APPENDIX:
Review of the *Kansas Science Education Standards*
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p. iv:
The statements made here are critical to our final decision about granting copyright permission. These statements are troubling and I have inserted commentary about each point that is made. Text from this page of the draft of the Kansas Science Standards is reproduced verbatim although I have placed in italics text to which my comments are addressed. In those places where I have broken paragraphs to insert comments, I have indicated those breaks with an ellipsis (…). Where the flow of text is disrupted with comments, the entire block of text is provided in endnotes to this document.

Rationale of the State Board for Adopting these Science Curriculum Standards[1]

We believe it is in the best interest of educating Kansas students that all students have a good working knowledge of science: particularly what defines good science, how science moves forward, what holds science back, and how to critically analyze the conclusions that scientists make.

Regarding the scientific theory of biological evolution, the curriculum standards call for students to learn about the best evidence for modern evolutionary theory, but also to learn about areas where scientists are raising scientific criticisms of the theory. These curriculum standards reflect the Board's objective of 1) ***to help students understand the full range of scientific views that exist on this topic, 2) to enhance critical thinking and the understanding of the scientific method by encouraging students to study different and opposing scientific evidence, and 3) to ensure that science education in our state is "secular, neutral, and non-ideological."***

All scientific theories are subject to criticism by the scientific community. At a minimum, this text implies that evolution is the only controversial topic within science. This is the same kind of tactic that will be heard in the 11th Circuit Court of Appeals regarding disclaimer stickers in textbooks in Cobb County, GA. Further, the overwhelming majority of scientists accept the massive amounts of evidence from many scientific disciplines to support the theory of evolution as the most robust explanation for how life has diversified on this planet. The "controversies" among scientists focus on *mechanisms* for evolutionary change, not on evolution itself. There really is no "range of scientific views" on this issue – those views that are being touted today are not scientific (despite statements to the contrary by their proponents) co, but they are ideological.

The language used here is consistent with that contained in the Santorum Amendment and conforms to the strategies employed by proponents of intelligent design.

From the testimony and submissions we have received, we are aware that the study and discussion of the origin and development of life may raise deep personal and philosophical questions for many people on all sides of the debate. But as interesting as these personal

questions may be, the personal questions are not covered by these curriculum standards nor are they the basis for the Board's actions in this area.

Evolution is accepted by many scientists but questioned by some. The Board has heard credible scientific testimony that indeed there are significant debates about the evidence for key aspects of chemical and biological evolutionary theory…

As was widely publicized, these hearings were boycotted by scientists and major scientific organizations (e.g., American Association for the Advancement of Science) because their participation would have made it appear that these non-scientific alternatives were on equal footing with the theory of evolution and that evolution needed to be defended. The "significant debates about the evidence" are not debates at all. All of the challenges to evolutionary theory that have been raised by proponents of intelligent design have been addressed numerous times (e.g., see http://www.ncseweb.org/icons/pdfs.html).

All scientific theories should be approached with an open mind, studied carefully, and critically considered…

Another statement taken directly from the Santorum Amendment.

We therefore think it is important and appropriate for students to know about these scientific debates and for the Science Curriculum Standards to include information about them…

See comments above. This statement is without merit.

In choosing this approach to science curriculum standards, we are encouraged by the similar approach taken by other states, whose new science standards incorporate scientific criticisms into the science curriculum that describes the scientific case for the theory of evolution.

The fact that other states are doing this does not change the fact that when only evolution is singled out for this kind of scrutiny that science education suffers because students are likely to become confused and misconstrue other areas of science as having nothing controversial. Challenges to these actions (in the case of two districts in GA and PA) will soon be heard in the federal courts.

We also emphasize that the Science Curriculum Standards do not include Intelligent Design, *the scientific disagreement with the claim of many evolutionary biologists that the apparent design of living systems is an illusion…*

This text confuses "design" with "designer." Depending on one's definition, there are many "designs" in nature which are easily understood by natural mechanisms (e.g., complex patterns of sand ridges on a beach that are produced by winds of varying velocities, rock bridges). The question here is: what is the source of the complexity of living things? Evidence to date indicates that natural (vs. supernatural) mechanisms can account for the diversity and complexity of life given the amount of time that it has existed on Earth.

