Review of the proposed draft revisions of the
Texas Essential Knowledge and Skills (TEKS) Science Standards

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Comments on the K-5 Science Standards Draft

Kindergarten

The skills statements strike me as rather sophisticated for such young children, but I assume the workgroups know how these are implemented and what the children can handle.

1. Expectation 3(C): "Identify scientists and their contributions, such as Jane Goodall, Thomas Edison and Jacques Cousteau."

Comment: The study of these scientists' contributions seems to me to be a good thing, but this expectation does not follow from the skills statement, which reads, "The student knows that information and critical thinking are used in scientific problem solving.…"

Recommendation: Reword skills statement to read, "The student knows that information and critical thinking are used in scientific problem solving, and the contributions of selected influential scientists…"

2. Expectation 7(A): "observe and describe physical properties of including shape, color…"

Comment: Physical properties of what? This standard is not clear at all.

Recommendation: Reword as: "observe and describe physical properties such as shape and color of everyday human-made objects and natural objects…"

Grade 1

These standards seem complete and reasonable.

1. Expectation 3(C): "Identify scientists and their contributions, such as Ben Franklin and Dian Fossey;"

Comment: The study of these scientists' contributions seems to me to be a good thing, but this expectation does not follow from the skills statement, which reads, "The student knows that information and critical thinking are used in scientific problem solving.…"

Recommendation: Reword skills statement to read, "The student knows that information and critical thinking are used in scientific problem solving and in the contributions of selected influential scientists.…"

Grade 2

1. Expectation 3(C): "Identify scientists and their contributions, such as Orville Wright, John Muir and Eugenie Clark;"

Comment: This expectation does not follow from the skills statement, which reads, "The students knows that information and critical thinking are used in scientific problem solving…" Also, why isn't Wilbur Wright paired with Orville Wright as is done in Grade 4?

Recommendation: Reword skills statement to read, "The student knows that information and critical thinking are used in scientific problem solving and in the contributions of influential scientists.…"

Grade 3

1. Expectation 3(C): "Identify scientists and their contributions, such as George Washington Carver, Maria Mitchell, and Alejandro Acevedo-Gutiérrez;"

Comment: This expectation does not follow from the skills statement, which reads, "The student knows that information and critical thinking are used in scientific problem solving.…"

Recommendation: Reword skills statement to read, "The student knows that information and critical thinking are used in scientific problem solving and in the contributions of selected influential scientists.…"

2. Skills 7: In the current TEKS standards, the names and positions of the planets were included in the expectations. This is not present in the draft. Was the omission intentional?

3. Skills 7: (F) Grammatical error, should read "construct models that demonstrate…"

Grade 4

1. Knowledge and skills (1): The statement, "The student, for at least 40% of instructional time, conducts field and laboratory investigations…" is absent only from the Grade 4 draft standards. This is another example of inconsistency. Was this intentional?

2. Expectation 3(D): "Identify scientists and their contributions, such as Thomas Edison and Wilbur and Orville Wright;"

Comment: This expectation does not follow from the skills statement, which reads, "The student knows that information and critical thinking are used in scientific problem solving.…" Also, Thomas Edison and Orville Wright are repeated in Grade 2; was this repeat intentional?

Recommendation: Reword skills statement to read, "The student knows that information and critical thinking are used in scientific problem solving, and the contributions of selected influential scientists…." Also, reconsider repeating scientists from earlier grades, especially if this repeat was unintentional. There could be value to re-emphasizing the contributions of certain scientists, but there could also be value to allowing students to learn about new scientists.

3. Critical thinking expectation omitted from draft proposal.

Science Grade 4 **TEK**	Science Grade 4 **Draft**	Comments
(b) Knowledge and skills. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:	(b) Knowledge and skills. (3) Scientific investigation and reasoning. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:	
(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;		This section information is not included in the 4th grade Draft. For the purposes of consistency, and for the purpose of implementing a rigorous standard of critical thinking throughout all grade levels, I recommend that this "strengths and weaknesses" standard be implemented across the board for all grade levels and not left off certain grade levels.

Recommendation:

1. Include it as (3) (A) and word it as it was in the 4th grade TEK.

4. Expectation 8(B): "explore how adaptations enable organisms to survive in their environment, such as comparing birds' beaks and leaves on plants;"

Comment: The term "adaptation" is defined as "a characteristic of an organism that has been favored by natural selection and increases the fitness of its possessor." (Wikipedia) This expectation is, in effect, an early introduction to evolution. I think it is important to use examples for which it is **known** that adaptations have occurred, that is, where earlier versions of the same animal (or close ancestor thereof) lacking the adaptation in question are known from the fossil record, or by similar evidence. Of course, the theory of biological evolution posits that **all** species are derived from earlier ones. But doesn't that suggest that there should be **many** specific examples that could be used at this grade level? In the case of bird beaks, the adaptation might be appropriately well documented, especially in the case of bird beaks of the Galápagos finches. But students should realize that this example represents meager evolutionary change, and it has been documented that the bird beaks returned to their normal sizes after the end of a drought. Thus, this is "oscillating selection," and these sorts of examples don't imply a great creative power of natural selection. Is the evolutionary history of tree leaves well-documented? At this age I think that well-documented examples should be used, rather than the assumption that every remarkable ability of living things is an adaptation.

Recommendation: Reword as either:

(a) "critically investigate how inherited traits enable organisms to survive in their environment;"
or
(b) "critically investigate how known adaptations enable organisms to survive in their environment, such as…(known examples);"

Grade 5

1. Expectation 7(B): Poor grammar, should read, "demonstrate that the flow…"

2. Expectation 7(C): Poor grammar, should read, "…can be reflected such as with mirrors, and refracted such as when looking…"

3. Expectation 8(A): Poor grammar, should read, "draw conclusions about the past using data such as Texas land and marine fossils..."

4. Expectation 10(B): Poor grammar, should read, "recognize the rotation of the Earth as the cause of the day/night cycle…across the sky, and that the tilt of the Earth on its axis causes the seasons;"

5. Expectation 11(C): Include nuclear as an alternative energy, as it is an increasingly important non-fossil-fuel option.

6. Expectation 12: "The student knows that adaptations affect an organism's ability to survive. The student is expected to:

(A): Explain how organisms use their adaptations to modify their environment to insure survival such as beavers using their tails to build dams and animals burrowing during forest fires and how these changes may effect the environment."

Comment: Adaptation is defined as "a characteristic of an organism that has been favored by natural selection and increases the fitness of its possessor." (Wikipedia) This term involves an inherent assumption that the animals in question developed the adaptations at some point in the past through a blind Darwinian process. Is there such evidence for the specific examples described here? Can it be demonstrated that beavers (or beaver ancestors) without dam-building tails ever existed? What exactly is the "adaptation" (claws, toenails?) that allows burrowing during forest fires, and is there evidence that forest animals ever existed without them? If "adaptation" is well-established, specific, proven examples should not be hard to identify and use. If such examples are not available, then assumed examples should not be substituted, and the term "adaptation" should be changed to "inherited traits."

Recommendation: At this grade level, specific well-documented examples of adaptation should be used. It is not acceptable to give the impression that every remarkable ability of every organism is simply an acquired trait without specific documented examples that go beyond weak inferences based upon huge extrapolations.

