MODERN SCIENCE AND THE SEARCH FOR TRUTH

Brian Tonks—Department of Physics

I have pondered the question, "What is truth?" for many years. My intellectual journey has convinced me that truth comes in many ways through a variety of sources. I began my schooling believing that scientists were searching for the truth, but my undergraduate training included classes in the history and philosophy of science that disillusioned me towards the scientific process. Then my service in the United States Navy showed me the practical utility of scientific principles, and my graduate studies provided real experience in how science really works. For five years I was involved in nearly all facets of the scientific process.

My adult life spans the period of the Voyager missions to the outer planets, the Viking, Pathfinder, and Global Surveyor missions to Mars, and the Pioneer and Magellan missions to Venus. These missions demonstrated the power of scientific observation. Before Voyager, we knew little about the outer planets and even less about their satellites. Even in the largest ground-based telescopes, these appeared as mere pinpoints of light. Voyager revealed them as real worlds with actual, albeit bizarre, geology. Years of speculation were dispelled in a relative moment, reminding me of the Prophet Joseph Smith's statement, "Could you gaze into heaven five minutes, you would know more than you would by reading all that was written on the subject" (*History of the Church*, 6:50). I have come full circle, believing today that science is an important source of truth.

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The prophets of our dispensation echo this sentiment. Brigham Young said, "'Mormonism' embraces all truth that is revealed and that is unrevealed, whether religious, political, scientific, or philosophical. It comprehends all true science known by man, angels, and the gods" (*Discourses of Brigham Young*, 2). John Taylor, Joseph F. Smith, and Ezra Taft Benson have all made statements supporting and encouraging the search for truth using the methods of science (*The Gospel Kingdom*, 93-94).

The Truth of Science: How Scientists View the Scientific Process

Just what is truth in science? How should scientists go about finding the truth? Philosophers have debated these questions without resolution. Even scientists do not universally agree. Each scientist views the scientific process uniquely. Einstein said, "I hold it true that pure thought can grasp reality, as the Ancients dreamed.…We can discover by means of purely mathematical constructions the concepts and the laws connecting them with each other, which furnish the key to the understanding of natural phenomena" (Barrow, 349). Einstein apparently believed that nature can be understood through purely mental processes, although in later years he acknowledged that theories should match observation.

Paul Dirac, who predicted the existence of neutrinos from theory, stated, "It is more important to have beauty in one's equations than to have them fit experiment" (Davies, 176). At the other extreme, Edwin Hubble emphasizes that theories come and go, but observations are the permanent contribution to man's knowledge (Hubble, 1-4). An individual scientist's philosophy depends on his or her experiences, training, and, to some degree, field of study. The views I express here are my own, based on my study and experience, and do not reflect the views of all scientists and philosophers of science.

However, most scientists agree on some fundamentals. There is closer agreement about the scientific process among scientists today than at any time in the past. Ancient Greek, Medieval, and Renaissance scholars held a much wider range of philosophical viewpoints than do modern scientists.

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Certain social scientists argue that science isn't about the truth at all. Rather, it is a social construct and "truth" in science is simply the common consent of its practitioners (Newton, 23-44). Others believe that science is the only way to search for truth. I disagree with both of these extreme positions. I am convinced through my experience that science can learn truths about nature. Right after my graduate school experience, I read *Doctrine and Covenants* 121: 26-31, a scripture I'd read many times before. This scripture entered deeply into my heart. "God shall give you knowledge by his Holy Spirit…that has not been revealed since the world was until now.…If there be bounds set to the heaven or to the seas, or to the dry land, or to the sun, moon, or stars—All the times of their revolutions, all the appointed days, months, and years, and all the days of their days, months, and years, and all their glories, laws, and set times, shall be revealed in the days of the dispensation of the fullness of times."

We do not have to wait until the Millennium for this glorious promise to be fulfilled—it will happen in our dispensation. A look at God's dealings, however, shows us that He reveals little, if any, scientific information directly to his children, except in rare individual cases. Instead, He seems to allow us, his children, to deeply search after truth. Science is certainly one way that this revealed promise might be fulfilled. Observations using telescopes and space probes have surely brought mankind closer to fulfillment of this promise.

