.

Many scientists also use personal *intuitive insight* (inspiration) to come up with new ideas.[6] However, *intuitive insight* by itself is not part of the scientific method. Scientists know that *intuitive insight* can very easily be contaminated by wishful thinking; consequently, scientists gather *empirical observations* to: 1. test (confirm or refute) their own *intuitive insights*; and 2. communicate these data to other scientists.

Trusting someone else's *intuitive insights* (even a fellow scientist's) is not a form of personal *intuitive insight*; it is a form of "trusting authority," where one sees another person as an *authoritative source* without having any data to verify the information from that source. Consequently, scientists are very careful and do not blindly trust each other's intuition.

Science students benefit from repeated practice in observation and analysis.

Any student can grow up to become
an excellent scientist
if he or she develops strong skills in
empirical observation and rational analysis!

---

[4] The word *empirical* denotes information gained by means of observation, experience, and/or experiment.

[5] See **Grade 4: Standard Set 6. Life Sciences: 6a:** "Differentiate observation from inference (interpretation), and know scientists' explanations come partly from what they observe and partly from how they interpret their observations."

[6] Einstein came up with some brilliant ideas in his dreams; he later tested those ideas and described them mathematically.