If specific documented examples are not identified, then reword the expectation as: “explain how organisms use their inherited characteristics to modify their environment” **and** replace the word “adaptation” in the skill statement with “inherited traits.”

If specific documented examples are available, then reword the expectation as: “show known examples of how organisms have adapted to survive in their environment.”

Comments on Middle School Science Standards Draft

The draft standards appear to propose a significant change in the Middle School science curriculum. Rather than studying a wide variety of science areas with no particular emphasis as the current TEKS dictate, the draft proposes that grade six primarily study Physical Science, grade 7 study mainly Biological Science, and grade 8 focus on Earth and Space Science. These changes appear to have been coordinated with the High School draft proposal in that grades 6, 7 and 8 mirror High School Chemistry/Physics, Biology and Earth and Space Science, respectively. It is not clear whether these emphases will be beneficial or harmful in the curriculum. Possibly, the in-depth study might encourage student interest in the sciences, a laudable goal. On the other hand, there appears to be a lot of overlap with what will be studied at the High School level, but repetition is not necessarily a bad thing. **It would have been very useful to have been given a narrative that explained what the workgroups had in mind when they proposed major changes like these.**

My overall impression is that the draft proposal for grades 6-8 is not a clear improvement over the current TEKS standards. In particular, the tone of the presentation regarding evolutionary biology has become far too dogmatic in places. For example, it is typical for the draft standards to refer to scientific theory as fact; statements such as, "The student knows that traits are acquired by natural processes over many generations," are common, when they should read, "The student **understands** the **evidence** for traits being acquired by natural processes over many generations." In addition, it is not clear that the proposed emphasis on specific areas of science in each grade is an improvement, as it may lead to unnecessary overlap.

Recommendation: Retain the current TEKS Middle School standards rather than adopt the draft proposal. However, if the draft is to be adopted, the following are areas in need of attention:

Grade 6

1. Critical thinking expectation was omitted from the draft proposal.

Science Grade 6 **TEK** (b) Knowledge and skills. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:	Science Grade 6 **Draft** (b) Knowledge and skills. (3) Scientific investigation and reasoning. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:	Comments
(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	(A) review and analyze scientific explanations by using student-generated empirical evidence, logical reasoning and observational and experimental testing;	Critical thinking was omitted from the draft expectation. To implement critical thinking, I recommend retaining the language which states, "analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;"

Recommendation:

Reword (3) (A) as it was in the 6th grade TEK.

2. Expectation 3(C): "relate the impact of scientific thought on society and the environment including the history of science and contributions of scientists such as Rachel Carson, Galileo Galilei, Carl Linnaeus and William M. Jackson;"

Comment: This expectation does not follow from the skills statement, which reads, "The student uses critical thinking and scientific reasoning, and problem solving to make informed decisions…."

Recommendation: Reword skills statement to read, "The student uses critical thinking and scientific reasoning, and problem solving to make informed decisions, and knows the contributions of selected influential scientists.…"

Grade 7

The draft proposes a drastic increase in the emphasis on living systems, rather than the survey of several areas of science described in the current TEKS. Even subjects like Matter and Energy are focused on living systems in the draft. These standards read almost like introductory biology one would take at the high school level.

1. Critical thinking expectation was omitted from the draft proposal.

Science Grade 7 **TEK**	Science Grade 7 **Draft**	Comments
(b) Knowledge and skills. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:	(b) Knowledge and skills. (3) Scientific investigation and reasoning. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:	
(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	(A) review and analyze scientific explanations by using student-generated empirical evidence, logical reasoning and observational and experimental testing;	Critical thinking was omitted from the draft expectation. To implement critical thinking, I recommend retaining the language which states, "analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;"

Recommendation:

Reword (3) (A) as it was in the 7th grade TEK.

2. Expectation 3(C): "evaluate the impact of scientific thought on society and the environment including the history of science and contributions of scientists such as Robert Hooke, Antoine Von Leeuwenhoek, William Beaumont, Lazzaro Spallenzani, George Washington Carver, and Barbara McClintock;"

Comment: This expectation does not follow from the skills statement, which reads, "The student uses critical thinking and scientific reasoning, and problem solving to make informed decisions.…"

Recommendation: Reword skills statement to read, "The student uses critical thinking and scientific reasoning, and problem solving to make informed decisions, and knows the contributions of selected scientists.…"

3. Expectation 7(C): Phrase "its light" is vague and inaccurate. This should read, "recognize and diagram how an object is seen by reflected light refracting through the lens of the eye."

4. Expectation 9(A): Would better read, "analyze the characteristics of Earth and objects in the solar system that allow life to exist;"

5. Skill statement (11): "The student knows that populations and species demonstrate a variety of life and acquire many of their unique traits through gradual processes over many generations."

Comments: (a) "Variety of life" is unnecessarily inexact. (b) The "student…**knows** that populations and species…acquire…," rather than understanding the **evidence** that this occurs? It is not clear from any of the expectations that follow that the student will be exposed to **known**, **proven** examples of traits being acquired naturally over time. The selective breeding (expectation C) is not "natural selection," and what **specific** evidence is there that the Yucca plant/Yucca moth symbiosis developed "through generations"? Or is there no evidence in this particular case and this process is only assumed to have happened?

Recommendation: Science classes should present evidence to support the generalized theory. Suggestive symbiotic arrangements are <u>consistent with</u> but not <u>proof or documentation of</u> "gradual processes over many generations." Presumably, such a universal phenomenon would have many **documented** examples that could be used.

I recommend either:

(a) Use specific, documented examples of "gradual processes over many generations" and reword to convey the student's understanding the evidence for this as follows: "The student understands and critically evaluates the evidence (both direct observational and circumstantial) for the scientific theory that populations and species acquired many of their unique traits through gradual processes over many generations."
or
(b) If specific, documented examples are not specified, this skill statement should be deleted from the draft, expectations (A) and (B) moved into skill statement 10, and expectations (C) and (D) be deleted.

6. Expectation 11(C): "identify some changes in genetic traits that can occur over several generations through natural selection and selective breeding;"

Comments: Natural selection does not make changes; it only selects beneficial changes. Moreover, the word "identify" is dogmatic—it implies that the evidence of natural selection is always well-documented.

Recommendation: Reword as "critically evaluate changes that can occur over several generations through inherited diversity and natural selection or selected breeding;"

7. Expectation 11(D): If evidence of gradual change "over many generations" is not available specifically for the Yucca plant/Yucca moth system, replace this expectation with an example for which specific evidence IS available, or else delete this expectation entirely.

Grade 8

The draft proposes that science for grade 8 be concerned with Earth and Space Science.

1. Critical thinking expectation was omitted from the draft proposal.

Science Grade 8 **TEK** (b) Knowledge and skills. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:	Science Grade8 **Draft** (b) Knowledge and skills. (3) Scientific investigation and reasoning. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:	Comments
(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	(A) review and analyze scientific explanations by using student-generated empirical evidence, logical reasoning and observational and experimental testing;	Critical thinking was omitted from the draft expectation. To implement critical thinking, I recommend retaining the language which states "analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;"

Recommendation:

Reword (3) (A) as it was in the 8th grade TEK.

