What is Science?

LBST 2213 Lecture 1

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(Hohenberg, 2010)

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Science is…

- The process by which humans attempt to explain natural phenomena within the universe
- The culture practiced by communities of scientists
- Collective, public knowledge, or “public culture”
- Science emerges from science
- Partial and always changing
- One of many paradigms through which humans can observe and explain the universe

(Hohenberg, 2010)

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Paradigms in Western Science

We'll start by talking about Western science - science that has its roots in the Greek, Latin, or Arab world. *This includes physics, chemistry, biology, geology, astronomy, and disciplines relating to the applied use of medicine and technology.*

With so many paradigms through which to explain the universe, what makes Western science unique?

Part of what makes Western science unique as a knowledge-making system is the methodologies involved. The scientific method has been in the works for hundreds of years. Today, most of you know the scientific method as a process by which hypotheses are

(a) developed,
(b) tested in a consistent and duplicable way, and
(c) found to be supported or unsupported by empirical evidence *(that's evidence that can be observed in the real world, rather than simply existing in theory)*

With so many paradigms through which to explain the universe, what makes Western science unique?

Something else that makes Western science unique is a distinction between objective and subjective knowledge. Objectivity has emerged as a cultural value in communities who practice Western science. Objectivity is the idea that there are truths that exist independently of human interpretation.

But where do these ideas come from?

Let's take a quick (and very limited) journey through the history of Western science, specifically focusing on the development of the scientific method and objectivity.

Natural Philosophy

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Natural philosophy emerged in Ancient Greece around the sixth century BCE, and people who published their observations about the natural world were commonly referred to as natural philosophers until the 19th century in Europe.

Natural philosophy depended on logic and rhetoric. Empirical evidence was less important than the strength of a natural philosopher's logical proof and debate skills.

Natural Philosophy

It's important to note that at the advent of natural philosophy, objectivity is not the goal. In fact, Socrates admits that we can't know anything objectively. Meanwhile, Aristotle stresses the role of the five human senses in the gathering of knowledge. At this point, the human body and its five senses play an instrumental role in knowledge-making.

Types of Knowledge: Techne and Episteme

In Ancient Greece and Rome, a distinction is made between two types of knowledge. The first is ***techne,*** which refers to “useful knowledge” - something that is learned as part of a trade and applied toward the improvement of a society’s infrastructure. The second is ***episteme,*** which refers to theoretical or abstract knowledge. Episteme was the domain of natural philosophers in the Greek, Roman, and Arab world. Theoretical science and applied science were kept more separate in ancient times than they are today.

Knowledge and Power

It's important to keep in mind that the production of knowledge through science (or natural philosophy) was not explicitly separate from the production of knowledge through religion until very recently. During the Renaissance and Enlightenment periods (between the 15th and 18th century), European governments and royal families employed imperial scientists and mathematicians. At the same time, the first scientific journals were founded by royal governments and churches. (Imagine publishing evidence that contradicted the beliefs of the publishing institution.)

Observation vs. Objectivity

At the founding of the first scientific journals in the 1600s, logic and rhetoric still took precedence over empirical evidence. The definition of empirical evidence also differed from the definition we have today. Observation was a key research method for many natural philosophers, such as Carolus Linnaeus, who invented the taxonomic system for species names. In *Systema Naturae,* his master classification of all known species, he listed four subspecies of humans. This was based on his observation that humans from different parts of the world looked different. When Linnaeus published his work to British audiences in 1758, observations were considered by most to be empirical evidence.

Observation vs. Objectivity

Today, we consider observation to be the first step in the formation of a hypothesis, which must then be tested in a duplicable way. By using genetic testing, we can now tell that there is not enough genetic variation between humans to consider any group a subspecies. There are no subspecies of humans.

But Linnaeus' argument was compelling, especially to a society in the process of colonizing and enslaving humans from other parts of the world. If we could explain that those other humans were biologically different, it could help to justify colonization. However, just because an argument is logically sound does not mean it is evidence based.

Observation vs. Objectivity

This is something noticed by Rene Descartes in the 17th century. Descartes pointed out that logical conclusions from false pretenses still lead the observer to the wrong answer, and he was concerned that our human senses were unreliable. It was too easy, Descartes said, to be deceived by science.

Observation vs. Objectivity

Descartes was one of the first natural philosophers to informally call for objectivity in science. According to Descartes, human observation and reasoning was not enough to determine whether or not something was true. But apart from his own senses, what observational tools did Descartes have?