While the testimony presented at the science hearings included many advocates of Intelligent Design, ***these standards neither mandate nor prohibit teaching about this scientific disagreement.***

Implicit in this statement is that intelligent design represents a scientific challenge to evolution science. It does not. Thus, by refusing to prohibit the introduction of non-scientific "alternatives" into science courses, these Standards would contribute to students' confusion about the nature and processes of science.

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Development of the Kansas Science Education Standards

The original *Kansas Curricular Standards for Science* was drafted in 1992, approved by the Kansas State Board of Education in 1993, and up-dated in 1995. Although all of this work occurred prior to the release of the *National Science Education Standards* in 1996, the original Kansas standards reflect early work on the national standards.

At the August, 1997 meeting of the Kansas State Board of Education, the Board directed that academic standards committees composed of stakeholders from throughout Kansas should be convened in each curriculum area defined by Kansas law (reading, writing, mathematics, science, and social studies). ***The 1998-2001 science standards committee was able to build upon and benefited from a great deal of prior work done on a national level; the National Science Education Standards published by the National Research Council; Benchmarks for Science Literacy from Project 2061 of the American Association for the Advancement of Science (AAAS); and Pathways to the Science Standards, published by the National Science Teachers Association (NSTA). This allowed the foundation for the Kansas Science Education Standards (2001) to be based on research and on the work of over 18,000 scientists, science educators, teachers, school administrators and parents across the country that produced national standards as well as the school district teams and thousands of individuals who contributed to the benchmarks.*** *Kansas Curricular Standards for Science* was approved by the Kansas State Board of Education on February 14, 2001.

This statement suggests that the Kansas Standards are based in large part on these three documents from the NRC, AAAS, and NSTA. However, all three documents are clear about the central role of evolution to the life and physical sciences. Because of the changes that a minority of members of the Kansas State Board of Education made to those state standards in removing aspects of biological and physical evolution and related topics, all three organizations denied copyright permission to the Kansas Board in 1999 (see http://www4.nationalacademies.org/news.nsf/isbn/s09231999?OpenDocument). When the composition of the State Board of Education changed in 2000 and these areas of science were returned to the Kansas Science Standards, our three organizations jointly issued a statement praising this action of the Board (see http://www.nasonline.org/site/PageServer?pagename=NEWS_statement_president_02142001_BA_science_education).

Page xi: Nature of Science

Science is a systematic method of continuing investigation that uses observations, hypothesis testing, measurement, experimentation, logical argument and theory building, to lead to more adequate explanations of natural phenomena. Science does so while maintaining strict empirical standards and healthy skepticism. Scientific explanations are built on observations, hypotheses, and theories. A hypothesis is a testable statement about the natural

world that can be used to build more complex inferences and explanations. A theory is a well-substantiated explanation of some aspect of the natural world that can incorporate observations, inferences, and tested hypotheses.

Scientific explanations must meet certain criteria. Scientific explanations are consistent with experimental and/or observational data and testable by scientists through additional experimentation and/or observation. Scientific explanation must meet criteria that govern the repeatability of observations and experiments. The effect of these criteria is to insure that scientific explanations about the world are open to criticism and that they will be modified or abandoned in favor of new explanations if empirical evidence so warrants. Because all scientific explanations depend on observational and experimental confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core theories of science have been subjected to a wide variety of confirmations and have a high degree of reliability within the limits to which they have been tested. In areas where data or understanding is incomplete, new data may lead to changes in current theories or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest. Science has flourished in different regions during different time periods, and in history, diverse cultures have contributed scientific knowledge and technological inventions. Changes in scientific knowledge usually occur as gradual modifications, but the scientific enterprise also experiences periods of rapid advancement. The daily work of science and technology results in incremental advances in understanding the world.