The Lord defined truth as "knowledge of things as they are, as they were, and as they are to come" (*Doctrine and Covenants* 93:24). In other words, we live on a planet we call the Earth in the year 2001. We are here. We got here somehow. We enjoy relationships with each other and with our Heavenly Father. This planet works in some way. The things we see happening around us occur for some reason. The Earth had a history. Things will actually happen in the future. If we knew how the Earth got to this point, if we knew how the Earth presently operates, and if we knew its exact future, we would know the "truth" about the Earth. The truth is extremely broad, constituting not only the physical universe in which we now live, but our pre-earth life and the life hereafter. It includes the plan of salvation and all the principles and ordinances of the gospel of Jesus Christ.

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Because truth is so broad, we need many different intellectual and spiritual tools to discover and understand it. Perhaps an analogy will help. Most of us have a toolbox containing many different tools. Perhaps it contains a hammer, a wrench, a pry bar, a screwdriver (or many), and a tape measure. Each tool is important because each tool has certain strengths and limitations. Its strengths allow us to perform specific jobs; its limitations prevent us from using it in place of others. For example, you would not use a hammer to remove the lug nuts from your flat tire. It would be hard on the lugs and wouldn't help the hammer either. Rather, you would use a wrench for the job. Likewise, I submit that science is one of the tools in our intellectual toolbox. If we understand its strengths and limitations, we will understand what it can and can't do. We certainly would not throw out the hammer just because we can't use it to remove lug nuts. Instead, we will be grateful for the jobs it can perform. Below, I attempt to briefly describe the strengths and limitations of modern science.

The Truth of Science: Objective Observation

Most scientists agree that objective observation is the foundation of modern science. Edwin Hubble claims, "Science is the one human activity that is truly progressive," because science restricts its inquiry to questions "concerning which it is possible to obtain universal agreement." Agreement is "secured by means of observations and experiments." These "tests represent external authorities which all men must acknowledge, by their actions if not by their works, in order to survive" (Hubble, 1-4).

Scientists require that two observers performing the same experiment in the same way get the same result (within the limits of measurement error). This is what is meant by objectivity in science. For example, if two individuals measure the distance between two light poles, both will agree on the measurement's numerical value (to within experimental error) regardless of the observer's belief system, attitude, or mood. In addition, the property that a scientist measures must also have the same meaning to all observers. Because of this stringent requirement, not all possible observations are admissible as scientific observations. This, in my opinion, is both a major strength and the major limitation of the scientific method.

Objects in the physical world are described by a number of physical properties. A major goal of science is to measure the values of as many of these properties as possible. Once measured, scientists establish experimental relationships between these physical properties. These relationships summarize many, many experiments. These relationships are sometimes called scientific laws. I agree with Hubble's claim that "observations and the laws which express their relations are permanent contributions to the body of knowledge" (Hubble, 1-4). These laws are certainly "truths" according to the Lord's definition.

Theories of Modern Science and Their Functions

There must be reasons why these relationships exist. These reasons would also be truths. Without answering "how" and "why," science is incomplete. To answer the how and why questions, we create "theories." A scientific theory is an idea that describes why we see a set of observations, and is subjected to observational testing. Even false theories can still provide useful explanations that work in some situations. For example, a book on celestial navigation might start, "Assume that the stars are located on a huge sphere with the Earth at its center." This statement is the ancient Greek concept of the universe's construction. We of course now know that this statement is false. However, for the purposes of navigating by the stars, the concept is useful. Thomas Kuhn notes that providing a useful explanation of nature is one of the three functions of scientific theory (Kuhn, 36-41).

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Theories cannot be just any statement. A valid scientific theory must predict observations that should be observable if the theory is true. These predictions allow us to test the theory. In addition, the theory must have the potential of being false. For example, I believe the statement, "In the beginning, God created the heavens and the Earth" is perfectly true. However, it is not a scientific theory. To be a theory, I would need to state what should be observed if God created the heavens and Earth. Testing might show that the statement is false. Statements like this do not encourage further exploration. If the statement is true with certainty, why search further?