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Enter the microscope and telescope, invented in the 1600s. Then the camera in the 1800s. These give way to the possibilities of radiographic imaging, genetic testing, isotope analysis. Enter the discipline of ***techne***.

Observation vs. Objectivity

According to Lorraine Daston and Peter Galison in their book, *Objectivity,* objectivity didn't become a value in Western science until the mid-1800s. At this time, technology began to play an instrumental role in scientific methodologies. Our relationship with technology transformed our relationship with knowledge. While their predecessors had placed great value on the role of human observation and sensation in the procurement of knowledge, scientists in the nineteenth century believed that human intervention was an obstacle to the truth. Knowledge that could be determined by a machine was now privileged over knowledge determined by human observation. In the nineteenth century, information with the least human intervention was considered the most valuable.

Daston and Galison - Objectivity

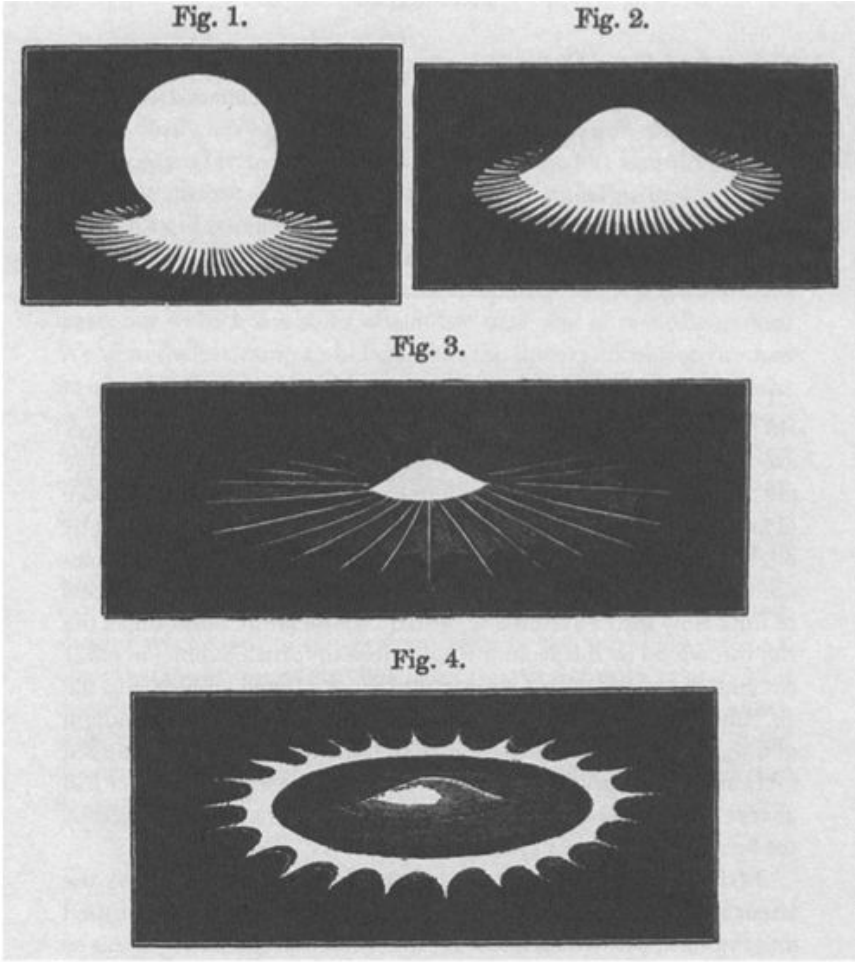
In their book, Daston and Galison introduce three "epistemic virtues," or ways of looking at scientific objects. *(Remember that "episteme" is the study of knowledge.)* The three epistemic virtues are:

- Truth-to-Nature
- Mechanical Objectivity
- Trained Judgment

Truth-to-Nature

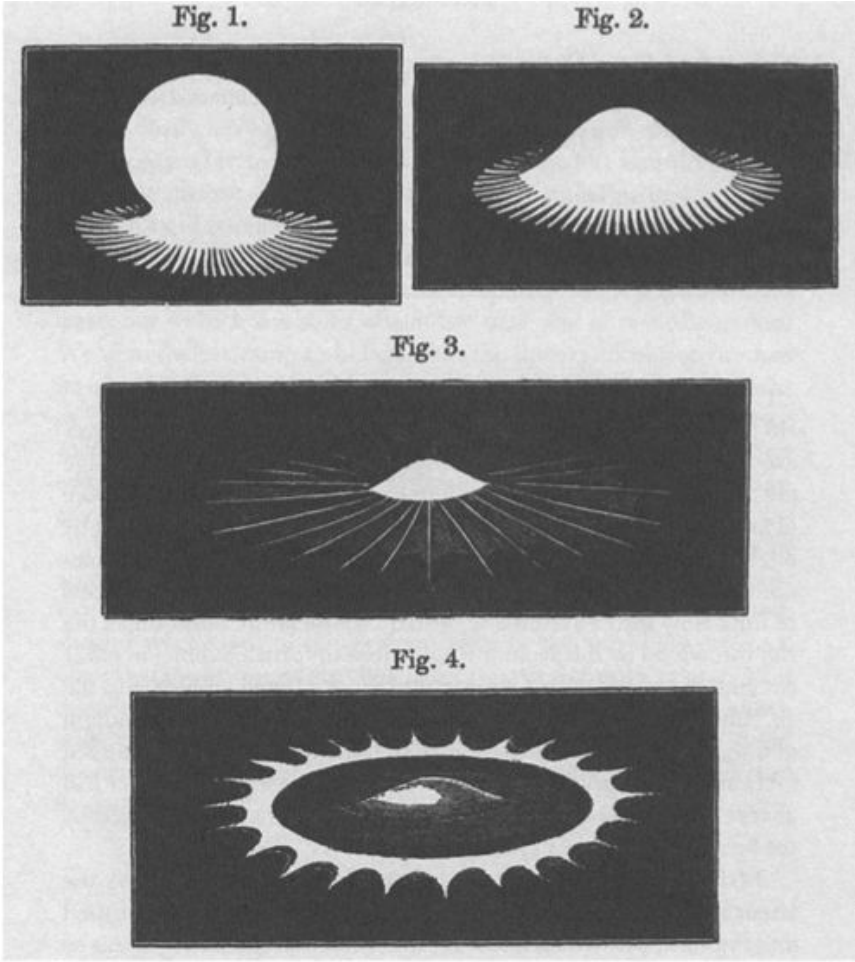
Things as they appear to the human eye; the "prototypical" version of something.

This was the epistemic virtue of natural philosophers until the nineteenth century.