Based on the edits that were included with the draft document that we received, this statement fundamentally changes the definition of science from a search for natural explanations of phenomena to one that completely omits this point and thereby suggests that explanations can be other than natural ones. Such approaches are not scientific. In addition, the revised text above omits a very important statement that was contained in the original language (see emphasized text in the third paragraph below). Rather than emphasizing that science develops increasing confidence in evidence that is continually verified and repeatable, the revised text suggests a much narrower role of scientific theory ("The core theories of science have been subjected to a wide variety of confirmations and have a high degree of reliability within the limits to which they have been tested.").

Below is the original text that would be deleted if this version of the Standards were to be adopted (emphases are mine):

Science is a human activity of systematically seeking natural explanations for what we observe in the world around us. Throughout history people from many cultures have used the methods of science to contribute to scientific knowledge and technological innovations, making science a worldwide enterprise. Scientists test explanations against the natural world, logically integrating observations and tested hypotheses with accepted explanations to gradually build more reliable and accurate understandings of nature. Scientific explanations must be testable and repeatable, and findings must be confirmed through additional observation and experimentation. ***As it is practiced in the late 20th and early 21st century, science is restricted to explaining only the natural world, using only natural cause. This is because science currently has no tools to test explanations using non-natural (such as supernatural) causes.***

Hypothesis, law, and theory are frequently misunderstood terms used in science. A hypothesis is a testable statement about the natural world that can be used to design experiments and to build more complex inferences and explanations. A law is a descriptive generalization based on

repeated observations. A theory is a well-substantiated explanation of the natural world that incorporates observations, inferences, laws, well-tested hypotheses and experimental findings to explain a specific aspect of the natural world. Theories drive research because they draw attention to areas where data or understandings are incomplete, suggesting additional directions for research.

The effect of these criteria is to ensure that scientific explanations about the world can be modified or abandoned in favor of new explanations if empirical evidence so warrants. Because all scientific explanations depend on observational and experimental confirmation, all scientific knowledge is, in principle, subject to change as additional evidence becomes available and/or as new technologies extends our abilities to explore. This open-endedness of science is its greatest strength, and allows for constant refining and improvement of explanations. ***Although all scientific knowledge is in principle tentative, science has a high degree of confidence in explanations that have been repeatedly tested and shown to be valid.*** The willingness of scientists to change explanations based on evidence, actually results in more reliable information. Changes in scientific knowledge can occur gradually or rapidly. The early 21st century is a time of quite rapid scientific advancement, characterized by a high rate of both discovery and accumulation of knowledge. Rather then developing "new" theories, the current explosion of knowledge has greatly expanded the basic and well-accepted principles from physics, chemistry, earth sciences, and biological sciences. Scientists recognize that there are still new frontiers of science.

Page xiii: Patterns of cumulative change

This section and several that precede it are based to some degree on the *National Science Education Standards* and are specifically marked as text for which the KSBE seeks copyright permission. Some of this text is verbatim from the NSES. However, there are some important changes.

The text below is taken verbatim from Page 119 of the NSES and the revisions that have been made to it in this passage of the revised KSES are shown (using strikethroughs for deletions and underlining for insertions):

"~~Evolution and Equilibrium~~ Patterns of Cumulative Change:

~~Evolution is a series of changes~~ Accumulated changes through time, some gradual and some sporadic, ~~that~~ account~~s~~ for the present form and function of objects, organisms, and natural ~~and designed~~[1] systems. The general idea ~~of evolution~~ is that the present arises from materials and forms of the past. An example of cumulative change is the formation of galaxies, explained by cosmological theories involving (among other theories) gravitation and the behavior of gasses, and the present diversity of living organisms (NSES, pp. 115-119), which ~~Although evolution is most commonly associated with~~ the biological theory of evolution, or ~~explaining the process of~~ descent with modification of organisms from common ancestors, ~~evolution also describes changes in the universe~~ seeks to explain. The present position of the continents is explained by the theories of continental drift, which involves plate tectonic theory, fossilization, uplift and erosion. Patterns of cumulative change also help to describe the current structure of the universe. Although science proposes theories to explain changes, the actual causes of many changes are currently unknown (e.g. the origin of the universe, the origin of fundamental laws, the origin of life and the genetic code, and the origin of major body plans during the Cambrian explosion)."