2. Expectation 3(C): "evaluate the impact of scientific thought on society and the environment including the history of science and contributions of scientists such as Alfred Wegener, Issac Newton, Marie Curie, Warren Washington, Edwin Hubble, Mario Molina, Dmitri Mendeleev, Jacques Cousteau, and Albert Einstein;"

Comment: This expectation does not follow from the skills statement, which reads, "The student uses critical thinking and scientific reasoning, and problem solving to make informed decisions…."

Recommendation: Reword skills statement to read, "The student uses critical thinking and scientific reasoning, and problem solving to make informed decisions, and knows the contributions of selected scientists.…"

Comments on the High School Science Standards Draft

I compared the draft carefully to the current TEKS standards and attempted to determine the intent and value of omissions or additions. I found that different sections of the standards were often inconsistent, and a narrative as to what the teacher workgroups had in mind when writing the draft would have been very helpful. The most problematic proposed changes about the definition of science is the language discussing "purported forces outside of nature," and the inconsistent application of the valuable critical thinking standard that would require students to learn about both the "strengths and weaknesses" of scientific theories. These, and other items, will be discussed in further detail below.

About the debate over "strengths and weaknesses" language

As the process to review and revise the Texas Science Standards has progressed, there has been controversy over the "strengths and weaknesses" language that has been in the standards for over a decade. I believe this clamor is largely without merit. In my opinion, it is driven by certain vocal and ardent supporters from the historical sciences, particularly biologists and geologists, who are frustrated that the general public tends not to be accepting of the grand picture of "evolution," or to put it roughly, they are angry that many people hold doubts about certain aspects of current explanations for the existence and diversity of life. I think they hope that by eliminating criticism of evolutionary theory, they will eventually produce a public far more accepting of the theory and in agreement with their own view of the world. This is the wrong approach. By removing the "strengths and weaknesses" language, they will produce a public that does not understand how science works, blindly accepts authoritative scientific claims on faith, not evidence, and is incapable of independent thought or individual scientific decision-making. Further reasons why I think the "strengths and weaknesses" wording, or the equivalent, should be retained, are detailed below.

Certain fields of science, particularly astronomy, geology and biology, try to explain the ancient history of our universe and planet. Scientists in these fields have to work harder (and they do) to gather conclusive evidence than do scientists who study laboratory-based phenomena. There are at least two reasons for this: evidence is often harder to find or interpret, and (more importantly) what is gathered is necessarily circumstantial evidence rather than direct observation of proposed events. When only circumstantial evidence is available, conclusions require much more of that evidence and the conclusions are usually less specific. The new TEKS draft mentions in several places that scientific theories must be testable, yet how "testable" are historical events? In general, the proposed event itself cannot be repeated, and only circumstantial evidence can be collected. Thus, the most conclusive statements that can be made will be "the evidence is consistent with…" rather than "the evidence

demonstrates that…". There is an unfortunate tendency to blur the distinction between these two kinds of conclusions. In addition, scientific theories are afforded a special status in which they are assumed to be true, or at least closer to the truth, than any other explanation, even when the evidence is also consistent (and perhaps more consistent) with other explanations. In other words, no matter how poor the supporting evidence, any theory that is scientific is assumed to be better than any explanation that is not.

The best example of this is studies of the origin-of-life (OOL) chemistry, sometime referred to as chemical evolution. As an organic chemist, I keep track of this field and am in a position to evaluate the significance of various discoveries and hypotheses. Since at least the 1950s, scientists have tried to identify chemistry that could account for the appearance of life on Earth. They have had some success; most of the amino acids, some sugars, and some of the constituents of RNA and DNA have been observed to form under some abiotic conditions, and some of these compounds have also been found in meteorites. On this basis, some scientists may conclude that "life from chemicals" is well supported, and this impression is widely promoted, appearing commonly in high school biology textbooks. Yet an objective evaluation requires that the evidence be compared to the magnitude of what is trying to be explained, which is the complex structure of a living cell, or at least the simplest cell that could be imagined. Such a comparison reveals that origin-of-life chemistry does not even remotely approach the complexity required for even the simplest imaginable cell. Roughly speaking, one optimistically could see the glass as 0.0001% full, but in fact it is at least 99.9999% empty. All of this is to illustrate that the scientific theory that life could come from chemicals is very poorly supported. Yet because the alternative conclusion, "life could not come from chemicals", would violate the philosophical beliefs of a large part of the scientific community, that community continues to promote (and include in high school textbooks) the poorly-supported, almost ridiculous notion of chemical evolution simply because it is "scientific." While it is true that "science classes should only teach science" and that non-science or religion should not be taught in science classes, the plausibility of and evidence for the more speculative scientific theories must be critically evaluated. The scientific conclusion that "life from chemicals" is poorly supported by the evidence in no way brings religion or pseudoscience into the classroom. Rather, the discussion ends where the science ends.

The Cornell astronomer Carl Sagan said, "Extraordinary claims require extraordinary evidence," and I believe all scientists would agree. The most extraordinary scientific claim is that "life came from chemicals," and the lack of extraordinary evidence for this claim must be part of any discussion of the theory. But there are other extraordinary claims, such as "all living things are descended from earlier life forms" or "random mutation, gene transfer, etc., and natural selection can account for all the

observed variety of life on Earth" or "dark matter and dark energy make up most of the matter and energy in the universe but are very different from normal matter." These claims, though they are better supported than chemical evolution, should not be immune from critical analysis of the strengths and weaknesses of the evidence. It is not enough to simply let statements like "most scientists believe…" put an end to critical thinking. Students being prepared for science in the 21st century need to understand both why scientists believe and why scientists doubt particular theories based on the nature of the evidence and the magnitude of the phenomena being explained.

Some have said that including requirements that students learn the "strengths and weaknesses" of scientific theories would bring religion or pseudoscience into the classroom. I have been able to find no evidence of this, and I believe such statements are the result of undue paranoia or simply a ploy to prevent critical analysis of certain fields of science. I contacted Dr. Daniel Bolnick, the head of the 21st Century Science Coalition and Assistant Professor of Integrative Biology at the University of Texas, for data to support their petition's claim that "…strengths and weaknesses… have (been) used to introduce supernatural explanations into science courses." (see http://www.texasscientists.org/sign.html). He directed me to a paper published by Berkman, et. al., in PLoS Biology (see http://biology.plosjournals.org/) in May 2008 that described a nationwide survey of biology teachers. I saw no evidence in this paper that teaching the weaknesses of a scientific theory would somehow necessarily introduce religion into the classroom. Rather, it included a study whose main conclusion was that state standards had little or no impact on whether these topics were being taught. Beyond this paper, Dr. Bolnick could offer me only the anecdotal evidence that in talking with his college biology students, roughly one-third "had creationist views taught in their high school classrooms here in Texas." Note that this anecdote says nothing about *science* classrooms. But the relevant point is that if religion is discussed in science classrooms, it is in **violation** of the "strengths and weaknesses" standards (which specify "scientific evidence and information"), not **because** of them. The debate is not about religion at all, but about whether we will teach evolution and other scientific theories in a scientific fashion by letting students learn about both the strengths and the weaknesses, or if we will teach such subjects as dogmatic fact that can't be scientifically questioned. In my opinion and experience, the critical analysis of strengths and weaknesses of scientific evidence in no way promotes religion or the supernatural. On the other hand, a blind acceptance of anything "scientific" without regard to the strength of the evidence fails to prepare our students for life in a technological world.