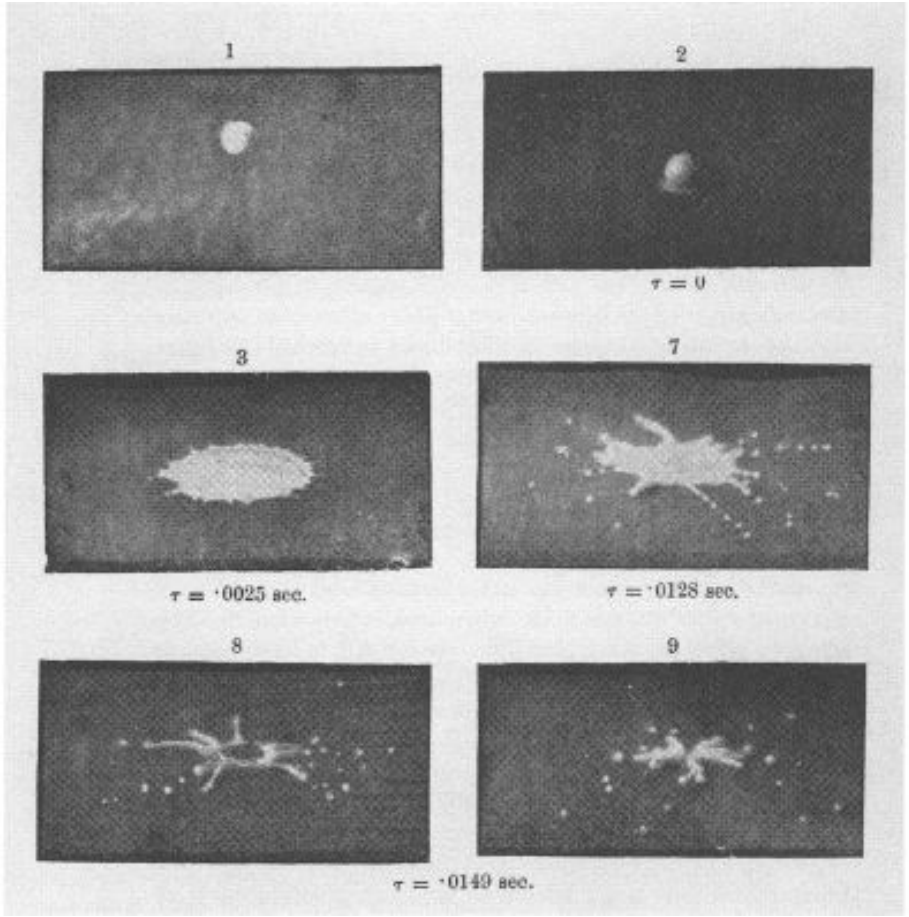
Truth-to-Nature

Daston and Galison tell the story of Arthur Worthington, a British physicist who was studying the behavior of liquid in the 19th century. Based on observations with his naked eye, Worthington had concluded that drops of liquid mercury scatter with perfect symmetry, most often with 24 rays, as depicted in Worthington's illustration (right). According to truth-to-nature, which is based on data gathered from the human senses, this conclusion made sense.



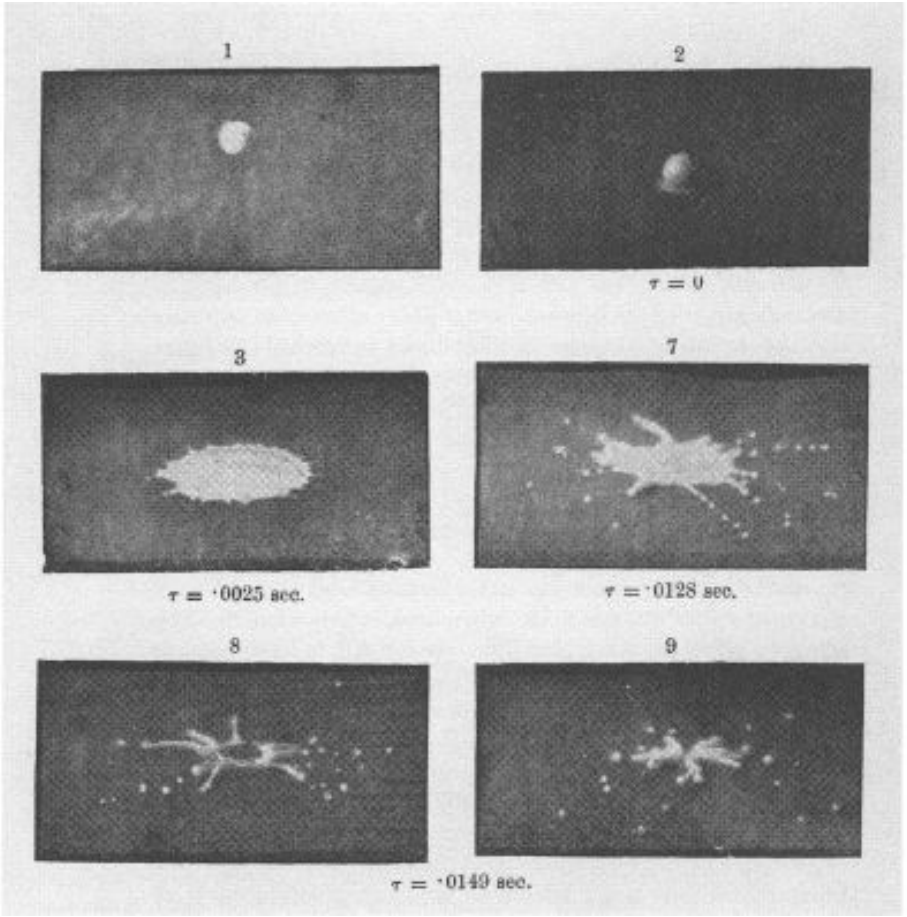
Mechanical Objectivity

However, in 1894, Worthington captures the droplet's scatter in a photograph. Symmetry shatters. When magnified, the droplets aren't symmetrical at all. Each scatters in a seemingly random pattern.