[1] Note: in the *NSES*, "designed" is used interchangeably with "human constructed" or "engineered."

Two primary points about this passage*:* First, while the NSES passage was written specifically to discuss evolution, this modified passage makes this concept much more general. Second, the final sentence of this passage makes it appear that virtually nothing is known about these scientific phenomena or, in the case about the "Cambrian explosion," repeats ideas that have been refuted many times by modern science.

P. 46: Teacher notes:

Millions of species of animals, plants and microorganisms are alive today. Animals and plants vary in body plans and internal structures. The theory of biological evolution (NSES p. 158.) ***is an explanation of how*** gradual changes of characteristics of organisms over many ***generations may*** have resulted in variations among populations and species…Therefore, a structural characteristic, process, or behavior that helps an organism survive in its environment is called an adaptation. When the environment changes and the adaptive characteristics are insufficient, the species becomes extinct.

Two points here. First, the following comment was inserted into the text above (where the ellipse is found) by the people overseeing the Standards revision: "Note that in the previous passage KS Standards change the language for NSES and omit 'common ancestry.'" Second, the text in italics in the passage also was inserted during the revision process with the apparent intent of making it appear that this information is controversial.

P. 59: Standard 7: History and Nature of Science Grades 5-7

1. ***practices intellectual honesty***, demonstrates skepticism appropriately, displays open-mindedness to new ideas, and ***bases decisions on evidence.*** NSES p. 170

This is another statement from the NSES for which copyright permission is sought. Based on the text that precedes this statement in the standards (as identified above), it's ironic that students will be expected to base decisions on evidence but the people who wish to revise these standards continue to cast the appearance of doubt on one of the most robust principles of modern science in ways that are completely unwarranted based on the evidence.

P. 62, Science as Inquiry, Grades 8-12

Grades 8-12 Indicators	Additional Specificity
6. ***understands methods used to test hypotheses about the cause of a remote past event (historical hypothesis) that cannot be confirmed by experiment and/or direct observation by formulating competing hypotheses and then collecting the kinds of data (evidence) that would support one and refute the other***	a ***Formulates multiple hypotheses about a singular historical event and develops a "best current explanation" of what caused the event, such as the cause of a fire or death.*** ***b. Predicts the kinds of circumstantial evidence that one would observe under each hypothesis.*** ***c. Collects evidence and draws an***

	inference as to the best explanation and whether the evidence fits either hypothesis. Explains why either explanation can not be entirely validated by a laboratory experiment.

The first five standards in this category for this grade band are based on the NSES. This 6th standard and the accompanying specificity text was added by the revision committee and marked as not conforming to the NSES. Without singling out evolution issues (they use "fire" and "death" as examples), it appears that the intent of this standard is to open the door for various kinds of explanations that may not be scientifically based (e.g., "Explains why either explanation can not be entirely validated by a laboratory experiment."

Page 76, Life Science Grades 8-12

Grades 8 -12 Indicators	Additional Specificity
1. ▲ understands living organisms contain DNA or RNA as their genetic material, which provides the instructions that specify the characteristics of organisms. NSES p. 185	a. **Nucleotides** (adenine, thymine, guanine, cytosine and uracil) make up DNA and RNA molecules. b. Sequences of nucleotides that either determine or contribute to a genetic trait are called genes. ***c. The sequence of the nucleotide bases within genes is not dictated by any known chemical or physical law.*** d. DNA is replicated by using a template process that usually results in identical copies. e. DNA and associated proteins supercoil during cellular replication to become structured as chromosomes.