High School Science Standards

112.42: Integrated Physics and Chemistry
(begins on draft pg 3)

The draft proposal is slightly shorter than the currents TEKS standards; what were 30 Science Concepts expectations have been reduced to 27. Although there are only four Science Concepts skills statements (versus six in the current TEKS), the necessary parts of the course are represented and the expectations appear to be well-chosen.

Integrated Physics & Chemistry **TEKS** (c) Knowledge and skills (3) Scientific Processes	Integrated Physics & Chemistry **Draft** Knowledge and skills (3) Scientific Processes	Comments
Pg 2: (A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	Pg 4: (3) (A) analyze and evaluate scientific explanations, using empirical evidence, logical reasoning, and experimental and observational testing;	The proposed process of analyzing (breaking down into constituent parts) and evaluating (determining the significance of) scientific explanations does not necessarily involve the critical thinking inherent in the current TEKS "critique (of)...strengths and weaknesses." Critical thinking should involve both scientific evidence (directly related) and information (indirectly related) concerning the questions under discussion. Review of theories improves learning.

Recommendation:

The draft version should be reworded to foster critical thinking. In particular, developing the skills to evaluate strengths and weaknesses using both scientific evidence and scientific information should be specified. I recommend merging the best parts of both wordings to read, "Review, analyze and evaluate the strengths and weaknesses of scientific explanations using scientific evidence and information."

Integrated Physics & Chemistry **TEKS** (c) Knowledge and skills (3) Scientific Processes	Integrated Physics & Chemistry **Draft** Knowledge and skills (3) Scientific Processes	Comments
Pg. 2: (3) (E) research and describe the history of physics, chemistry, and contributions of scientists.	Pg 4: (3) (E) research describes the history of physics, chemistry, and contributions of scientists.	The grammar in draft is incorrect.

Recommendation:

The draft version should be corrected to read as current TEKS does.

Note: The inclusion of Science Concepts expectations 4(G) (electrical force compared with gravitational force) and 5(I) (advantages and disadvantages of various energy sources) in the draft are notable improvements and should definitely be retained.

112.43: Biology
(begins on draft pg 7)

The biology standards have expanded somewhat, from 36 Science Concepts expectations in the currents TEKS to 39 in the draft. This is due mainly to additional expectations in the areas of genetics (6) and evolution (7).

Biology **TEKS** (b) Introduction	Biology **TEKS Draft** (b) Introduction (5)	Comments
(this material is not in current TEKS)	Pg 7: Introduction (5) Science uses observational evidence to make predictions of natural phenomena and to construct testable explanations.	While this is the ideal, there are several propositions in biology and the other historical sciences that are widely accepted as "scientific" that are not really testable. The most notable example of "untestable science" is the origin-of-life chemistry, where 50 years of research have resulted in little or no relevant evidence, yet the "scientific" status of this field is rarely questioned. When direct "testing" is not possible, it is consistency of the observational evidence with a given theory that is considered to validate a hypothesis.

Recommendation:

The draft should be rewritten to reflect the variations in "testability" among different areas of science, or else the wording dropped entirely. If the sentence is retained, I would suggest wording as follows: "Science ideally uses observational evidence to make predictions that can be tested; however, in some areas of study, particularly those dealing with the ancient past, predictions may be difficult to make or test."

Biology **TEKS** (b) Introduction	Biology **TEKS Draft** (b) Introduction (5)	Comments
(this material is not in current TEKS)	Pg 7: Introduction (5) If ideas are based on purported forces outside of nature, they cannot be tested using scientific methods.	Can this statement be proven scientifically? It seems to me that the Big Bang was "outside of nature" and it is considered to have been scientifically tested. Also, some events supposedly based on forces within nature (like origin-of-life chemistry) really cannot be directly tested either. In many areas of the historical sciences (including biology), direct "testing" is not possible, and in those cases it is consistency of observations with a given theory that is considered to validate a hypothesis. This language seems philosophically biased and inappropriate for objective and neutral science standards.

Recommendation:

This statement is at best unprovable and at worst inaccurate, and it should be deleted from the draft. Item (5) flows quite well without this sentence.

Biology **TEKS** (c) Knowledge and skills (3) Scientific Processes	Biology **TEKS Draft** (c) Knowledge and skills (3) Scientific Processes	Comments
Pg 6: (A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	Pg 8: (A) analyze and evaluate scientific explanations, using empirical evidence, logical reasoning, and experimental and observational testing;	Again, the process of analyzing (breaking down into constituent parts) and evaluating (determining the significance of) scientific explanations does not necessarily involve the critical thinking inherent in the current TEKS "critique (of)...strengths and weaknesses." Critical thinking should involve both scientific evidence (directly related) and information (indirectly related) concerning the questions under discussion. The critical analysis of strengths and weaknesses is especially important in biology, as this field of science makes the most sweeping claims, many of which are based on circumstantial or other indirect evidence.

Recommendation:

Given the importance of teaching critical thinking, the draft version should be reworded to foster such. In particular, developing the skills to evaluate strengths and weaknesses using both scientific evidence and scientific information should be specified. I recommend merging the best parts of both wordings to read, "Review, analyze and evaluate the strengths and weaknesses of scientific explanations using scientific evidence and information."

Biology **TEKS** (c) Knowledge and skills (3) Scientific Processes	Biology **TEKS Draft** (c) Knowledge and skills (3) Scientific Processes	Comments
Pg 6: (D) describe the connection between biology and future careers.	(this does not appear anywhere in the draft version)	Given the very large numbers of biology majors in college and intense competition for employment afterwards, students need to know what career opportunities and challenges there are in biology.

Recommendation:

Retain the current TEKS wording.

Biology **TEKS** (c) Knowledge and skills (5) Science Concepts	Biology **TEKS Draft** (c) Knowledge and skills (5) Science Concepts	Comments
(not in currents TAKS)	Pg 9: (D) recognize that disruptions of the cell cycle lead to diseases such as cancer.	Wording could be more accurate.

Recommendation:

Reword to read: "recognize that certain disruptions in the cell cycle can lead to diseases such as cancer."

About Section 7: Evolution

The section in the proposed TEKS dealing with biological evolution has been greatly expanded (from two expectations in the current TEKS to five in the draft), probably reflecting the influence of outside groups who are frustrated with the general public's skepticism about the more speculative claims of the theory. Although minor degrees of evolution are strongly supported by direct evidence (e.g., antibiotic resistance), the significant amount of evidence for greater degrees of change (i.e., major changes between groups) is necessarily circumstantial in nature. Circumstantial evidence supports conclusions of "the evidence is consistent with…" rather than "the evidence demonstrates

that…" These limitations should be made clear in the presentation of this subject, and indeed in any field based on circumstantial evidence. In addition, in my experience and that of many objective scientists, assumptions and speculation are more common in evolutionary biology than in perhaps any other field of science. Many published reports that mention evolution are not in fact evidence for evolution at all; rather, they simply attribute their observations to the process or interpret their data assuming it to be true. In many papers, there appears to be no need to invoke evolution to explain the results, but the authors feel obliged to make their belief in the theory evident as a kind of scientific political correctness. Much has been said about how "science classes should be limited to science, not religion," and I entirely agree. But speculation and assumptions are not science either. At the very least, assumptions should be identified as such. I am entirely supportive of teaching more about evolution in high school biology IF what is known versus what is speculated or assumed are clearly identified as such, and if the limitations of circumstantial evidence are clearly discussed. This could be accomplished if the TEKS apply a standard requiring that the "strengths and weaknesses" be learned by students.