Mechanical Objectivity

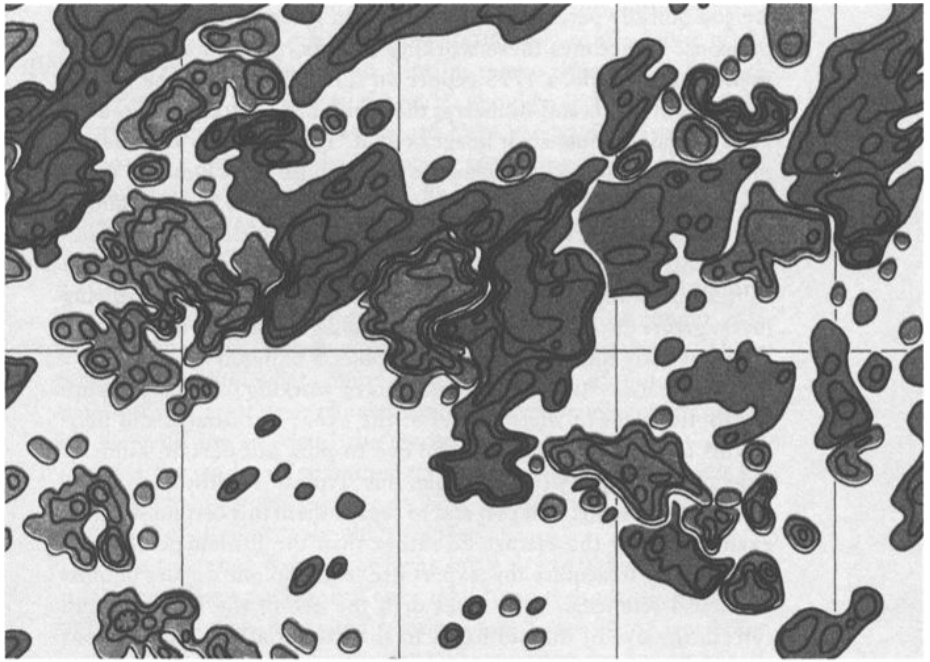
Mechanical objectivity portrays the world with as little human intervention as possible. This is the epistemic virtue held by scientists in the late 19th and early 20th centuries.



Trained Judgment

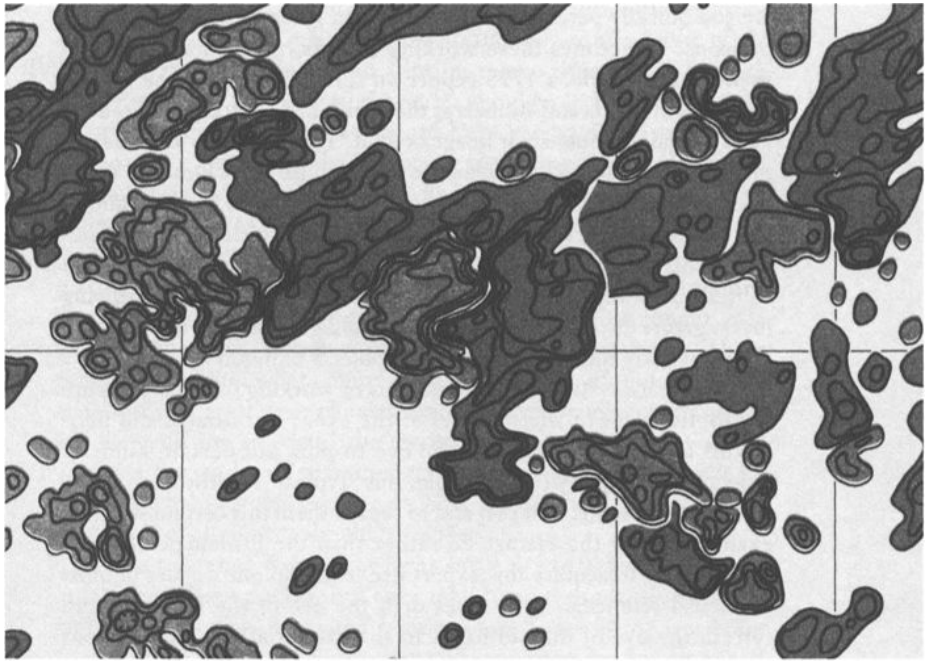
A portrayal of mechanical objectivity by humans, "smoothing out" perceived flaws or inconsistencies; a human interpretation of raw data.

In the 21st century, humans conduct experiments using technology, and do multiple trials to control for bias.



What is true?