This standard in life sciences and others that precede and follow it are based on the NSES. Additional Specificity C. was added to the other specificities by the KSES revision committee. This statement is misleading at several levels. First, ALL molecules conform to known chemical and physical laws for bonding. Second, since DNA is a double helix, the sequence of nucleotides on one chain of the helix predicts the sequence on the other chain (since adenine bonds with thymine, cytosine with guanine, or adenine with uracil in double-stranded RNA). Third, the sequence of nucleotide on genes is influenced by natural selection, because certain sequences will increase the fitness of the

cells and organisms in which they're found while others will other sequences will be less fit. Fourth, there is a very important difference in stating that the sequence of bases is not yet fully understood compared with the statement that lack of total understanding implies that there can be no natural explanation for what is observed.

Pages 78-80 Life Science Grades 8-12

The review committee has made so many changes to the original standards that were proposed by the drafting committee, that they must be addressed individually. Therefore, to provide readers with a more complete overview of this set of standards and how they have been changed by the revision committee, this section lists *all* of the Standards and Additional Specificities in a table. A third column has been added where I have offered comments next to text in question. In this table, changes made by the revision committee are indicated by underlining,

Benchmark 3: The student will understand the major concepts of the theory of biological evolution.

Grades 8-12 Indicators	Additional Specificity	Comments
The student … 1. understands biological evolution, descent with modification, is a scientific explanation for the history of the diversification of organisms from common ancestors NSES p. 185	a. Biological evolution postulates an unguided natural process that has no discernable direction or goal.	a. This statement appears to have been inserted to distinguish evolution from those that account for the purpose of life, a theological or philosophical consideration.
	b. The presence of the same materials and processes of heredity (DNA, replication, transcription, translation, etc.) is used as evidence for the common ancestry of modern organisms.	
	c. Patterns of diversification and extinction of organisms are documented in the fossil record. Evidence also indicates that simple, bacteria-like life may have existed billions of years ago. However, in many cases the fossil record is not consistent with gradual, unbroken sequences postulated by biological evolution.	c. The fact that the fossil record is incomplete, especially for single-celled and soft-bodied organisms, does not mean that it is inconsistent with what is predicted by evolutionary theory. Indeed, the fossil record is becoming more complete almost daily. Also, not all of modern evolutionary theory suggests that there is a "gradual, unbroken sequence." For example, S.J.

		Gould's ideas about punctuated equilibrium are also inconsistent with Darwin's original notions. However, Gould embraced evolution.
	d. The distribution of fossil and modern organisms is related to geological and ecological changes (i.e. plate tectonics, migration). There are observable similarities and differences among fossils and living organisms.	d. This insertion actually advances the idea of evolution, at least at superficial morphological levels of analysis. There are many ancient forms of organisms that no longer exist. However, many other forms of evidence have been gathered to show that extinct organisms share characteristics with living organisms through common ancestry.
	e. The frequency of heritable traits may change over a period of generations within a population of organisms, usually when resource availability and environmental conditions change as a consequence of extinctions, geologic events, and/or changes in climate.	
	f. The view that living things in all the major kingdoms are modified descendants of a common ancestor (described in the pattern of a branching tree) has been challenged in recent years by: ii [sic] Discrepancies in the molecular evidence (e.g. differences in relatedness inferred from sequence studies of different proteins) previously thought to support that view. iii. [sic] A fossil record that shows sudden bursts of increased complexity (the Cambrian Explosion), long periods of stasis and the absence of abundant transitional forms rather than steady gradual	f. All of these points have been cited in numerous publications by the intelligent design movement, and all of them have been refuted point by point. See comment on page 6 of this document that refers to the standard on History and Nature of Science for Grades 5-7.

