Unit plan
Daniel hartzog
TIP Evolutionary Biology 2020

Abstract

Young children need more science instruction now more than ever. There is a new focus on nonfiction reading instruction within the literacy block. And scientific thinking creates the foundation for analytical thinking that not only makes children better students but also better global citizens. The teaching of evolution to young children needs to be structured in a way that the information builds on prior knowledge the children have but also so that it attempts to avoid possible misunderstandings about this very complex material.

The unit is designed for a diverse class of 5 and 6 year old kindergarteners. It will draw students' attention to the variation within species, not just the variation between species. Students will develop vocabulary around evolutionary concepts. The unit will show that many organisms have two parents and that individuals inherit their traits or characteristics from their parents. Whether these traits help an organism to survive or not in an environment affects how many offspring this organism will have. The more survival, the more individuals, the more offspring there is. This unit will help to create a solid foundation on which children will be ready to learn about evolution, necessary for understanding how ALL biology works.

Overview

There is a growing trend in elementary education to solely focus on reading and writing and math skills. The reason children learn to read and write is to learn about the world. School districts are neglecting curricular focus on content knowledge as they focus on skill-based instruction around reading and writing. Teachers and students need more time to explore and acquire content knowledge about topics of interest to young children. And children need information that will form the foundation for later learning. Teaching young children about evolution and how it works not only expands children's knowledge base by addressing critical questions but also helps them to develop analytical thinking skills that will make them better learners as well as better global citizens.

My curricular unit will be presented to my kindergarten students, 5-6-year olds, in the spring. The learners will be prepared in the fall as we build excitement about scientists and how they study the world. We will need to develop some common vocabulary like "living" and "nonliving." With kindergarten aged children it is necessary to understand what prior knowledge on the topic the children have. Often it is best to teach these basic concepts as new learning even if many children come to school knowing these terms. Young children love to share what they already know. This experience of covering known information develops confidence and rarely results in the "I already know this" problem that teachers of older elementary students may face. We will illuminate the relationships of family- parents, offspring, children, siblings. We will discover that all living things came from parents. We will study wolves and bears in depth, learning that different animals share characteristics and body parts but they also differ depending on their habitat, prey, mating habits. In the winter we will investigate and uncover that animals get everything they need from their habitat. We will investigate that there are not enough resources and there are conflicting forces that ensure that not all living things will survive. Each of these units are necessary predecessors to understanding evolution.

In Spring, the seeds of biology and scientific method will have grown into a great fruitful vine, and we will be able to crack into the ripe fruit that is this evolutionary biology curriculum. In April we will wonder at variation among living things. Then zoom in and wonder at the variation within single species. We will have talked all year long about the seemingly endless variations in our similarities: our noses, our hair, our eyes. These attributes are ruled by genes. With a few different games we will begin to observe the randomness with which these genes operate. And only over a long period of time and across many many individuals and generations can we begin to describe evolution. Using classmates, school staff, local animals and domestic animals we will thoroughly exhaust the reality that there is variation within species. After a visit from or to the Goat project we will together create a family tree of inherited traits for several of the young kids. Finally, we will play a game of monster/robot family tree which will introduce the element of randomness in biological evolution.

Rationale

Young children have an internal struggle between imagination and fact. It is natural for children to remain in the concrete, the physical, the practical. But when they confront abstraction, envision theory, and draw conclusions they can find these modes of thinking challenging and instead rely solely on imagination, creativity, or supposition to answer scientific questions and explain their observations. Teaching young children about evolution will be an exercise with counterintuitive thinking. Children are egocentric and think of the world with themselves at the center. This experience is similar to the heliocentric thinking of scientists of the past.

One of the strengths of teaching Evolution is that it explains the immense diversity and complexity of life on earth. It is counterintuitive to think that all of this variety originated from shared ancestors. But of course, this is true. Experiencing an investigation into evolution prepares students to apply analytical thinking when presented with something that is counterintuitive or even scary or challenging to think about. It is easy and not surprising for people to see design and planning in the natural world (teleology). Some children are more anchored in teleological thinking than others. For some children, it is easier to balance an intuitive approach to learning versus an analytical approach. The experience of learning a challenging concept such as evolution will help illuminate these differences in learning styles. The teacher can then help children to grow their thinking in new directions. Children (and plenty of adults) tend to draw immediate, intuitive conclusions. Science gives educators an opportunity to require children to slow down and weigh the facts, to use observable data and to draw conclusions from the data collected rather than to create a preliminary, intuitive idea and argue against any contradictory data.