Biology **TEKS** (c) Knowledge and skills	Biology **TEKS Draft** (c) Knowledge and skills	Comments
Pg 7: (7) Science Concepts "The student knows the theory of biological evolution."	Pg 9: (7) Science Concepts "The student knows evolutionary theory is an explanation for the diversity of life."	The definition of "evolutionary theory" and of evolution should be made explicit, as should the claims of the theory. Evolutionary theory does not simply claim that there is common ancestry among some "groups" (see below), but that ALL diversity of life can be explained by only natural processes. These sweeping claims merit close scrutiny with respect to what is known and what is assumed about (a) WHAT changes are claimed; (b) HOW the changes occurred, by slow gradual changes or by more sudden changes ("punctuated equilibrium"); and (c) WHY the changes occurred, including the ability of natural variation (i.e., random mutation and possibly other mechanisms) and natural selection to accomplish major changes, especially with respect to changes between major classes of animals (reptiles, birds, mammals, etc.). Nowhere in science is critical thinking more appropriate than when discussing controversial claims about the origin of living things.

Recommendation:

Reword to read: "The student knows the definition and claims of evolutionary theory as an explanation for the diversity of life, distinguishing between what is known and what is assumed about the degree, rate and mechanism of changes in living things over time. The student is expected to:"

Biology **TEKS** (c) Knowledge and skills (7) Science Concepts	Biology **TEKS Draft** (c) Knowledge and skills (7) Science Concepts	Comments
Pg 7: (A) identify evidence of change in species using fossils, DNA sequences, anatomical similarities, physiological similarities, and embryology;	Pg 9: (A) identify how evidence of common ancestry among groups is provided by the fossil record, biogeography, and homologies including anatomical, molecular, physiological, behavioral and developmental;	What exactly is meant by "among groups"? I presume it refers to some level of taxonomic groups, but this proposed standard is vague and unclear. It should be made clear that different degrees of change are supported by different types of evidence: small changes within species have been directly observed, while major changes between species are inferred based on circumstantial evidence. Moreover, the strongest statement that can be made is that "the evidence is consistent with…" rather than "the evidence demonstrates that…" The evidence for one type of change is not proof of the other. In my opinion, the evidence for behavioral and developmental homologies is much more speculative than the other types. Students should thus approach this subject tentatively and critically.

Recommendation:

When discussing evolutionary theory, it is important the terms be clearly defined. Because different aspects of the theory are based on different types of evidence, where possible, the vague term "evolution" should be replaced with the more specific and meaningful terms "microevolution" for directly observed small changes within species, and "macroevolution" for major changes between species that are inferred based on circumstantial evidence. I recommend rewording to read, "Critically analyze how common ancestry within and between groups is supported by evidence of microevolution and macroevolution from direct observation, the fossil record, biogeography and homologies including anatomical, molecular and physiological, including analysis of the limitations and assumptions inherent in the evidence." An alternative to "limitations and assumptions" would be "strengths and weaknesses."

Biology **TEKS** (c) Knowledge and skills (7) Science Concepts	Biology **TEKS Draft** (c) Knowledge and skills (7) Science Concepts	Comments
Pg 7: (B) illustrate the results of natural selection in speciation, diversity, phylogeny, adaptation, behavior, and extinction. (This material is not in the current TEKS)	Pg 10: (D) recognize the significance of natural selection to adaptation, and the diversity of species; And Pg 10: (E) analyze the results of other evolutionary mechanisms including genetic drift, gene flow, mutation, and recombination.	Natural selection cannot accomplish changes without sources of natural variation, so these two points should be combined into one. As various biologists have recognized, selection only explains "the survival of the fittest," not the "arrival of the fittest." It is important to distinguish between what natural variation/natural selection are **known** to have accomplished and what they are **assumed** to have accomplished with regard to diversity of species. This statement assumes, without direct evidence, that the known mechanisms for minor changes within a species are responsible for major changes between species.

Recommendation:

Eliminate the inherent assumption by either replacing draft expectations (C), (D) and (E) with the current TEKS (B) wording, or else combine expectations (D) and (E) and reword to read, "Critically evaluate the ability of evolutionary mechanisms including inherited variation, genetic drift, gene flow, mutation and recombination along with natural selection to accomplish the diversity observed both within and between species, distinguishing between what is known and what is assumed."

Biology **TEKS** (c) Knowledge and skills (11) Science Concepts	Biology **TEKS Draft** (c) Knowledge and skills (11) Science Concepts	Comments
Pg 8: (C) analyze the importance of nutrition, environmental conditions, and physical exercise on health;	This sentence was not included anywhere in the Biology draft standards; rather, it appears to have been replaced with Pg 11: (D) describe events and processes that occur during ecological succession including changes in populations and species diversity.	The current TEKS requirement regarding the health of organisms appears to not be limited to humans. So while I assume human health has been discussed in earlier classes, there remain important areas of animal health in captivity (including household pets) and the influence of changing environment (for example, urban sprawl) on animal populations.

Recommendation:

Place the current TEKS 11(C) wording into a new draft expectation 11(E).

112.45: Chemistry
(begins on draft pg 12)

The Chemistry TEKS draft is somewhat shorter than the current TEKS standards, with 37 Science Concepts expectations from the Current TEKS standards having been condensed down to 31 expectations in the draft. In general, this was done by combining concepts or, in the case of nuclear processes, moving the material to Physics. I noticed the following:

(a) The material on nuclear fission and fusion in the current TEKS (9A-D) does not appear in the draft, but there is some discussion of this in the draft Physics 8(C-D) that was not there previously. I assume the reassignment of this material to Physics was intentional, and that is acceptable to me, especially since there might be more time to deal with these items within that subject. However, an understanding of nuclear processes is very important, especially given a renewed interest in nuclear energy, and I think it should be emphasized more in the Physics section.

(b) The material on corrosion (10(B)) in the current TEKS standards does not appear anywhere in the draft, but this is not a necessary component of high school chemistry in my opinion.

There is an issue with changes made in the introduction:

Chemistry **TEKS** Introduction	Chemistry **TEKS Draft** Introduction	Comments
This material is not found in the current TEKS standards.	Pg 12: (2) Scientific theories must be based on physical phenomena and must be capable of being tested by multiple independent researchers.	As I discussed earlier, not all scientific theories are truly "testable," especially when dealing with events of the distant past. However, chemistry deals almost entirely with laboratory-based phenomena in the present. While this wording is accurate enough for chemistry, this is a blanket statement that is not entirely true in the historical sciences.

