SCIENCE KNOWLEDGE SURVEY

Adapted from (http://www.indiana.edu/~ensiweb/lessons/unt.n.s.html#newsciencesurprises)

These are the "correct" answers to the Science Knowledge Survey. A = the statement is correct and D = the statement is incorrect. The reasoning for each is given as a guide for discussion.

Science is primarily a search for truth.	d	"Truth" means different things to different people. To many, it implies "the revealed truth" of God or other deity or authority, considered to be absolute, final, and always correct, regardless of observations or studies that may suggest alternative explanations. Since science cannot use supernatural explanations (see #4), such "authority" must be ignored in science, so it does not seek this kind of truth. Science does seek to understand natural phenomena, based on critical study and analysis of empirical (observed) evidence, and tries to get an accurate picture of the real, natural world, but several unavoidable limitations always make this an uncertain approximation. Nevertheless, science has been so successful in getting close enough to an accurate understanding of many natural phenomena that it has led to healthier and longer lives, more efficient agriculture, and engineering marvels.
Science can solve any problem or answer any question.	d	Science can only solve problems of the natural world - not the supernatural. If understanding of apparent supernatural phenomena is desired, science must adopt a working hypothesis that there is a natural explanation, which can be tested and studied scientifically.
Engineering can solve any problem.	d	Although engineers can solve many problems, they are limited to the physical world.
Science is primarily concerned with understanding how the natural world works.	a	Correct statement. Questions about the supernatural, or ethics, or beauty, or opinions or politics are really not suitable subject matter for science. Science can be used to provide understanding about the natural world that may inform those other areas of human interest, but where opinions, beliefs or "feelings" are dominant elements, science has limited application. With the progress in neuropsychological studies these days, we may come to understand how such opinions, beliefs and "feelings" are generated, but science would probably have little to say about which opinions, beliefs or "feelings" would be "right" for any individual.
Astrology (predicting your future from the arrangement of stars and planets) is a science.	d	Astrology is a "pseudoscience" - often presented as being supported by "scientific evidence." All such "evidence" has been fully discredited upon critical examination. Furthermore, the mystical connection between human behaviors and the positions of heavenly bodies is clearly a supernatural connection (see #4). Don't confuse with the legitimate science of astronomy.
Science requires a lot of creative activity.	a	Correct statement. Much creativity is needed for suggesting possible natural explanations (hypotheses), as well as for developing clever ways to test those explanations.
Science typically provides only temporary answers to questions.	a	Correct statement. Virtually all scientific statements start off as being tentative. With testing, many are replaced with better explanations, some become reinforced (increasing the likelihood of their validity), and a few become so well substantiated that they become widely and generally accepted as "reality" - e.g., the Earth is a globe - not flat."

Engineers can design anything they want, however they want	d	Every engineering design operates within constraints that must be identified and taken into account. One type of constraint is absolute—for example, physical laws such as the conservation of energy or physical properties such as limits of flexibility, electrical conductivity, and friction. Other types have some flexibility: economic (only so much money is available for this purpose), political (local, state, and national regulations), social (public opposition), ecological (likely disruption of the natural environment), and ethical (disadvantages to some people, risk to subsequent generations). An optimum design takes into account all the constraints and strikes some reasonable compromise among them. Reaching such design compromises—including, sometimes, the decision not to develop a particular technology further—requires taking personal and social values into account.
Science is most concerned with collecting facts.	d	Because scientific understanding must be based on real-world observations, observed facts ('data") are an important part of scientific work. However, its major concern is with what the facts show us, what do the facts "say" that help us to understand how our natural world works? Facts are just part of the means of getting there.
Any time you ask a question you are "doing" science.	d	Scientists ask questions that can be answered through scientific investigations. Testable questions are answered by collecting and analyzing evidence and developing explanations based on that evidence. Questions that cannot be answered through scientific investigation are those that relate to personal preference, moral values, the supernatural, or unmeasurable phenomena
Most engineers and medical doctors are actually scientists.	d	Engineering and medicine are two fields where the findings of science are applied. Most engineers or doctors do not do experimental science: formulating and testing hypotheses. Some do, and some do the science and practice its applications, but experimental science is not typically part of an engineer's or doctor's life.
A scientific fact is absolute, fixed, and permanent.	d	A scientific fact is typically defined as an observation confirmed repeatedly by many critical observers. With improved tools, or new ways of observing, some scientific facts can be replaced with new facts. At one time, it was generally accepted as a fact that humans had 48 chromosomes in each cell. Later studies using improved techniques showed that there are only 46 chromosomes. The fact changed.
All science is good science.	a	Correct statement. As in any human endeavor, some people are better at it than others, some are just not very good at doing science at all, and some scientists are even fraudulent. Fortunately, the ethics of science requires scientists to publish their work in peer-reviewed journals, where other scientists can critique the work and even repeat the work, so that sloppy or unreliable studies do not survive. Poor scientists don't last long in the field.
Some of the greatest moments in history have been made possible by engineering.	a	For example, engineers were to thank for saving the Chilean miners who were trapped inside their mine for 69 days
A scientific theory is merely	d	A scientific theory is a well-substantiated explanation of some aspect of