	increases in complexity, and iv. [sic] Studies that show animals follow different rather than identical early stages of embryological development.	
2. understands populations of organisms may adapt to environmental challenges and changes as a result of natural selection, genetic drift, and various mechanisms of genetic change. NSES p. 185	a. Genetic changes occur only in individual organisms. New heritable traits may result from new combinations of genes and from random mutations or changes in the reproductive cells. Except in very rare cases, mutations that may be inherited are neutral, deleterious or fatal. b. Natural selection and genetic drift occur within populations or organisms. c. Variation among individuals in a population allows individuals to respond differently to environmental challenges.	a. Research is ongoing about what proportion of mutations is beneficial as well as neutral, deleterious, or fatal.
3. understands biological evolution is used to explain the earth's present day biodiversity: the number, variety and variability of organisms.	a. Separate populations within a species may become sufficiently different enough that new species develop. This process is called speciation. b. Changes in inherited traits accumulate in populations. c. Historically only a small percentage of species have survived to modern times. d. Whether microevolution (change within a species) can be extrapolated to explain macroevolutionary changes (such as new complex organs or body plans and new biochemical systems which appear irreducibly complex) is controversial. These kinds of macroevolutionary	d. This extrapolation is not controversial for the vast majority of life sciences and is an integral component of evolutionary theory. The mechanisms that give rise to change within species as well as speciation are the same. The term "irreducibly complex" is language introduced by intelligent design advocate Michael Behe. The reference to

	explanations generally are not based on direct observations and often reflect historical narratives based on inferences from indirect or circumstantial evidence.	"historical narratives" rather than the use of the scientific method is also inserted into the revised standards and noted above (page 6 of this document, *Science and Inquiry, Grades 8-12*.
4. understands organisms vary widely within and between populations. Variation allows for natural selection to occur.	a. Heritable variation exists in every species. b. New heritable traits result from new combinations of genes and from mutations or changes in the reproductive cells. c. Variation of organisms within and among species increases the likelihood that some members will survive under changing environmental conditions. d. Times, populations, or entire lineages become extinct. One effect of this is to increase the differences between the surviving lineages.	
5. understands the primary mechanism acting on variation is natural selection. NSES p. 185	a. Favorable heritable traits are more advantageous to reproduction and/or survival than others. b. There is a finite supply of resources available for offspring; therefore not all survive. c. Individuals with beneficial traits generally survive to reproduce in greater numbers. d. Favorable heritable traits tend to increase in the population through time if the selective pressure is maintained.	
6. understands biological evolution is used as a broad, unifying theoretical framework for biology.	a. Organisms are classified and [sic] according to the rules of nomenclature, and are given scientific names.	

	b. The behavioral, physical, and genetic characteristics upon which these classifications are based are used as evidence for common descent. c. Natural selection, genetic drift, genomes, and the mechanisms of genetic change provide a context in which to ask research questions and help explain observed changes in populations. However, reverse engineering and end-directed thinking are used to understand the function of bio-systems and information.	c. Besides the fact that most students (and teachers) are unlikely to understand these concepts and how it applies to the standard in question,[2] Both of these terms as used here assume that living things are designed. Indeed, biologists look at the organs, organisms, etc. to understand what engineers might refer to as their design features. However, it is critically important to recognize the difference between "design" and "designer." See my earlier comments about this on page 2 of this document.
7. explains proposed scientific explanations of the origin of life as well as scientific criticisms of those explanations.	Some of the scientific criticisms include: a A lack of empirical evidence for a "primordial soup" or a chemically hospitable pre-biotic atmosphere; b. The lack of adequate natural explanations for the genetic code, the sequences of genetic information necessary to specify life, the biochemical machinery needed to translate genetic information into functional biosystems, and the formation of proto-cells; and c. The sudden rather than gradual emergence of	As noted above, all of these issues have been addressed by evolutionary biologists. Moreover, incomplete knowledge is different than criticism.

[2] **Reverse engineering** (RE) is the process of taking something (a device, an electrical component, a software program, etc.) apart and analyzing its workings in detail, usually with the intention to construct a new device or program that does the same thing without actually copying anything from the original. – Source: http://www.mywiseowl.com/articles/Reverse_engineering.

End-directed thinking is synonymous with **teleology,** i.e., **Teleology** is the supposition that there is design, purpose, directive principle, or finality in the works and processes of nature, and the philosophical study of that purpose. Sources: http://en.wikipedia.org/wiki/Teleology; http://www.2think.org/darwindesign.shtml.

	organisms near the time that the Earth first became habitable.	

Endnotes

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