1.2 Discovering Discovery

How Science Works

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I want to know God's thoughts … the rest are details. —Albert Einstein

Learning Objectives:

- Understand and be able to identify each of the following: scientific observation/data, natural pattern, scientific interpretation, (empirical) testing, falsification, scientific prediction, scientific hypothesis, scientific theory and *scientific underpinnings*.
- Understand the characteristics of science, including *the role of pattern recognition & explanation in science*; how predictions are used to test scientific ideas; the difference between hypotheses & theories; and how confident we can be that scientific observations, hypotheses, & theories are true.
- Understand the functions/benefits of scientific theories and the role of faith in science.

Did you know that you're an amateur scientist? It's true! At its core, science is nothing more than recognizing and explaining natural patterns and then testing those explanations to ensure that they accurately describe nature. You do this everyday. What separates most people—who intuitively dabble in pattern recognition and explanation—from skilled scientists is commitment to testing. Skilled scientists rigorously test the truthfulness of their explanations by comparing the way nature 'should be' if the interpretation is true to the way nature 'actually is'. Explanations that cannot accurately account for the attributes of nature are false. In contrast, those that accurately describe the characteristics of nature are valid (true)—because they represent 'knowledge of things as they are, were, and will be'.

So, although many people think of scientists as nerdy individuals in white lab coats, skilled scientists are just normal people with honed observational and interpretive ability, deep knowledge of a portion of nature, and enhanced commitment to using the attributes of nature as the arbiter of truth about the physical world. Many have been blinded by relying on lazy observation and untested interpretation. No matter your roles—artist, parent, disciple, entrepreneur, …—rigorous commitment to testing will significantly strengthen your ability to find truth about the physical world.

The Process and Meaning of Science

As you know, science employs two classes of truths—observations and interpretations. *Scientific observations* include individual descriptions of nature and summary descriptions of natural patterns, and *scientific interpretations* include explanations of nature known as scientific hypotheses and scientific theories. In addition, science relies on foundational ideas we will refer

to as scientific underpinnings.

Scientific observations are experiences made with the senses (or with instruments that extend the senses) that *all rational humans experience objectively*—regardless of their philosophical, political, or religious outlook. Scientific observations strive to *describe* the *actual* characteristics of nature. Even so, human inability to observe every aspect of nature ensures that scientific observations are incomplete. Nevertheless, as humanity observes ever-larger fractions of nature, our understanding of nature 'as it is' becomes more complete. This ever-growing pool of scientific observations allows humanity to test scientific explanations ever more fully.

Natural patterns, sometimes referred to as scientific laws or principles, summarize large numbers of individual *observations*. For example, when you drop something, it falls, right? By observing numerous dropped items, this pattern can be established: dropped things fall to Earth. We call this pattern the 'law of gravity'. Likewise, the principle of biological inheritance summarizes *many* observed parent-child relationships, in this way: offspring inherit characteristics from their parents.

Scientific hypotheses are *explanations* of how nature works that are untested or have not yet been extensively tested. The *extent of testing* differentiates scientific hypotheses and theories. A scientific hypothesis becomes a **scientific theory** when it has been tested in every way known to humanity, using all available observations—when it accurately describes nature 'as we know it'. Of course, humanity's ability to observe nature grows continuously, as individuals develop clever new ways to test ideas using existing observations and as new or better scientific instruments produce new observations. As a result, the testing of scientific theories never ceases. It can pause for a time, when observable predictions are exhausted, but it never ceases. As the number of independent observations that *fail to falsify* a theory grows, so too grows our confidence that the scientific theory describes nature 'as it is'—that the scientific theory is true (accurately describes nature). In these ways, scientific knowledge grows 'line upon line'.

Scientists use **falsification** to test the truthfulness of scientific explanations. No scientific tool exists for demonstrating that scientific explanations are true. Science can only identify false ideas. **Scientific predictions** are deductive conclusions of scientific explanations that answer this question: if the hypothesis or theory is true, what should we observe in nature? *Empirical* **testing** is seeking to observe scientific predictions by designing and carrying out experiments or observational campaigns. If the prediction is not observed, the hypothesis is *falsified* and we seek a new or revised explanation of the investigated aspect of nature. If observed, humanity's confidence in the truthfulness/accuracy/validity of a scientific hypothesis or theory dramatically increases.

Still, no amount of testing can prove that a theory is absolutely true, because science *demonstrates affirmatives* (true explanations) by *proving negatives* (identifying false explanations). The possibility always exists that a future observation will falsify a theory. Falsifying an extensively-tested scientific theory demonstrates that the explanation is not universal, that it has limited ability to accurately describe nature. Even so, extensively-tested

scientific theories that have been falsified continue, for all eternity, to be valid descriptions of nature in the areas in which observations could not falsify them.

Scientific theories *validly describe each area of the physical world in which testing has failed to falsify them*. Honest seekers of truth recognize that scientific theories contain abundant truth and represent humanity's very best preparatory explanations of natural processes. Scientific explanations are powerful and authoritative because scientific predictions and empirical testing ensure that scientific theories accurately describe nature. This self-correcting character distinguishes scientific explanations from most other forms of human explanation.

Correctly understanding the meaning of scientific explanations is an essential prerequisite to productively interacting with scientific ideas. For example, if you someone asserts, “using new observations, scientists have proven …”, you should understand that statement to mean, “scientists have made new observations that fail to falsify …”. Can you now see how the word ‘theory’ is used very differently in science than it is in everyday speech? When most people say ‘theory’, they mean ‘hypothesis’. It's OK to use ‘theory’ in this way, so long as you are clear about how you or others are using it.