a guess.		the natural world, incorporating facts, laws, inferences and well-tested hypotheses. In common usage, “theory” means a guess or speculation - far different from its scientific use. Unfortunately, even scientists will use the word in its vernacular sense, when they should be saying “hypothesis” or “hunch,” and this leads to much confusion. Users of “theory” should make very clear which meaning is intended, or avoid using the word.
Scientists have solved most of the major mysteries of nature.	d	Every scientific study that attempts to increase our understanding of some natural phenomenon always raises new questions and new problems. It has been estimated that science has just “scratched the surface” of the depths of our ignorance about the natural universe. Most of our ignorance is “Deep Ignorance” - things we don’t even know we don’t know! In other words, the more we learn, the more we realize how much we don’t know. Students interested in a career in science needn’t worry about having problems to work on!
Science can study and explain events that happened millions of years ago.	a	Correct statement. Just as forensic scientists (CSI) can often come to learn who committed the crime in a fairly recent event, just by seeking and analyzing the evidence, paleontologists and astronomers can determine with fairly high confidence just what happened in the distant past to produce what we see today, just from the clues they seek and find. This is “historical” science, often lacking the steps of “experimental science” that The Scientific Method seems to suggest must characterize any legitimate science. Methods of historical science are just as effective in getting reliable answers as the experimental sciences.
Knowledge of what science is, what it can and cannot do, and how it works, is important for all people.	a	Correct statement. Many of our current problems could have been prevented or reduced if political leaders, business leaders, and the voting public recognized how good science is done, and how its reliability is measured. The growing and undeniable evidence of man-made global warming (over natural warming) has been strongly (and increasingly) supported by scientific studies. Too many people in power, and most of the general public who could have created pressure, have simply not understood the potential benefit and power of science. Many people try to discredit science, or only look at the few studies that seem to fit their own vested interests or political leanings, and ignore the vast majority of scientific studies that clearly showed how our world is changing before it became obvious to everyone. We see this in quack medicine and many other frauds and pseudo-sciences that can be spread even faster now via the internet. Without knowing the nature of science, or how to critically analyze evidence, most of the world’s citizens are at the mercy of the hucksters.
Modern scientific experiments usually involve trying something just to see what will happen, without predicting a likely result.	d	There is still some of this (more common in earlier science). But most studies involve the testing of hypotheses, with predictable outcomes that differ depending on whether the hypothesis is correct - or not.
Anything done scientifically is always accurate and reliable.	d	“Scientific” is way overused, often applied to sell products, services or ideas when not deserved. Science can range from well-done to very poor (see #13), and even extend into the pseudo-sciences, where “studies” may claim to be “scientific,” but fail to follow one or more rules

		of science. So, just because it's called "science" is no guarantee that it's accurate and reliable. On the other hand, if it's legitimate science, it's more likely to be accurate and reliable than if it's just based on some casual observations or anecdotal experiences.
Scientists often try to test or disprove possible explanations.	a	Correct statement. This is the heart and soul of science. If a possible explanation cannot be subjected to testing - efforts to show that it does not work - then the explanation is pointless. This testing is much like the testing of the safety of a car by crashing it into a wall; if the dummies in the car "survive," the design is a good one. Likewise, if the hypothesis survives the testing, it's probably a good one.
Perpetual motion machines are a scientific fact.	d	Perpetual motion, although intriguing is impossible perpetual motion, the action of a device that, once set in motion, would continue in motion forever, with no additional energy required to maintain it. Such devices are impossible on grounds stated by the first and second laws of thermodynamics.
All scientific problems must be studied with The Scientific Method.	d	Textbooks tend to imply that there is only one "Scientific Method" and encourage students to memorize the steps, as if that was the only way real science could be done. Overlooked are the many variations in approaches followed in different fields of science (see #16 for one example). Also often overlooked are the several critical aspects of science collectively termed "The Nature of Science" or NOS. This includes a clarification of what science IS and is NOT, its realm (limited to the natural world), its limits, rules and assumptions, its tentativeness, the role of biases, and its social nature (collaboration and peer-reviewed publishing).
Disagreement between scientists is one of the weaknesses of science.	d	Quite the contrary. Passionate disagreement leads to mutual critiquing of methods and ideas, and searches for more evidence, ultimately leading to resolutions that bring us closer to a more accurate understanding of the phenomenon. This is a decided strength of science.
Engineers are inventors	a	An engineer is a professional practitioner of engineering, concerned with applying scientific knowledge, mathematics, and ingenuity to develop solutions for technical, societal and commercial problems. Engineers design materials, structures, and systems while considering the limitations imposed by practicality, regulation, safety, and cost. The word engineer is derived from the Latin roots ingeniare ("to contrive, devise") and ingenium ("cleverness").
Engineering does not involve creativity	d	Although design may sometimes require only routine decisions about the combining of familiar components, often it involves great creativity in inventing new approaches to problems, new components, and new combinations—and great innovation in seeing new problems or new possibilities.
Technology draws on science and contributes to it	a	Engineering, the systematic application of scientific knowledge in developing and applying technology, has grown from a craft to become a science in itself. Scientific knowledge provides a means of estimating what the behavior of things will be even before we make them or observe them. Moreover, science often suggests new kinds of behavior that had not even been imagined before, and so leads to new

