"Physicists are conservative revolutionaries. They do not give up tried and tested principles until experimental evidence - or an appeal to logical and conceptual simplicity - forces them into a new and sometimes revolutionary viewpoint. Such conservatism is at the core of the critical structure of inquiry. Pseudoscientists lack that commitment to existing principles, preferring instead to introduce all sorts of ideas from the outside."

- Dr. Heinz R. Pagels, "The Cosmic Code"

If it walks like duck, swims like duck, quacks like duck . . . it's probably not an elephant."

- Chief Petty Officer Ralph Caraway, Master Instructor, USN-retired, explaining the overarching theory of acoustic intelligence analysis.

You can observe a lot just by watching."

-Yogi Berra, American philosopher

The Scientific Method is a remarkably adaptable tool that allows us "mere mortals" to pursue the most profound truths. Its strength lies in both its beautifully articulated process and its flexibility.
We keep the Scientific Method around because it works, and most importantly, it has **never failed**. Not even once. Its self-correcting nature prohibits failure.
Now that's a pretty bold if not outrageous statement, so let's bring the topic into sharper focus by stipulating a distinction between the "Scientific Method" and "Science" itself:
While the Scientific Method does not fail, Science often does. It happens all the time, and is a normal, entirely expected part of the business. The Scientific Method gives us the means to (1) recognize and deal with these failures and (2) establish the credibility of successes through a rigorous, clearly defined vetting process.
In short, the Scientific Method is how we police the business of Science.

Though frequently viewed as an esoteric, intellectual protocol, it also has very practical, down-to-earth applications. One beautiful example of this (I believe) is the grand experiment of American Democracy. People a lot smarter and more credentialed than me have long argued that it's no coincidence that the architects of the American government were also products of the Galilean/Newtonian revolution of scientific rationale (think Thomas Jefferson and Benjamin Franklin, both well-established scientists, inventors, and philosophers in their own right). Look closely, and you will see a remarkable similarity between the Scientific Method and our constitutional system of informed candid debate, peer review, accountability and a formal regimen of "checks and balances."

Both protocols are ultimately beholden to unvarnished reality, and survive the most rigorous challenges to their very existence because they are specifically engineered as fluid, adaptive processes of deliberative, critical analysis and self-correction.

"Galileo was one of the first people to practice what we recognize today as the scientific process (or "method"): the dynamic interplay between experience (in the form of experiments and observations) and thought (in the form of creatively constructed theories and hypotheses). This notion that scientists learn not from authority or from inherited beliefs but rather from experience and rational thought is what makes Galileo's work, and science itself, so powerful and enduring.
"Galileo's methods have been crucial to science ever since. They included:

- *Experiments*, designed to test specific hypotheses
- *Idealizations* of real-world conditions, to eliminate (at least in one's mind) any side effects that might obscure the main effects
- *Limiting the scope of inquiry* by considering only one question at a time. For example, Galileo separated horizontal from vertical motion, studying only one of them at a time.

