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TEKS Review

I'm going to limit my comments to Middle School and High School Biology.

1. **Is the current structure or framework of the kindergarten–grade 12 science TEKS appropriate? If not, what recommendations do you have for organizing or structuring the TEKS?**

Mathematics should be integrated with the sciences, including biology. This is essential for students to understand why they are learning the math they are learning, as well as for understanding the quantitative aspects of biology. For example, probability can be integrated with genetics.

2. **Does each grade level and/or course follow a complete and logical development of science concepts presented within the grade level/course? If not, what improvements are needed?**

3. **Are the core concepts specific to the disciplines of science (e.g., life science, physical science, and earth and space science) adequately addressed across the K–12 TEKS? If not, please identify the discipline and the concepts that are missing.**

The core concepts in biology appear to be present. There are some conceptual errors and poorly worded statements. (See #9 and #11 below.)

4. **Do the standards adequately address the broader concepts that cross various science disciplines (e.g., systems and system models, energy and matter, stability and change)?**

5. **Are there topics that should be eliminated because they no longer reflect current research or practices within the field? If so, please identify.**

6. **Are the TEKS vertically aligned so that concepts are introduced, elaborated on, and refined across multiple grade levels and students will possess the necessary knowledge and skills to be successful in later grades?**

7. Do the high school courses sufficiently prepare students for postsecondary success?

• Mathematics needs to be integrated with the biology (and other science) curriculum.

• I thought it might be helpful to list here the Learning Outcomes for our BSA in General Biology degree at UT Austin. A more detailed version of these (with each learning objective broken into components) is attached to the end of this document. To be successful Biology Majors, Middle and High School students should have some experience with each of these learning outcomes.

KNOWLEDGE OUTCOMES FOR BIOLOGY BSA
Outcome 1: Apply the fundamentals of math, chemistry, and physics to the study of biology.
Outcome 2: Make connections between biological diversity and the genetic and evolutionary principles that lead to it.
Outcome 3: Explain biological processes at different levels of organization.
SKILLS OUTCOMES FOR BIOLOGY BSA
Outcome 4: Access and critically evaluate information.
Outcome 5: Communicate effectively in writing and orally.
Outcome 6: Generate and test biological hypotheses.
Outcome 7: Integrate quantitative data and reasoning into the process of discovery in biology.
Outcome 8: Evaluate the ethical implications of science on society.
Outcome 9: Learn in a self-directed manner.
Outcome 10: Work productively in a team.
Outcome 11: Explore and plan for biology-related careers.

• I thought it might also be helpful to list here the Key Features of our new Non-Majors Biology Courses at UT Austin. To be successful outside of STEM, Middle and High School students should have some exposure to these skills.

SCIENCE LITERACY AND NUMERACY SKILLS ARE THE MOST IMPORTANT THING TO BE TEACHING IN EACH NON-MAJORS COURSE, REGARDLESS OF SPECIFIC BIOLOGY SUBJECT MATTER.
I. Methods of inquiry that lead to scientific knowledge
1. Identify a valid scientific argument.
2. Evaluate the validity of sources.
3. Recognize the misuse of scientific information.
4. Evaluate elements of research design and how they impact conclusions.

II. Quantitative data
5. Create and interpret graphical representations of data.
6. Solve problems using basic quantitative skills (arithmetic and probability).
7. Apply basic statistics to quantify uncertainty.
8. Justify inferences based on quantitative data (view methods critically/skeptically)

III. Common Misconceptions/Weaknesses of Students that We Want to Correct
1. Inability to link claims with evidence.
2. Inability to identify accurate and credible sources.
3. All sides should be given equal weight independent of their validity.
4. Lack of understanding of good research design.
5. Inability to extract meaning from graph shape.
6. Thinking it's OK to "not be good at math".

8. The current K–5 science TEKS encourage districts to devote the percentage of instructional time to classroom and outdoor investigations as follows: kindergarten

and grade 1–80%, grades 2 & 3–60%, grades 4 & 5–50%. The secondary science TEKS require districts to devote at least 40% of instructional time to laboratory and field investigations.

Are these designations and percentages for instructional time appropriate? Do the current student expectations adequately support the instruction?