Scientific theories, on the other hand, encourage us to explore further. If we test a theory by attempting the observations it predicts, we learn new truths about nature. If the tests are positive, our faith in the theory grows. However, even if we prove the theory wrong by our test, we have made new observations about nature that must be incorporated into a

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fully consistent intellectual system. Thus, creating theories and testing them helps us learn more about nature even if theories are proven false. Thomas Kuhn points out that guiding future research is one of the three functions of scientific theory (Kuhn, 36-41).

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For example, the ancients believed that the celestial objects orbited the central Earth. Ptolemy developed the concept of a central Earth into a working mathematical system. This system reproduced the motion of the planets in the sky to within the accuracy they were measured at the time. In addition, the system predicts that the planets Mercury and Venus will always remain in the crescent phase. Copernicus' Sun-centered system, put forward some 1,400 years after Ptolemy, predicts instead that Venus and Mercury will go through the entire sequence of phases that we see the Moon going through. Crescent-shaped Venuses are larger in size than nearly full Venuses. This theory suggested observations that would distinguish between the two systems. We now know where to direct our research energies. If we were to observe Venus and notice that it remains in the crescent phase, we disprove Copernicus' system. On the other hand, if Venus does go through the full phases that the Moon does, we disprove Ptolemy's system. Either way, we learn something about nature that we did not know before—we know about the phases of Venus. Historically, it was 75 years after Copernicus suggested the Sun-centered Solar System before the phases of Venus could be observed. Copernicus' system was used to calculate the positions of the planets and create the Gregorian calendar well before it was accepted as true. The Sun-centered system provided a useful explanation of nature. In addition, the theory helped us learn more about the universe. Incidentally, Venus was observed going through the full set of phases that the Moon does, disproving Ptolemy's theory of the universe.

Hubble emphasized the temporary nature of scientific theory. In his words, "observations and the laws which express their relations are permanent contributions to the body of knowledge [whereas] theories change with the spreading background.…Not until the empirical results are exhausted, need we pass on to the dreamy realms of speculation" (Hubble 4 & 202). He draws, I believe correctly, a sharp separation between scientific theory and observation. Such separation is almost never emphasized today. Virtually all science publications from textbooks to professional papers present observation and theory as if they are both "the truth." Primary, secondary, and undergraduate college level texts are especially guilty in their failure to separate observations from theory. Generally speaking, there is a tendency to state the theory, then give observations that support it. In my opinion, this is exactly backwards from the way it should be done. Strictly speaking, if one observation disproves the theory (like observing the phases of Venus in the example above), then it cannot be "the truth" and another theory must be sought. Using observations to "support" theories easily glosses over observations that don't fit. Nevertheless, the tendency is real and understandable because scientific theory relate a number of otherwise unconnected observations and makes them easier to remember. It helps us see patterns that would not be obvious otherwise. Providing these connections is the third function of scientific theory (Kuhn).

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Examples abound throughout science. Newton's law of motion coupled with his law of gravity explain why the planets orbit the Sun, and why the Moon orbits the Earth. In addition, we use them to accurately predict the celestial objects' future locations (astronomy), explain why rocks thrown into the air follow a parabolic path (terrestrial physics), and describe why the atmosphere of the Earth gets thinner as we go higher in the sky (atmospheric science). The theory provides a mental picture that allows us to reproduce these observations in our minds. As a result, we remember them more easily.

The Limitations of Scientific Theory

Karl Popper, a 20th century philosopher of science, emphasizes that all human knowledge is fallible. (He apparently does not believe in revelation.) There are no untainted observations. We use some underlying theory to interpret the information that comes through our senses. Likewise, we depend on our traditions, languages, and culture. As a result, we must continually look for errors. He suggests that we search for errors by subjecting our knowledge (including scientific theories) to the most severe tests we can devise (Popper, 51-53 and 73).