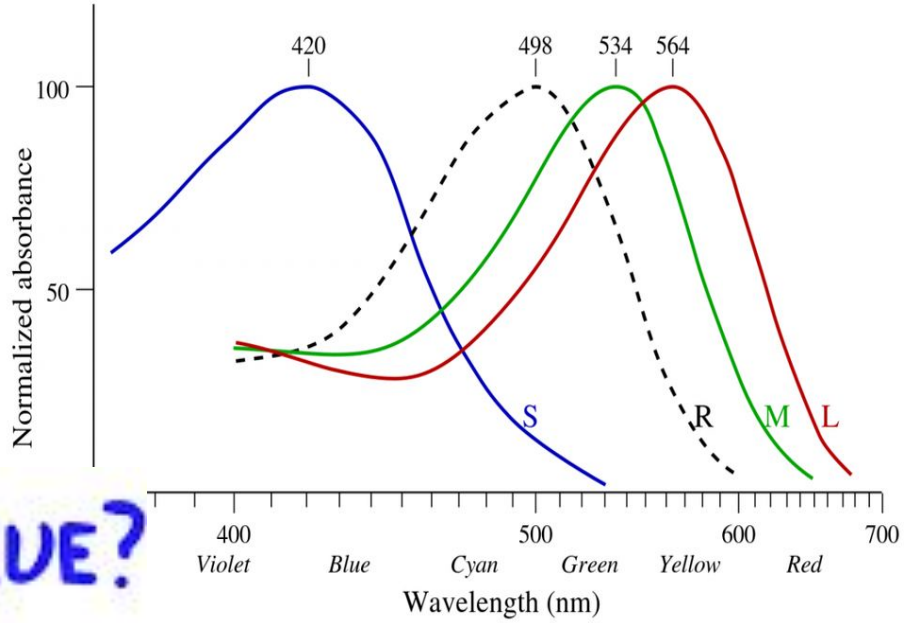
Our definition of truth has shifted. Sometimes we discover that the way we perceive the world around us is not backed up by science. In this case, what functions as the truth in day-to-day life may not be the "objective" truth.



As it turns out, our senses aren't as reliable as we once thought

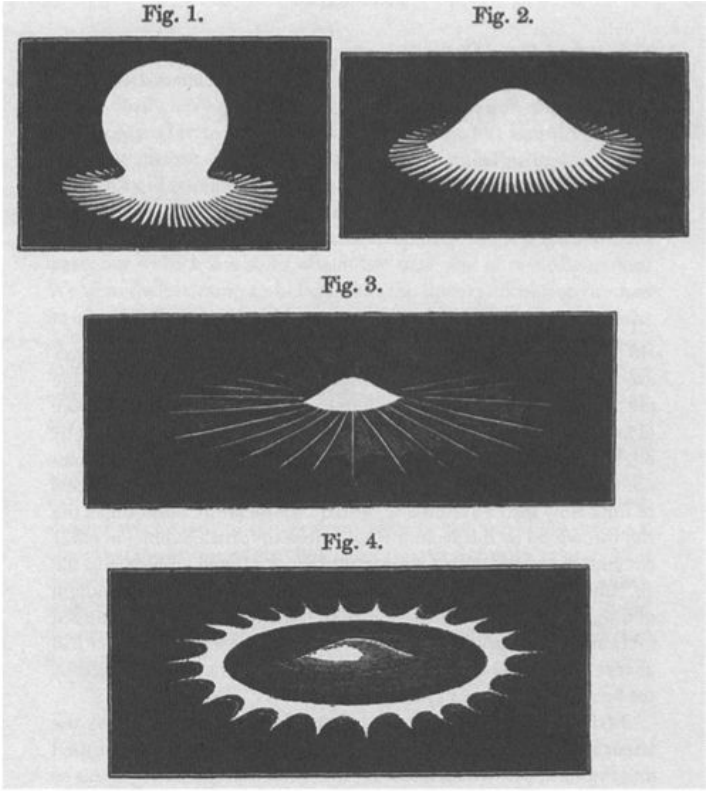
Science: the sky is violet

Perception: because our retinas are more sensitive to blue light than red, the sky appears blue



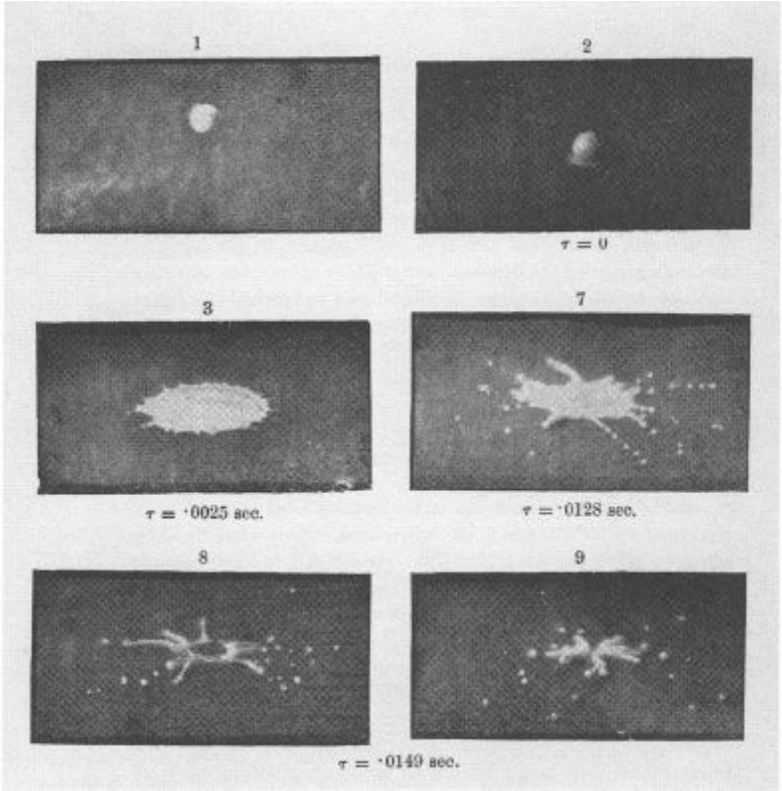
WHICH IS TRUE?