Recommendation:

Either delete this sentence, or replace it with the more accurate wording: "Science ideally uses observational evidence to make predictions that can be tested; however, in some areas of study, particularly those dealing with the ancient past, predictions may be difficult to make or test."

Chemistry **TEKS** (c) Knowledge and skills (10) Science Concepts	Chemistry **TEKS Draft** (c) Knowledge and skills (10) Science Concepts	Comments
Pg 15: (A) identify oxidation-reduction processes;	Pg 15: (F) know and understands acid-base reactions, precipitation reactions, and redox reactions;	Improper grammar: should read "understand".

Recommendation:

Correct the grammar.

Chemistry **TEKS** (c) Knowledge and skills (14) Science Concepts	Chemistry **TEKS Draft** (c) Knowledge and skills (10) Science Concepts	Comments
Pg 16: (D) describe effects of acids and bases on an ecological system.	This concept is not in the Chemistry draft.	Given the importance of acid rain, this material merits inclusion in the standards. Both the causes and effects should be discussed.

Recommendation:

Add following as Chemistry concept 10(I): "describe the chemistry that leads to acid rain, and its effect on ecological systems."

112.47: Physics

(begins on draft pg 17)

In the Physics TEKS, 22 Science Concepts expectations from the Current TEKS standards became 30 Science Concepts expectations in the draft. In general, this was done by combining concepts or adding expectations in places. The draft standards are excellent, lacking nothing from the current TEKS standards and stronger in important places.

I would point out that the material on nuclear fission and fusion in the current TEKS standards for Chemistry has been moved into the Physics draft standards, section 8(C-D). Since nuclear power is likely to be an increasingly important energy source, I would encourage a solid discussion of this material and I hope there is more time available in the Physics curriculum for this than in Chemistry.

There is an issue with changes made in the introduction:

Physics **TEKS** Introduction	Physics **TEKS Draft** Introduction	Comments
This material is not found in the current TEKS standards.	Pg 17: (2) Scientific theories must be based on physical phenomena and must be capable of being tested by multiple independent researchers. A hypothesis is a tentative and testable statement that is based on observation.	As I discussed earlier, not all scientific theories are truly "testable", especially when we consider events of the distant past. However, physics deals almost entirely with laboratory-based phenomena in the present. While this wording is accurate enough for physics, this is a blanket statement that is not entirely true in the historical sciences.

Recommendation:

Either delete these sentences, or replace it with the more accurate wording: "Science ideally uses observational evidence to make predictions that can be tested; however, in some areas of study, particularly those dealing with the ancient past, predictions may be difficult to make or test."

Physics **TEKS** (c) Knowledge and skills (3) Scientific Processes	Biology **TEKS Draft** (c) Knowledge and skills (3) Scientific Processes	Comments
Pg 21: (A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	Pg 18: (A) analyze and evaluate scientific explanations, using empirical evidence, logical reasoning, and experimental and observational testing;	Again, the process of analyzing (breaking down into constituent parts) and evaluating (determining the significance of) scientific explanations does not necessarily involve the critical thinking inherent in the current TEKS "critique (of)...strengths and weaknesses." Critical thinking should involve both scientific evidence (directly related) and information (indirectly related) concerning the questions under discussion.

Recommendation:

Given the importance of teaching critical thinking, the draft version should be reworded to foster such. In particular, developing the skills to evaluate strengths and weaknesses using both scientific evidence and scientific information should be specified. I recommend merging the best parts of both wordings to read, "Review, analyze and evaluate the strengths and weaknesses of scientific explanations using scientific evidence and information."

112.44: Environmental Systems
(begins on draft pg 21)

The Environmental Systems standards have expanded somewhat from the current TEKS; what were five Science Concepts and 23 concept-related expectations have become six Science Concepts and 29 expectations. I think this expansion is justified as it mirrors an increase in both a scientific and public awareness of environmental issues in recent years. However, it is important that this course is taught as a science course and NOT as an introduction to political activism. Environmental issues are very important, but an objective approach is necessary to avoid highly politicized fads. Much has been said about "only science taught in science courses"; let that be true here as well.

Having said that, the topics chosen for the standards remain generally the same as in the current TEKS standards. Where changes have been made, they appear to be improvements to the course.

There is one minor point in the introduction (5) that is new to the draft standards:

Environmental Systems **TEKS** Introduction	Environmental Systems **TEKS Draft** Introduction	Comments
This material is not found in the current TEKS standards.	Pg 21: (5) Major scientific understandings are premised upon a preponderance of evidence rather than on opinion.	While this is probably true, there are often scientific disagreements about what the "preponderance of evidence" says. This standard makes it sound like science is a court of law, where all scientists agree on a given verdict, but that is not always how science works. For this reason, this is not a useful standard for understanding scientific thought. This makes me wonder why this wording was added in the draft. Given the subject, I think the point being made is that public policy decisions should be based on science rather than on public opinion.

Recommendation:

I have no recommendation for changes, but as I discussed above, I think the Texas Education Agency should be vigilant that this course is taught as serious science and not as a shallow exercise in political activism for or against certain environmental causes.

Environmental Systems **TEKS** (c) Knowledge and skills (3) Scientific Processes	Environmental Systems **TEKS Draft** (c) Knowledge and skills (3) Scientific Processes	Comments
Pg 10: (A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	Pg 22: (A) analyze and evaluate scientific explanations, using empirical evidence, logical reasoning, and experimental and observational testing;	Again, the process of analyzing (breaking down into constituent parts) and evaluating (determining the significance of) scientific explanations does not necessarily involve the critical thinking inherent in the current TEKS "critique (of)...strengths and weaknesses." Critical thinking should involve both scientific evidence (directly related) and information (indirectly related) concerning the questions under discussion.

Recommendation:

Given the importance of teaching critical thinking, the draft version should be reworded to foster such. In particular, developing the skills to evaluate strengths and weaknesses using both scientific evidence and scientific information should be specified. I recommend merging the best parts of both wordings to read, "Review, analyze and evaluate the strengths and weaknesses of scientific explanations using scientific evidence and information."

Physics **TEKS** Knowledge and skills (8) Science Concepts	Physics **TEKS Draft** Knowledge and skills (8) Science Concepts	Comments
Pg 12: (C) describe how communities have restored an ecosystem;	Pg 24: (C) examine how natural processes restore habitats and ecosystems.	The ability of communities (which I take to mean human communities) to restore ecosystems has been intentionally replaced by "natural processes." Is the intent to deny the ability of humans to fix habitats? I think both means of improving the environment are important parts of the course.

Recommendation:

Reword 8(C) to read: "examine how communities and natural processes can restore habitats and ecosystems;"

112.46: Aquatic Science
(begins on draft pg 25)

The draft standards for Aquatic Science have expanded from seven Science Concepts points in the current TEKS standards to nine in the draft, for a total of 28 expectations versus 24 in the current TEKS. There were many organizational changes, but practically all of the current TEKS expectations were incorporated into the draft. There were approximately seven additional expectations added to the draft, but these appear to all be well-chosen and assets to the course. Chemistry is a pre-requisite (or co-requisite) and I gather that this course is intended to be taught as serious science rather than as a shallow experience in environmental activism.