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Popper argues that our ignorance is infinite. We cannot know whether something is true or false. All we can do is guess (i.e. create a hypothesis). All possible sources of truth are welcome. (He seems to be less restrictive in this regard than most scientists.) All types of arguments are welcome. Comparing prediction to observation is only one. He emphasizes that we must continually ask if our guesses square with the facts. Although coherence does not guarantee the truth, incoherence alerts us to errors. He claims that "only the falsity of the theory can be inferred from empirical evidence, and this inference is a purely deductive one" (Popper, 102). As a result, Popper emphasizes that all theories (in fact all human knowledge, in his view) must be regarded as tentative. This emphasis is consistent with Hubble's attitude described above. In other words, a scientific theory is accepted as the truth by faith. This is a major limitation of modern science.

Allowing only objective observations is both a strength and limitation of modern science. It is a strength because, as Hubble said, "it is possible to obtain universal agreement." It is a limitation because many of our most important issues are inherently subjective. As a result, science cannot address many of life's questions although some scientists and philosophers apply its theories in areas where they probably shouldn't.

Assumptions of Modern Science and the Role of Faith

Every system of human thought, whether religious, cultural, philosophical, mathematical, or scientific, is built on a set of underlying assumptions. Assumptions are concepts that seem "intuitively obvious," but that cannot be proven either by the force of logic or by observation. These axioms are the foundation upon which the rest of the system is based. For example, Euclidian geometry, which most of us learned in high school, makes certain assumptions about the construction of space. The proofs that we had to perform in geometry used these assumptions, coupled them together logically, and constructed theorems. These concepts seem perfectly reasonable based on our experience in the world. However, there is no way to prove them for certain. The geometry you constructed is only as true as these assumptions.

Likewise, modern science is based on a set of underlying assumptions. They serve as the foundation upon which all observations are interpreted. Our assumptions are vastly different from those made anciently. These assumptions include: man can understand the universe; theory should be quantitative, testable, and fit observations; simple laws are best: reductionism, uniformitarianism, and mechanism.

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If we don't assume that we can understand the universe, the scientific enterprise is doomed from the start. We assume that theories are testable. This assertion presumes that the modern scientific method is the best way to discover the truth about nature. A quantitative theory uses mathematics to describe nature. We assume that mathematics is the language of the universe and that the physical universe corresponds to the mathematical universe. If a theory is quantitative, its predictions can be accurately compared to observation. Only testable theories are considered by science. Theories must also fit the observations. We've already argued that this is a reasonable point of view. This argument, however, is not proof.

If two theories explain the same observations, the simpler one is selected. This idea is now called "Occam's razor" after a thirteenth century scholar, but the concept is much older, stemming back to Plato.

Reductionism is most easily stated as "The whole is equal to the sum of its parts." It assumes that we can understand nature by understanding each individual part of it separately, then linking the parts together to understand the whole. Reductionism began in earnest with Galileo. He understood that the motion of a falling object in the Earth's atmosphere was a combination of gravity's effect coupled with air resistance. He reasoned that if he could understand each part of that motion individually, he could put them together to understand the entire complex motion. Reductionism is one of the most powerful concepts in modern physics. It reduces a complex problem to the sum of many simpler problems. The power of this method cannot be overstated. By this assumption, all natural phenomena ought to be governed by a single set of laws, the so called "grand unifying theory." Life, geology, and large-scale physics ought to stem from the forces that exist among atoms and their constituent parts. Reductionism has been extended to other sciences, including biology and geology, in hopes that its power will help solve the exceptionally complex problems in these sciences.

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Uniformitarianism presumes that the laws/theories of science apply without change throughout space and in time. In other words, the laws that apply to the Earth apply on other planets as well. The laws that govern the behavior of the Sun apply to other stars. These laws have operated since near the beginning of the universe. This means that the Earth and its neighborhood are a representative example of the universe as a whole. This assumption is one of the two postulates that Einstein used to develop the theory of relativity (along with the postulate that the speed of light is the same for every observer). It allows geologists not only to understand how the Earth got to its present condition, but permits construction (in principle) of the history and future of the Earth. Because light travels at a finite speed, distant objects we observe in a telescope are not seen as they appear now, but as they appeared when the light left them in the past. Understanding them requires this assumption. Without this assumption, we severely limit the part of the universe we can study and understand.