		technologies. Engineers use knowledge of science and technology, together with strategies of design, to solve practical problems.
Technology provides the eyes and ears of science (and sometimes the muscle, too)	a	The electronic computer, for example, has led to substantial progress in the study of weather systems, demographic patterns, gene structure, and other complex systems that would not have been possible otherwise. Technology is essential to science for purposes of measurement, data collection, treatment of samples, computation, transportation to research sites (such as Antarctica, the moon, and the ocean floor), sample collection, protection from hazardous materials, and communication. More and more, new instruments and techniques are being developed through technology that make it possible to advance various lines of scientific research.
A "hypothesis" is just an "educated guess" about anything.	d	A hypothesis is typically a tentative, testable explanation. Many textbooks and teachers use the overly simplistic definition of “an educated guess.” Unfortunately, this leads students to assume that the predicted result of an experiment to test a hypothesis is the hypothesis - that what is actually a prediction IS the hypothesis. I would encourage teachers to help their students make a clear distinction between a hypothesis and a prediction - they are not the same thing. And a guess could be about anything; guessing that your teacher’s age is 34 is NOT a hypothesis - that’s not an explanation, tentative or otherwise.
New technologies always have side effects	a	In addition to its intended benefits, every design is likely to have unintended side effects in its production and application. On the one hand, there may be unexpected benefits. For example, working conditions may become safer when materials are molded rather than stamped, and materials designed for space satellites may prove useful in consumer products. On the other hand, substances or processes involved in production may harm production workers or the public in general; for example, sitting in front of a computer may strain the user's eyes and lead to isolation from other workers. And jobs may be affected—by increasing employment for people involved in the new technology, decreasing employment for others involved in the old technology, and changing the nature of the work people must do in their jobs.
Engineering always provides the right solution.	d	There is never just one way to solve an engineering design challenge; there is no single, “right” answer to a problem. Engineers must accept a degree of uncertainty regarding a solution's endpoint, and creativity helps here, too. Engineering requires a sense of vision that goes beyond constraints to “see” a solution that others might miss or dismiss as farfetched.
Engineering only provides the tools for science	d	Engineering does not just provide tools for science, however; it also may provide motivation and direction for theory and research. The theory of the conservation of energy, for example, was developed in large part because of the technological problem of increasing the efficiency of commercial steam engines. The mapping of the locations of the entire set of genes in human DNA has been motivated by the technology of genetic engineering, which both makes such mapping possible and provides a reason for doing so.

Scientists have observed that nature apparently follows the same "rules" throughout the universe.	a	Correct statement. This was once just a basic assumption of science, but over the years, repeated observations have confirmed the correctness of that assumption. We've had to refine and modify some old ideas (e.g., Newton's laws of motion to Einstein's rules of relativity at velocities near the speed of light), but they are clearly and observably universal as far as we can tell.
Engineering is applied science	d	"Scientists study the world as it is, engineers create the world that never has been." (Theodore von Karman, Hungarian/American Aeronautical Engineer, 1881 – 1963). Science is about discovery, about exploring the world around us and explaining it. While science is focused discovering the world that is, engineering is focused on creating the world that could be. Engineering is about invention and creativity, about developing products that have never existed before. "A scientist can discover a new star but he cannot make one. He would have to ask an engineer to do it for him." (Gordon L. Glegg) http://www.calvin.edu/weblogs/deusexmachina/comments/engineering-is-not-applied-science/
Proving a hypothesis is correct makes a study valid.	d	An experiment does not prove a hypothesis; it merely provides supporting evidence. Future experiments may reveal flaws.
Science proves ideas	d	Journalists often write about "scientific proof" and some scientists talk about it, but in fact, the concept of proof — real, absolute proof — is not particularly scientific. Science is based on the principle that any idea, no matter how widely accepted today, could be overturned tomorrow if the evidence warranted it. Science accepts or rejects ideas based on the evidence; it does not prove or disprove them.