There is an issue with changes made in the introduction:

Aquatic Science **TEKS** Introduction	Aquatic Science **TEKS Draft** Introduction	Comments
This material is not found in the current TEKS standards.	Pg 25: (5) Science uses observational evidence to make predictions of natural phenomena and to construct testable explanations. Scientific explanations are open to testing under different conditions, over time, and by independent researchers.	As I discussed earlier, not all scientific theories are truly "testable", especially regarding events of the distant past. However, this is probably not an issue with Aquatic Science, since it tends to not be historical in nature. While this wording is accurate enough for Aquatic Science, this is a blanket statement that is not entirely true in the historical sciences.

Recommendation:

Either delete these sentences, or replace it with the more accurate wording: "Science ideally uses observational evidence to make predictions that can be tested; however, in some areas of study, particularly those dealing with the ancient past, predictions may be difficult to make or test."

Aquatic Science **TEKS** (c) Knowledge and skills (3) Scientific Processes	Aquatic Science **TEKS Draft** (c) Knowledge and skills (3) Scientific Processes	Comments
Pg 18: (A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;	Pg 26: (A) analyze and evaluate scientific explanations, using empirical evidence, logical reasoning, and experimental and observational testing;	Again, the process of analyzing (breaking down into constituent parts) and evaluating (determining the significance of) scientific explanations does not necessarily involve the critical thinking inherent in the current TEKS "critique (of)...strengths and weaknesses." Critical thinking should involve both scientific evidence (directly related) and information (indirectly related) concerning the questions under discussion.

Recommendation:

Given the importance of teaching critical thinking, the draft version should be reworded to foster such. In particular, developing the skills to evaluate strengths and weaknesses using both scientific evidence and scientific information should be specified. I recommend merging the best parts of both wordings to read, "Review, analyze and evaluate the strengths and weaknesses of scientific explanations using scientific evidence and information."

112.48: Astronomy
(begins on draft pg 29)

The draft standards for Astronomy have expanded from seven Science Concepts points and in the current TEKS standards to nine in the draft, for a total of 28 expectations versus 24 in the current TEKS. The draft standards appear to contain all the essential elements of an excellent astronomy course.

There was one minor wording problem:

Astronomy **TEKS** Knowledge and skills	Astronomy **TEKS** Knowledge and skills	Comments
This statement is not found in the current TEKS standards, though the basic content is.	Pg 33: 12 (B) recognize the type, structure, components, and location of our solar system in the Milky Way galaxy;	I think the intent was to say "recognize the type, structure and components of the Milky Way galaxy, and the location of our solar system in it;"

Recommendation:
Change the wording to "recognize the type, structure and components of the Milky Way galaxy, and the location of our solar system in it;".

112.xx: Earth and Space Science
(begins of draft page 34)

Earth and Space Science is an entirely new course designed to be a "capstone" of the science curriculum and taken primarily by seniors. Much of the information in this course was covered in earlier science courses, but here various areas of science are to be integrated and applied to more advanced studies. I found an almost continual aggressive, dogmatic tone to much of the ESS standards. This will not instill students with the scientific values of skepticism, openness, or tentativeness. In several places, concepts are presented to students as if they were established fact (see, for example, (5), (6) and (6A) below), rather than scientific hypotheses. In my opinion, those who wrote the proposed ESS standards have an agenda that, in places, borders on indoctrination. This casts some doubt on the real purpose of the course, and I encourage the Texas Education Agency to monitor its implementation or change its tone drastically. In fact, the entire ESS section would be an ideal

place to implement "strengths and weaknesses" language to teach students about critical thinking and help them understand how scientists approach and test scientific claims with openness and skepticism. **In addition, I recommend that the TEA afford this course only a probationary status until it is established that it is taught within the bounds of science.**

	Earth and Space Science **TEKS** Introduction	Comments
This material is not found in the current TEKS standards, but is entirely new.	Pg 35: (5) Scientific explanations must be based on naturally occurring phenomena, and must be capable of being tested by multiple independent researchers. If scientific explanations are based on purported forces outside of nature, scientists have no way of testing those explanations. Unless a proposed scientific explanation is framed in such a way that some observational evidence could potentially refute it, that explanation cannot be subject to scientific testing.	As I discussed earlier, not all scientific theories are directly "testable," especially regarding proposed events in the distant past. ESS introduction (5) is a blanket statement that is not entirely true in the historical sciences, including parts of ESS itself. For example, in ESS section 8(A), the study of origin-of-life chemistry is specified. How could any evidence possibly refute the "scientific" hypothesis that "life arose from chemical mixtures"? Conceivably, chemistry might be discovered by which the statement might be proven true, but it could never be proven false. No matter how many mixtures and conditions had been studied to no avail, one would simply postulate that we had not identified the right conditions yet. Either acknowledge that not all "scientific" theories are testable, or else reclassify **all** untestable proposals as non-scientific.

Recommendation:

Either delete ESS introduction section (5), or replace it with the more accurate wording: "Science ideally uses observational evidence to make predictions that can be tested; however, in some areas of study, particularly those dealing with the ancient past, predictions may be difficult to make or test."

Current **TEKS**	Earth and Space Science **TEKS Draft** Scientific Processes (3)	Comments
Earth and Space Science is not in the current TEKS.	Pg 37: (A) analyze and evaluate scientific explanations using empirical evidence, logical reasoning, and experimental and observational testing;	As in other places, the "strengths and weaknesses" wording has been dropped from the draft ESS standards. In my opinion, this wording, or some equivalent standard that encourages critical thinking, is especially necessary in ESS because this course deals with many subjects that are more speculative than the subject matter in most fields of science. The most egregious example of this is (8A) origin-of-life chemistry, but other topics that contain significant amounts of speculation are (5) formation of the solar system, (6) the evolution of Earth's atmosphere, (8C) mechanisms of fossil formation, and (9E) the process by which the Earth's magnetic field was formed. This is not to say that there are not evidential reasons many scientists accept certain scientific models pertaining to these topics, but these models should be conveyed tentatively to teach students how scientists approach these issues.

Recommendation:

Given the importance of teaching critical thinking, the draft version should be reworded to foster such. In particular, developing the skills to evaluate strengths and weaknesses using both scientific evidence and scientific information should be specified. I recommend merging the best parts of both wordings to read, "Review, analyze and evaluate the strengths and weaknesses of scientific explanations using scientific evidence and information".

Current **TEKS**	Earth and Space Science **TEKS Draft** Knowledge and skills	Comments
Earth and Space Science is not in the current TEKS.	Pg 37: (5) Earth in Space and Time: The student **knows** that Earth's place in the solar system is **explained** by the star, planets, and minor bodies of a stellar system that accrete from a stellar nebula as explained by the nebular-planetesimal-protoplanet model. (emphasis mine)	While this may be the view held by most cosmologists, the statement is overly dogmatic. A search on the N-P-P model revealed that it is better known as the Solar Nebular Disk Model and there is a significant degree of uncertainty about nearly every aspect of the model. (see http://en.wikipedia .org/wiki/Nebular_hypothesis). I also discussed this with an astrophysicist, who strongly agreed that this wording was overly dogmatic.

