SC DEPARTMENT OF EDUCATION

Bundling Guide for Biology 2

Office of Assessment and Standards

Purpose and Use

This document is intended to be a guide to provide examples of ways Performance Expectations (PEs) could be bundled. For this purpose, a bundle as defined by Pruit (2014), is, "a set of PEs that provide students with coherent connections among concepts within and across disciplines." This document is not intended to be read from cover to cover, but to be used, when needed, to support teacher professional learning and curriculum decisions. This is not intended for student use, and thus is not written in student-friendly language. This is not a curriculum or a means to limit instruction in the classroom. The bundles presented in this guide are not ordered for instruction. Although each PE states a dedicated Science and Engineering Practice (SEP) and Crosscutting Concept (CCC), students will need to use the whole range of SEPs and CCCs to achieve success by the end of instruction.

The bundles in this document do not represent the only way the PEs can be bundled. PEs bundled together may change depending upon the selected anchoring phenomenon that students are working to explain. The bundles presented in this guide were developed using an iterative process informed by the work of Krajick and colleagues (2014). This process is summarized in the steps below:

1. Review bundles that already exist.
2. Build bundles around an anchoring phenomenon.
    a. The "Example anchoring phenomena to support 3D instruction" provided in this resource is just that, an example. There are myriad phenomena to support 3D instruction, and different phenomena may be more appropriate for different learning contexts.
3. Explore and look for unexpected relationships among the PEs, including bundling across disciplines (Earth and Space Science, Life Science, Physical Science) when appropriate. This can include identification of PEs that are only partially met in the bundle.
    a. PEs within a bundle marked with an asterisk (*) share an authentic connection with the bundle but may not fully met.
    b. PEs from additional high school content areas with a close connection to the bundle are listed. This is not intended to add to the instructional demand, but instead to provide teachers with additional content to build upon and/or support student sensemaking.
4. Make sure each PE in the grade/course is found in at least one bundle.

Ecosystem Dynamics

Ecosystems have carrying capacities, which limit the number of organisms and populations they can support. These limits come from factors like the availability of resources and challenges such as predation, competition, and disease. If resources were unlimited, organisms could produce very large populations. However, because resources are finite, this limits the number of individuals in any ecosystem. Interactions within an ecosystem can keep the numbers and types of organisms relatively constant over long periods when conditions are stable. If a small disturbance happens, the ecosystem might return to its original state (meaning the ecosystem is resilient). However, large changes in conditions or population sizes can disrupt the ecosystem's balance, affecting resources and habitats.

PEs aligned to this bundle:

- B-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- B-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions but changing conditions may result in a new ecosystem.
- B-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.*

Connected PEs from additional content areas:

- B-LS2-1. Use mathematical and/or computational representations to support explanations of biotic and abiotic factors that affect carrying capacity of ecosystems at different scales.
- B-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.
- E-ESS3-3. Use computational representation to illustrate the relationships among the management of Earth’s resources, the sustainability of human populations, and biodiversity.

Example anchoring phenomena to support 3D instruction:

- Impacts of urbanization
- Megafauna extinction

Bundle B2.2: Biogeochemical Cycles

Photosynthesis and cellular respiration provide most of the energy for life processes. Plants and algae are at the base of the food web. As you move up each level of the food web, only a small fraction of the energy from the lower level is transferred upward. This means there are usually fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some is stored in new structures, and much is discarded. The elements that make up organisms pass through food webs, moving in and out of the atmosphere and soil, and they are combined and recombined in different ways. Matter and energy are conserved at each level in an ecosystem.

PEs aligned to this bundle:

- B-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- B-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
- B-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.*

Connected PEs from additional content areas:

- B-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
- B-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and other large carbon-based molecules necessary for essential life processes.
- B-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.
- B-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
- E-ESS2-6. Develop a quantitative model to describe the cycling of carbon through the hydrosphere, atmosphere, geosphere, and biosphere.

Example anchoring phenomena to support 3D instruction:

- *Cordyceps* fungi
- Aquaponics
- Nutrient cycling and agriculture

Bundle B2.3: Complex Inheritance

All cells contain genetic information in the form of DNA molecules. The instructions for forming an organism's characteristics are carried in DNA. Each chromosome consists of a single, very long DNA molecule, and each gene on the chromosome is a specific segment of that DNA. Genes are sections of DNA that provide the instructions for making proteins. The sequence of nucleotides in a gene spells out this information. DNA controls protein expression by being transcribed into messenger RNA (mRNA), which is then translated by the cell into a protein. All cells in an organism have the same genetic content, but the genes expressed by the cell may vary. Not all DNA codes for proteins; some DNA segments have regulatory or structural roles, while others have no known function. During sexual reproduction, chromosomes can exchange sections during meiosis, creating new genetic combinations and increasing genetic variation. Although DNA replication is usually accurate, errors can occur, resulting in mutations, which are another source of genetic variation. Environmental factors can also cause gene mutations, and these mutations can be inherited if they are viable. Environmental factors also influence the expression of traits, affecting the likelihood of certain traits appearing in a population. Thus, the variation and distribution of traits depend on both genetic and environmental factors.

PEs aligned to this bundle:

- B-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- B-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
- B-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
- B-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.*

Connected PEs from additional content areas:

- B-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- B-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

Example anchoring phenomena to support 3D instruction:

- Sickle Cell Trait
- CRISPR

Bundle B2.4: Biological Evolution

Traits that positively affect survival are more likely to be reproduced and become more common in the population. Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but many overlaps exist. By comparing DNA sequences of different organisms, scientists can infer the branching that produces multiple lines of descent. Similarities and differences in amino acid sequences, as well as anatomical and embryological evidence, also provide information about evolution. Natural selection happens only if there is variation in genetic information between organisms in a population and variation in the expression of that genetic information (trait variation) that leads to differences in performance among individuals. Group behavior has evolved because being part of a group can increase the chances of survival for individuals and their genetic relatives. Natural selection leads to adaptation, meaning a population becomes dominated by organisms that are anatomically, behaviorally, and physiologically well-suited to survive and reproduce in a specific environment. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human-induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline and sometimes extinction of other species. Humans depend on the living world for resources and other benefits provided by biodiversity. However, human activity is also negatively impacting biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Sustaining biodiversity is essential for maintaining ecosystem functioning and productivity, which supports and enhances life on Earth.

PEs aligned to this bundle:

- B-LS2-8. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.
- B-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
- B-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
- B-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
- B-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.*

Connected PEs from additional content areas:

- B-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
- B-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
- B-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Example anchoring phenomena to support 3D instruction:

- Peacock tail
- Ant cooperation
- Hox genes

References

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