Ideally, the students would all spend 90-100% of their time learning-by-doing. Data shows that students learning best when they are actively problem-solving, as opposed to listening to someone else talking.

Are the laboratory experiences the students are having really experimental, or merely demonstrations (formulaic)?

9. **Are the student expectations clear and specific? If not, please give examples of how the language might be improved.**

Some statements are poorly worded, less straightforward than they could be, or have conceptual errors. Suggested edits are below:

• **§112.19 (a) (E) (ii):** Students learn that all organisms obtain energy, get rid of wastes, grow, and reproduce. During both sexual and asexual reproduction, genes that control traits are passed onto the next generation. These genes ~~traits~~ are contained in the chromosomes of the parents. ~~genetic material that is found on genes within a chromosome from the parent.~~ Changes in genes (mutations) and thus changes in traits ~~sometimes~~ can occur in an individual within a population and spread to other individuals over many generations. One of the ways the traits within a population can ~~a~~ change ~~can occur~~ is through ~~the process of~~ natural selection. Students extend their understanding of structures in living systems from a previous focus on external structures to an understanding of internal structures and functions within living things.

• **§112.19 (a) (E) (iii):** All living organisms are made up of smaller units called cells. All cells use energy, get rid of wastes, and most contain genetic material. Students will compare…

(Not all cells have nuclei – e.g. red blood cells.)

• **§112.19 (b) (11):** Organisms and environments. The student knows that populations and species demonstrate variation and ~~inherit~~ evolve many of their unique traits through ~~gradual processes~~ a variety of processes that occur over many generations, all of which operate through random mutations that occur in genes. The student ….

• **§112.19 (b) (12)(F):** recognize the components of cells ~~theory~~.

(Everyone accepts that organisms are made up of cells – it's not really a theory anymore – but a fact.)

• **§112.19 (b) (14)(C):** recognize that inherited traits of individuals are ~~governed in the genetic material found in the~~ determined by genes within chromosomes in the nucleus.

• **§112.34 (c)(6)(A):** identify components of DNA, ~~identify how information for specifying the traits of an organism is carried in the DNA~~, describe the chemical structure of a gene, and examine scientific explanations for the origin of DNA;

• **§112.34 (c)(6)(E):** identify and illustrate changes in DNA (mutations) and evaluate the causes and significance of these changes;

THE FOLLOWING CONTAINS A REALLY BAD CONCEPTUAL ERROR:
• **§112.34 (c)(7)(F):** analyze other evolutionary mechanisms, including genetic drift, gene flow, ~~mutation,~~ and recombination.

All evolutionary processes exert their effects on random mutations that occur in the DNA of genes. Mutation produces the variation through which natural selection, drift, etc., work.

I was troubled that this misinformation appears to come from Khan Academy. Khan Academy is not a reliable source of information – at least about genetics. It seems that the information there is not reviewed, as it is rife with errors.

10. **Are there student expectations that are not essential or unnecessarily duplicative and can be eliminated? If so, please identify by grade level/course and student expectation number.**

11. **What other suggestions do you have for ways in which the science TEKS can be improved?**

• With regard to the following: [**§112.34 (c)(3)(B):** communicate and apply scientific information extracted from various sources such as current events, published journal articles, and marketing materials;] An important component of this is to begin to teach the **students how to tell which sources are reliable.**

• Students should learn – beginning in middle school - **the difference between correlation and causation** and how to design experiments that distinguish them.

• **Current events should be used** to get students interested in science: antibiotic resistance; climate change; genetic genealogy to solve crimes; what companies like 23andMe are doing; extinction and de-extinction of animals; cloning; GMOs in agriculture; etc…

• In high school biology, students could begin to learn – at a rudimentary level - about **biotechnology: analysis of genomes, cloning, gene therapy, genome editing.**

• **Quantitative reasoning should be stressed in biology. All science should be integrated with math.**

• It's important **to teach evolution intentionally.** By that I mean to be explicit about the scientific evidence for evolution: homology of anatomy and genes, fossils, direct observation of microevolution, inefficiency and messiness of biology (for example, genes exist whose sole functions are to negate the functions of other genes), DNA sequence analysis supports common descent.