High School Conceptual Progressions Model Course III

Narrative and Rationale: This model course map is the third course in a three-year course sequence. It uses a customized version of the High School Conceptual Progressions model from NGSS Appendix K as the instructional year end goals. The PEs from Course 3 were then arranged into five different bundles of PEs based on a conceptual flow throughout the year.

Course 3 begins by expanding upon what was learned in Course 1 about ecosystems and heredity by taking a deeper look into the evolution of Earth systems and organisms. The course then focuses on how humans influence Earth systems and vice versa. It is important to note that the practices and crosscutting concepts described are intended as end-of-instructional unit expectations and not curricular designations – additional practices and crosscutting concepts should be used throughout instruction in each bundle.

Bundle 1: Evolution of Earth ***~5 weeks***	**Bundle 2:** Evolution of Life ***~7 weeks***	**Bundle 3:** Human Influence on Earth ***~8 weeks***	**Bundle 4:** Earth's Impact on Humans ***~4 weeks***
HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. **HS-ESS1-6.** Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. **HS-ESS2-3.** Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.[1] **HS-ESS2-7.** Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [1]	**HS-LS2-1.** Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. **HS-LS2-2.** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. **HS-LS2-6.** Evaluate the 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. **HS-LS2-8.** Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. **HS-LS4-1.** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. **HS-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. **HS-LS4-3.** Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to	**HS-LS2-7.** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* **HS-LS4-6.** Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* **HS-ESS2-7.** Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. **HS-ESS3-2.** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* **HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* **HS-ESS3-6.** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. **HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. **HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a	**HS-ESS3-1.** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. **HS-ESS3-3.** Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. **HS-ESS3-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

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	increase in proportion to organisms lacking this trait. **HS-LS4-4.** Construct an explanation based on evidence for how natural selection leads to adaptation of populations. **HS-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.	range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **HS-ETS1-4.** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	

1. The bundle only includes part of this PE; the PE is not fully assessable in a unit of instruction leading to this bundle.

High School Conceptual Progressions Course III Flowchart

Bundle 1

PS1.C as found in HS-ESS1-5 and HS-ESS1-6
- Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other minerals.

ESS1.C as found in HS-ESS1-5
- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.

ESS1.C as found in HS-ESS1-6
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.

ESS2.A as found in HS-ESS2-3
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.

ESS2.B as found in HS-ESS1-5
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history.

ESS2.B as found in HS-ESS2-3
- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

ESS2.D as found in HS-ESS2-7
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.

To LS4.C in Bundle 2

ESS2.E as found in HS-ESS2-7
- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.

To LS4.C in Bundle 2

Bundle 2

To ESS3.A in Bundle 4

LS2.A as found in HS-LS2-1 and HS-LS2-2
- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

LS2.C as found in HS-LS2-2 and HS-LS2-6
- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

LS2.D as found in HS-LS2-8
- Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

LS4.A as found in HS-LS4-1
- Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

LS4.B as found in HS-LS4-2 and HS-LS4-3
- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information — that is, trait variation — that leads to differences in performance among individuals.

LS4.B as found in HS-LS4-3
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.

LS4.C as found in HS-LS4-2
- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.

LS4.C as found in HS-LS4-3 and HS-LS4-4
- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.

Bundle 3

LS2.C as found in HS-LS2-7
- Moreover, anthropogenic changes (induced by human activity) in the environment — including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species.

LS4.C as found in HS-LS4-6
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species.

LS4.D as found in HS-LS2-7
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).

LS4.D as found in HS-LS2-7 and HS-LS4-6
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

ESS2.D as found in HS-ESS2-7
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.

ESS2.D as found in HS-ESS3-6
- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere.

ESS2.E as found in HS-ESS2-7
- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.

ESS3.A as found in HS-ESS3-2
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

ESS3.C as found in HS-ESS3-4
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

ESS3.D as found in HS-ESS3-6
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Bundle 4

ESS3.A as found in HS-ESS3-1
- Resource availability has guided the development of human society.

ESS3.B as found in HS-ESS3-1
- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

ESS3.C as found in HS-ESS3-3
- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

ESS3.D as found in HS-ESS3-5
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

LS4.C as found in HS-LS4-3

- Adaptation also means that the distribution of traits in a population can change when conditions change.

LS4.C as found in HS-LS4-5

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species.
- Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

To LS2.C and LS4.C in Bundle 3

ETS1.A as found in HS-ETS1-1

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

ETS1.B as found in HS-LS2-7, HS-LS4-6, HS-ESS3-2, HS-ESS3-4, and HS-ETS1-3

- When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.

ETS1.B as found in HS-LS4-6 and HS-ETS1-4

- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

ETS1.C as found in HS-ETS1-2

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.