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Mechanism (also known as naturalism) assumes that every observation is produced by a describable mechanism. Matter is assumed to be inert—it cannot do anything of itself. The laws of nature act on inert matter. These laws acting on matter produce every observation we make. Extended to its logical extreme, life itself, including human life, is just a machine, resulting from the laws of nature acting on inert matter.

This assumption is perhaps the most powerful of all, and the most devastating. At first glance, there seems nothing wrong with it. Several references in modern scripture refer to nature working by law (see *Doctrine and Covenants* 88, especially verses 34-38, 42-44). However, the assumption has some very interesting implications. If we understand how a machine works, we are able to fix it if it is broken and make it more efficient by eliminating errors and problems. If nature is a big machine, we ought to some day be able to efficiently utilize natural resources and even transform other planets into habitable worlds. We ought to be able

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to "subdue" nature, in accordance with Divine direction. This is the hope of science, and we have seen it benefit man in many, many ways.

However, if pushed to its logical limits, the assumption implies that human beings are nothing but complex machines. We have nothing that could be termed as an "immortal soul." When we die, that is the end. In essence, we have no eternal purpose. Thus, we may as well "eat, drink, and be merry, for tomorrow we die." This extreme is exceptionally unpleasant, and contrary to the message of the gospel of Jesus Christ.

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These assumptions seem logical and make sense to us. Scientists cite many observations as evidence that they are correct. However, most make sense to us because we grew up with them. Many of these ideas would not have made sense to ancient philosophers. Our acceptance of these ideas is an act of faith. Because science is built upon these assumptions, I submit that faith plays an important role in science.

According to the scriptures, faith is "the substance of things hoped for, the evidence of things not seen" (Hebrews 11:1). The *Book of Mormon* prophet Alma defined faith as "not to have a perfect knowledge of things, therefore, if ye have faith ye hope for things which are not seen, which are true" (Alma 32:21). The Prophet Joseph Smith (*Lectures on Faith*, Lecture 1, verse 9) emphasized that faith is the principle of action in rational beings. Faith requires not only belief (the mental activity), but impels a person to do something about it. Using these scriptural definitions, we can define faith as acceptance of something that has not been observed, then taking action in accordance to that belief. By this definition, science relies on faith as surely as does religion.

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The Apostle Paul wrote "for now we see through a glass, darkly, but then face to face" (1 Corinthians 13:12). Through science, we can never know for certain when we've arrived at the correct answer. We cannot know if our assumptions about the universe are correct. As a result, faith is the guiding principle of our lives, whether we believe in God or not. Faith serves the same role in science as it does in religion.

Conclusions

Science is an important tool in our intellectual toolbox as we seek to discover truth. Like all tools, it has strengths and limitations. If we know the strengths and limitations of each tool, we can apply the proper tool for the proper purpose.

Science has many strengths. Because of its requirement of objectivity, we do not have to rely on the word of an esteemed authority. We can search out the truth ourselves. The observations of science will be the same for everyone. How we interpret these observations, on the other hand, depends on our philosophical outlook and the assumptions we make. Even so, our interpretations are subject to observational testing, so if we've made a mistake we are obliged to correct it. Because the theories of science make specific observational predictions, we can apply them practically to "subdue" nature for man's benefit. In addition, scientific theories help us learn more about nature by asking questions we would not otherwise have thought of and tie otherwise unconnected observations together into a coherent whole.

Like any tool, science has limitations. It is limited to the objective part of nature. It must, therefore, be silent on questions that are inherently subjective. Some of the most important questions man asks are inherently subjective. Scientific theories, our explanations of why things work, can never be proven true. They can only be falsified. As a result, scientific theories must be accepted as true on faith. Faith plays the same role in science as it does in religion.

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Even though science has what seem like severe limitations, we ought not denigrate its value. You would not throw out the hammer just because it's the wrong tool to remove lug nuts. We need all the intellectual tools in our intellectual toolbox. Rather than minimize the value of any of our tools, let us seek to understand their individual strengths and limitations and apply them properly as we continually search for truth.

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