Which do you think is more true?



how things seem

OR



how things are?

This is where the limits of objectivity come into play.

Can we ever find an "objective" truth when all knowledge is subject to human interpretation by human senses?

Knowledge Systems and Ways of Knowing

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+ Rigorous testing of hypotheses, like Linnaeus' conjecture that there were four human subspecies, can help us to avoid potentially harmful fallacies. It helps us to have high confidence that the information we share can be applied consistently by everyone who uses it.
- On the other hand, it's important to note that not everyone values the methodologies used in Western science, and some may even see them as harmful or disrespectful. For example, while most Western scientists find it ethical to do research with ancient human remains, many indigenous groups think that it is unethical to take remains out of the ground, regardless of age.

Knowledge Systems and Ways of Knowing

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While natural philosophers debated in Ancient Greece and Rome, hydro-powered automatons were being built in Turkey, the circumference of the earth was accurately calculated in India, Chinese and Indian doctors came up with the most sophisticated medical and surgical practices of their time, and indigenous Americans came up with the first taxonomic system of plant species, including the bark that contains the active ingredient in aspirin.

Knowledge Systems and Ways of Knowing

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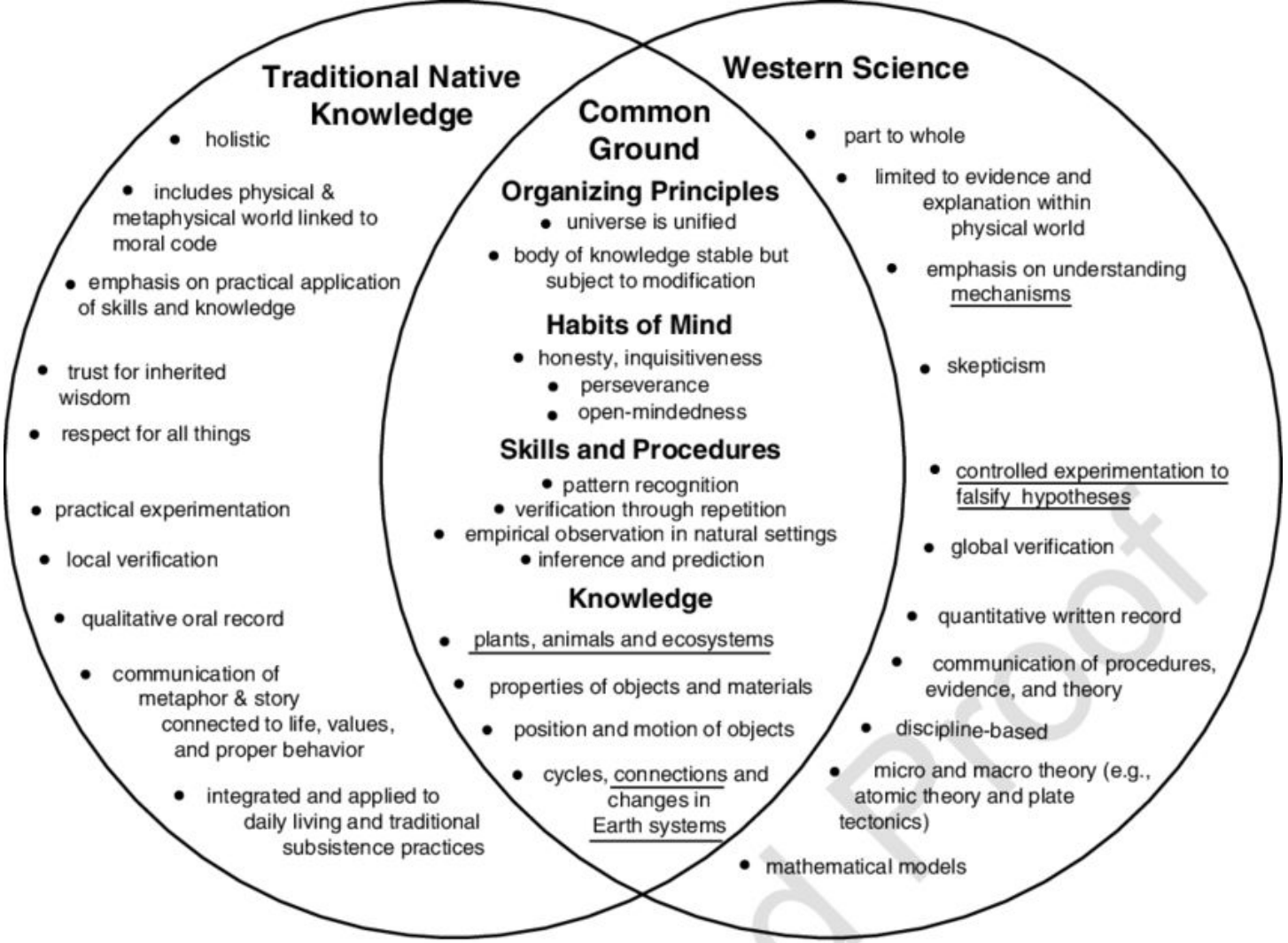
In some cases, information in the oral tradition survives longer than information in the written tradition. For example, some of the most prolific libraries in history have been burned down, such as the Library of Baghdad and the Library of Alexandria. However, knowledge that is passed orally from generation to generation sometimes dates back thousands of years.