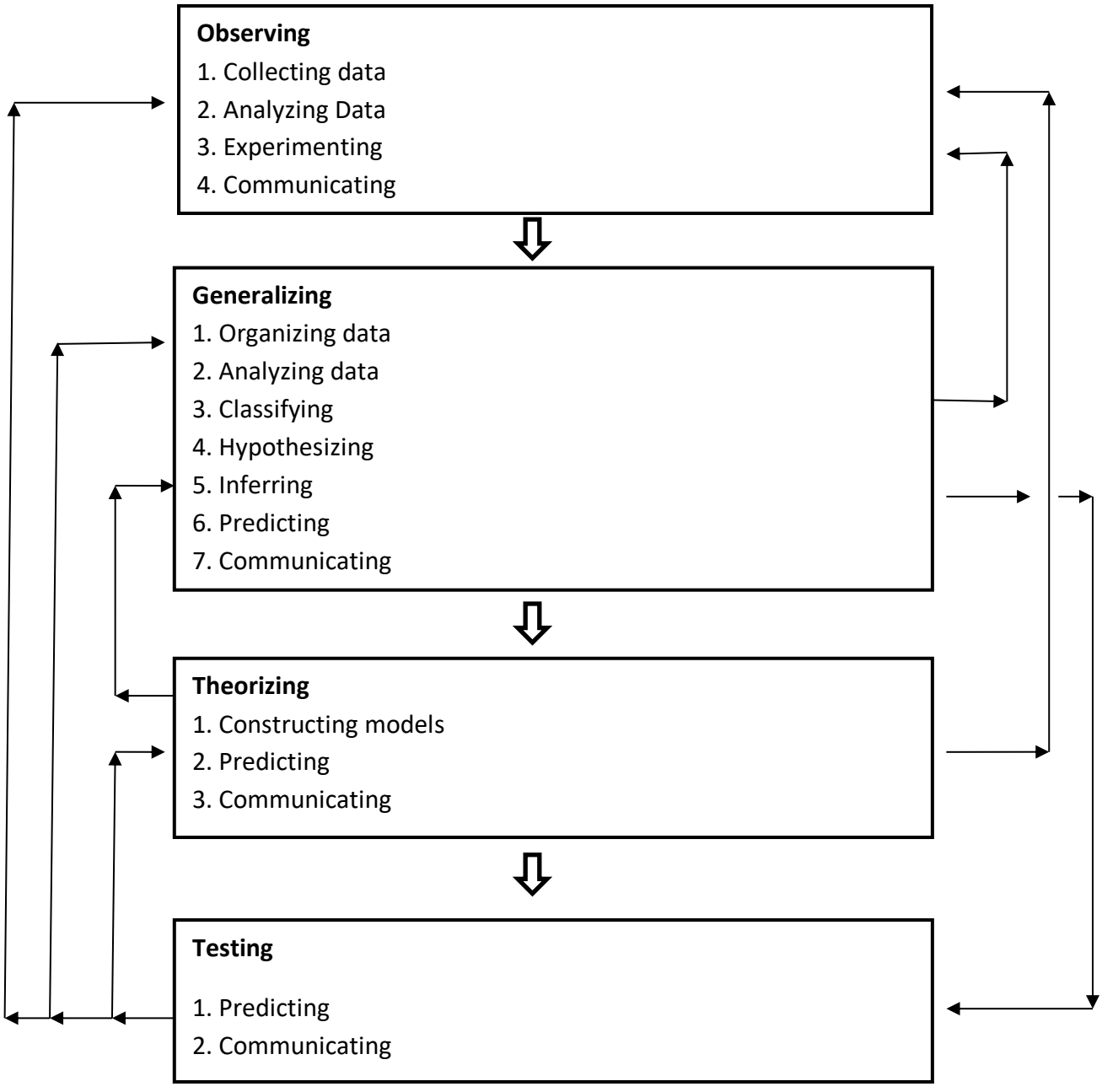
- *Quantitative methods*. Galileo went to great lengths to measure the motion of bodies. He understood that a theory capable of making quantitative predictions was more powerful than one that could make only descriptive predictions, because quantitative predictions were more specific and could be experimentally tested in greater detail

"**Observation** refers to the data gathering process. A **measurement** is a quantitative observation, and an **experiment** is an observation that is designed and controlled by humans, perhaps in a laboratory." A scientific **theory** is a well- confirmed framework of ideas that explain what we observe. A **model** is a theory that can be visualized, and a **principle** or **law** is one idea within a more general theory. The word *law* can be misleading because it sounds so certain. As we will see, scientific ideas are never absolutely certain.
"Note that a theory is a well-confirmed framework of ideas. It's a misconception to think that a scientific theory is mere guesswork, as nonscientists occasionally do when they refer to some idea as 'only a theory'. Some people who disliked Copernican theory [heliocentric system] argued that it was a 'mere theory' that need not be taken seriously. Today, people who dislike the theory of biological evolution attack it on similar grounds. Theories - well-confirmed explanations of what we observe – are what science is all about and are as certain as any idea can be in science.

"The correct word for a reasonable but unconfirmed scientific suggestion (or guess) is **hypothesis**. For example, Kepler's first unconfirmed suggestion that the planets might move in elliptical orbits was a hypothesis. Once the data of Brahe and others confirmed Kepler's suggestion, elliptical orbits took on
the status of theory rather than mere hypothesis."

- Dr. Art Hobson, "Physics -concepts and connections"

Scientific Method Flow Chart



IMPORTANT:

"Communication": Common to *all steps* of the Scientific Method

Theory:

- A body of knowledge that is supported by laws, mathematical and physical evidence, and repeatable, testable predictions and results

Hypothesis:

- An untested idea
- S.W.A.G.

Idealizations:

- Elimination or discounting of insignificant or irrelevant data/conditions in a given problem, scenario, or experiment

Limiting the scope of inquiry:

- Breaking a complex problem into individual pieces
- The “Pizza Principle”

Quantitative methods:

- Numbers, numbers, numbers!

Creating a model:

- May be an actual model
- A sketch
- A mathematical description

Repeatable, testable predictions and results:

- The Deal – Breaker!

Fact – based versus Authority – based knowledge

- Fact: tangible evidence
- Authority: “because the institution says so”