Recommendation:

Reword to read less dogmatically: "The student knows the solar nebular disk model of formation of the solar system, including the role of the central star, planets and minor bodies."

Current **TEKS**	Earth and Space Science **TEKS Draft** Knowledge and skills	Comments
Earth and Space Science is not in the current TEKS.	Pg 38: (6) Earth in Space and Time: The student knows the evidence for the formation of the Earth's atmospheres, hydrosphere, and geosphere.	This proposed standard is poorly worded: I think the draft means to say, "The student knows the evidence for how the Earth's atmospheres, hydrosphere, and geosphere were formed."

Recommendation:

Reword as, "The student knows the evidence for how the Earth's atmospheres, hydrosphere, and geosphere were formed."

Current **TEKS**	Earth and Space Science **TEKS Draft** Knowledge and skills (8) Earth in space and time	Comments
Earth and Space Science is not in the current TEKS.	Pg 39: (A) analyze the evolution of Earth's atmosphere over time from the original protoplanet hydrogen-helium atmosphere, the carbon dioxide-water vapor-methane atmosphere, and the current nitrogen-oxygen atmosphere; (B) evaluate the role of volcanic outgassing and impact of water-bearing comets in creating the Earth's atmosphere and hydrosphere;	Though they may reflect the scientific community's current best models based upon sparse evidence, these topics are highly speculative and should be worded much less dogmatically. The statements make it sound like these proposals are established fact!

Recommendation:

These statements illustrate the rather extreme dogmatism that permeates much of the Earth and Space Science standards. Reword to at least suggest the high degree of uncertainty currently present in the theory:

(A) Critically analyze the proposed evolution of Earth's atmosphere over time from an original protoplanet hydrogen-helium atmosphere to a carbon dioxide-water vapor-methane atmosphere, to the current nitrogen-oxygen atmosphere;

(B) Critically evaluate and investigate the proposed role of volcanic outgassing and impact of water-bearing comets in creating the Earth's atmosphere and hydrosphere;

Even this wording probably overstates the certainty that can be afforded these events.

Current **TEKS**	Earth and Space Science **TEKS Draft** Knowledge and skills (8) Earth in space and time	Comments
Earth and Space Science is not in the current TEKS.	Pg 39: (A) Analyze prominent scientific hypotheses for the origin of life by abiotic chemical processes, such as the transport of organic compounds to Earth by comets, low-energy clay mineral replication, primitive Earth replication experiments, and the significance of primitive extremophilic archaeans;	This is a topic that demands a significant response. See comments below

Background

The chemical origin of life, sometimes referred to as "chemical evolution," is an important topic that should be included in high school science. For example, this topic appears in virtually every high school and college-level biology textbook. The emphasis is on conditions in which abiotic chemistry has been observed to produce small molecules of possible biological relevance such as amino acids and a few other types of organic molecules. The most notable of these experiments were done by Miller and Urey beginning in 1953. Because the proteins that are essential to life are long polymers of amino acids, the products of Miller-Urey type experiments are often hailed as "the building blocks of life." There typically follows a little discussion about various small molecules, and some speculation as to how they may have assembled into the larger molecules of real biological interest. The presentation leaves the impression that, while there are still questions to be answered, good evidence exists to suggest a chemical origin of life.

There are three major pieces of evidence that are typically left out of the textbook story that might otherwise cause the reader to reach a very different conclusion:

The first is that there are severe criticisms of the Miller-Urey experiment, specifically that it used gasses that are necessary but were not actually present in the Earth's early atmosphere.

The second is that there are many insurmountable problems associated with assembling amino acids into any of the numerous specific polymers required for even the simplest conceivable living cell.

The third feature left out of the typical textbook story is the extreme chemical complexity now known to exist within all living cells, which are essentially very sophisticated factories built out of complex molecules.

The more one knows about the molecular complexity of cells and the inability of organic compounds to self-organize as required, the less likely one is to believe that a chemical origin of life is possible. So extreme are the differences between the chemistry that is known and the chemistry required for life to form spontaneously that many scientists have concluded that none of the current origin of life hypotheses are remotely plausible. So why are the various theories of chemical evolution so prominent (to use the term in ESS 8A)? Simply put, it is because "life from chemicals" is considered "scientific" and suitable for science classrooms, no matter how poorly supported by the evidence.

Carl Sagan said "Extraordinary claims require extraordinary evidence," and I believe all scientists would agree. Given the extreme complexity of living cells, the most extraordinary scientific claim I know is that "life came from chemicals." The lack of extraordinary evidence for this claim must be part of any discussion of chemical evolution theories. To do otherwise is to essentially deceive our students. Nowhere else in all these science standards are "strengths and weaknesses" more appropriate.

Recommendation:

Both good science and ethical considerations demand that the evidence in origin of life chemistry be presented in light of the extreme complexity of what is trying to be explained. The expectation 8(A) should be rewritten to read: "Critically evaluate the strengths and weaknesses of prominent scientific hypotheses for the origin of life by abiotic chemical processes in light of the complexity of living systems, distinguishing between what is known and what is assumption or speculation;"

Current **TEKS**	Earth and Space Science **TEKS Draft** Knowledge and skills (8) Earth in space and time	Comments
Earth and Space Science is not in the current TEKS.	Pg 39: (C) explain how sedimentation, fossilization, and speciation affect the completeness of the fossil record;	This could be construed as explaining away aspects of the fossil record that do not fit particular assumptions of what should be observed. This is a topic in which it is important to distinguish between what is actually known and what is assumption or speculation. Otherwise, this could be the equivalent of promoting a misinterpretation of the fossil data.

Recommendation:

Reword to remove any possible bias in the interpretation of the fossil record, as follows: "describe what is known of the process of fossilization, including any limitations the process may impose on the fossil record;"

Current **TEKS**	Earth and Space Science **TEKS Draft** Knowledge and skills (11) Solid Earth	Comments
Earth and Space Science is not in the current TEKS.	Pg 40: (D) …; and the impact of humans on Earth's subsystems, such as population growth in costal regions, increased fossil fuel burning, deforestation, and desertification.	Desertification seems out of place as it is not an intentional human activity, as are all the rest of the points listed.

Recommendation:

Move "desertification" to the upper part of expectation 11(D) with the other nature-caused phenomena (tsunamis, volcanoes, etc.).

Current **TEKS**	Earth and Space Science **TEKS Draft** Knowledge and skills (12) Solid Earth	Comments
Earth and Space Science is not in the current TEKS.	Pg 40: (B) compare the formation of fossil fuels, including petroleum and coal;	Compare to what? The ESS standards repeatedly use the term "formation" to mean the process by which something was formed. Natural gas was left out.

Recommendation:

Reword to read: "compare the processes by which the various fossil fuels (petroleum, coal, and natural gas) are thought to have formed;"

112.xx: Engineering Design and Problem Solving (ENG)
(begins of draft pg. 43)

This course is entirely new to the TEKS standards, and a welcome addition. It represents an opportunity for students to creatively solve problems while learning techniques and recognizing constraints. I found the ENG standards to be extremely well written and complete, and in fact identified nothing needing correction or even clarification. I would encourage the Texas Education Agency to strongly support this new course.