Knowledge Systems and Ways of Knowing

In this example, the indigenous people of Flores in Indonesia long told of the existence of a dwarf species of humans that lived in the forest - which was backed up by the fossil record in 2004. Meanwhile, some indigenous peoples of North America recount arriving by boat, rather than the land bridge. Archaeological evidence discovered in the 21st century backs up this claim. In addition, indigenous knowledge of ecological issues has proven to be more accurate than predictions made by Western science on a number of occasions.


Traditional Native Knowledge
holistic
includes physical & metaphysical world linked to moral code
emphasis on practical application of skills and knowledge
trust for inherited wisdom
respect for all things
practical experimentation
local verification
qualitative oral record
communication of metaphor & story connected to life, values, and proper behavior
integrated and applied to daily living and traditional subsistence practices
Common Ground
Organizing Principles
universe is unified
body of knowledge stable but subject to modification
Habits of Mind
honesty, inquisitiveness
perseverance
open-mindedness
Skills and Procedures
pattern recognition
verification through repetition
empirical observation in natural settings
inference and prediction
Knowledge
plants, animals and ecosystems
properties of objects and materials
position and motion of objects
cycles, connections and changes in Earth systems
Western Science
part to whole
limited to evidence and explanation within physical world
emphasis on understanding mechanisms
skepticism
controlled experimentation to falsify hypotheses
global verification
quantitative written record
communication of procedures, evidence, and theory
discipline-based
micro and macro theory (e.g., atomic theory and plate tectonics)
mathematical models

Knowledge and Authority: how do you consume knowledge?

While indigenous knowledge values the wisdom of elders, Western knowledge about science is enshrined in different power structures: universities and peer-reviewed journals. In an where most people can publish their knowledge online, how do we know what knowledge to consume?

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You might believe that glaciers are melting or that staying 6 feet away from someone will keep you from getting COVID-19. But it's not likely that you did your own experiments to come to these conclusions. How do you decide to who to believe when it comes to science?

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One system is peer-review. In order to publish findings in a scientific journal, a scholar must have these findings reviewed by a committee of other scientists.

Knowledge and Authority: how do you consume knowledge?

Can you identify sources that have been peer-reviewed? While all forms of knowledge are valuable, the review process is an important thing to consider when deciding what kind of knowledge to consume.

Conclusion

Long story short, there's more than one way of knowing, and ways of knowing can work together to give us a more holistic and complete picture of the world around us. As we look at more examples, I invite you to consider the ways in which traditional ways of knowing and Western science can work together in North America.

For the rest of the term, we will explore some of these ways of knowing, as well as applied uses of knowledge through the disciplines related to technology.