Importantly, science is a godly endeavor that allows humanity to make steady progress—line upon line—towards the goal of understanding nature perfectly. Even so, scientific knowledge is just one of two authoritative paths to truth. The other path is revelation. These two paths are authoritative because each provides reliable methods for identifying the validity of explanations: correspondence with nature and confirmation by God. In this way, discovery and revelation form complementary paths to truth that, for the dedicated student of truth, can become ‘one in thine hand’ (Ezekiel 37).

The Importance of Scientific Theories

Despite their limitations, scientific theories fill three essential **functions**:

- They *explain* how nature works—how natural processes produce the observable physical world. In this role, scientific theories represent explanations of nature in which humanity can place tremendous confidence, because extensive empirical testing has demonstrated that these theories correspond to nature across presently available observations.
- They *connect* apparently unrelated aspects of nature. In this role, scientific theories accurately describe relationships between large sets of otherwise disconnected observations and illuminate natural patterns that would otherwise remain undiscovered.
- They *guide* future research. In this role, scientific theories make *testable predictions* about what should exist if the theory is true. These predictions guide human inquiry and are thus vital to perfecting human knowledge of the natural world.

In addition to these important functions, scientific theories provide two important **benefits**:

- They *improve human lives.* Scientific theories provide knowledge that empowers us to

protect humanity from aspects of nature such as earthquakes, plagues, and climate change and to improve human life through inventions and by designing solutions to natural problems. Of course, science is only beneficial if humanity *chooses* to *use* scientific knowledge *correctly*. These choices are guided by principles that lie outside the domain of science, in areas such as morality and sociology.

- They *satisfy human yearning to understand* the world around us. Scientific theories satisfying humanity's nearly insatiable curiosity. What aspects of nature are you most curious about? Have you become more or less curious as you've aged? If less, why?

As you can see, scientific theories facilitate human discovery and bless humanity!

The Role of Faith in Science

All human explanations and actions rely on foundational notions. For example, opening your front door to go somewhere relies on the notion that the rest of the Universe continued uninterrupted while in your house. Likewise, praying relies on the notion that there is a higher power with which humans can communicate. Foundational notions also *underpin* scientific action and explanation. **Scientific underpinnings** are ideas about fundamental aspects of nature that allow humanity to develop explanations of natural phenomena. Scientific underpinnings are distinct from scientific observations and theories. Examples of scientific underpinnings include the following:

- *Humans can understand the universe*. Ancient Greek philosophers developed this underpinning, the notion that the human intellect is capable of understanding natural patterns. No previous known human group—hunter-gatherers, agriculturalists, or the early civilizations of Sumer, Egypt, Rome, India, or China—was so fully committed to this important idea.
- *Natural processes acting on natural matter produce the physically observable Universe*. Known as 'mechanism' or 'naturalism', this underpinning states that nature operates according to lawful processes.
- *Natures operates the same everywhere and every-when*. This underpinning, known as 'uniformitarianism', states that the laws and processes discovered by science apply throughout space and time—that is, that the Earth and its environs are sufficiently representative of the Universe that the operations of nature can be discovered from here.

Initially, underpinnings are assumptions—untested ideas that serve as a useful foundation upon which to begin interpreting nature. However, as humanity uses scientific underpinnings successfully, our confidence in the validity of underpinnings grows—in much the same way that increasing confidence produces theories from hypothesis. Despite their stupendous success, scientific underpinnings are preparatory truths—and progress in human understanding will identify 'line upon line' improvements to these important ideas in which we exercise such faith.

Faith is the basis for accepting something as true that has not yet been observed (Hebrews 11).

Thus, faith is not blind acceptance; instead, it relies on evidence-without-proof. Said differently, faith is a belief in something that we don't yet know that is strong enough to cause us to as if it were true. Religious belief and action, of course, are founded in faith. Few have observed God, and yet primary spiritual experiences have produced faith in many individuals that God is real. As these individuals act on this faith, additional experiences increase their certainty that God is real—and this knowledge leads them to live their lives according to that reality. Faith plays precisely the same role in science. (No surprise there, since *all* human knowledge and action begins with fiath.) Science requires faith in at least three ways:

- *Accepting scientific underpinnings.* Science involves interpreting observations, and all scientific interpretations are founded in the underpinnings of science. Accepting these underpinnings is an act of faith.
- *Accepting observations made by others.* No one can make every observation. A million lifetimes would not be enough. As such, we must presently accept that observed patterns are representative of everywhere and every-when. We must also accept the observations of others. Accepting these observations is an act of faith. Of course, scientists routinely repeat and extend observations and tests. In this process, humanity can discover errors and needed refinements. In this way, science is self-correcting. The history of science is replete with such corrections.
- *Accepting scientific theories.* Theories are interpretations based on scientific underpinnings and founded in scientific observations made by others. For these reasons, and because scientific theories cannot generally be proven true, accepting scientific theories requires faith.

In short, all human perspectives, actions, and knowledge are founded in faith—because they require acceptance without perfect knowledge. As such, accurately identifying the degree of certainty associated with knowledge will appropriate contextualize your present position on the path to truth and provide the flexibility needed to adjust to ever-more-valid preparatory truths —scientific and religious.