A unit in evolution can direct children to practice more flexible thinking. It will help them to develop trust in randomness. And finally, this study can eventually help to disprove natural design and challenge the idea that homo sapiens are some ultimate culmination of evolution, that we are the predetermined “perfect” ending to the process of evolution.

Objectives

This Unit is planned to serve a diverse kindergarten class of students aged 5 and 6. The classroom is self-contained with thematic curriculum that weaves reading, writing, math, science, and social studies together.

The objectives of the class will include:

1- There is not just variation between species but also variation within a species.

2- Understand “characteristic” as “trait”.

3- Many living things have two parents and individuals get traits from each parent.

4- Animals are adapted to their environment. Animals compete for resources within habitats and are suited to find food, mates, homes, etc.

5- Observe physical characteristics that are adaptations responding to environmental conditions/factors. Different animals have different needs. Observe different animals’ needs to understand differences in habitats. Animals respond to the changing seasons in different ways. Animal traits are expressions of genes (genetic codes) inherited from their parents.

The inheritance is random but the effect on the animal's fitness is (evolution).

Background

In common usage, people understand evolution as change. Often people hear the connotation of the word evolution as change in the direction of improvement. It is hard to understand biological evolution if we are saddled with this connotation. Evolution is change, and it is change in the direction of adaptability or fitness in terms of survival, but it operates on an underlying randomness that people have a very hard time accepting. We want to be here for a reason, for a purpose. Biological evolution explains it more as a coincidence with an infinite number of variables that bring us to the point we are now.

Evolution is NOT a theory. It is simply an explanation of a plethora of facts. Evolution has been said to be the central binding idea of biology (Dobzhansky, Nothing in Biology Makes Sense Except the Light of Evolution). It is a fact that mutations occur which create variation. It is OBSERVABLE. But WHY do species change?! There are several ways DNA differences within genes can result in evolution; genetic drift, genetic mutation, migration, and natural selection. The theory of natural selection is what most people think of as evolution. But natural selection is only one way that species evolve. It is necessary to understand that individuals do not evolve. Evolution describes change in a population. Kindergarteners probably don’t understand that species have changed. Historically, people didn’t start thinking about species changing over time until theories in geology and astronomy started opening up the possibility of great expanses of time. Uniformitarianism, things operate now much like they have in the past and vice versa.

The history of the scientific theories that lead up to our understanding of evolution is compelling. It might give some insight into the ways we can introduce contradictory ideas into young children’s minds. Most people think the idea of biological evolution started with Charles

Darwin. That species evolved was observed by many people before Darwin wrote his historical marker of a text; <u>On The Origin of Species</u>. These scientists did not yet understand the mechanisms of evolutionary change so their understandings of evolution were incomplete. Darwin used the term "descent with modification" to describe the mechanism of change. Looking at entire populations (thanks to Thomas Robert Malthus) Darwin posited that survival of each individual was not possible and that environmental factors would select the individuals most suited for the ecological pressures. These individuals would survive and reproduce in larger numbers therefore ensuring the survival of their traits. Individuals with traits less suited to the environment would reproduce less and produce less offspring. This mechanism he referred to as natural selection. Darwin provided an explanation of HOW evolution happens, NOT simply that it happened… In On the origin of species, Darwin explained the process of evolution by suggesting that ALL species have descended, without interruption, from one or a few original forms of life, and that it is Natural Selection that is the causal agent of evolution. While genetic variation is always random, the variations that are useful to an organism will assuredly enable the organism to survive better and be more likely to pass on their genes. Some genetic variations are fatal or do not coincide with a greater fitness to the environmental conditions (the likelihood that individuals will survive and then produce more individuals that share its genes and physical traits). Later, scientists have combined natural selection and Mendelian genetics to create a grand unified theory of evolution referred to as modern synthesis.

All four processes of evolutionary change (genetic drift, genetic mutation, genetic migration, and natural selection) and the subsequent inheritance of traits are happening simultaneously. Each form of genetic variation listed above functions in evolution differently. But the way in which the DNA of organisms is passed on to offspring always operates the same way. Therefore, explaining how heredity works is necessary to understanding evolution.

Every organism contains deoxyribonucleic acid, or DNA, that provides cells with the necessary instructions about how to operate, grow, and how they should reproduce. DNA consists of only four different amino acids; cytosine, guanine, adenine, and thymine. The double helix structure of the DNA molecule allows for a shockingly large number of variations. Yet the two chains that make the double helix also contain exact duplicates of each other to help to reduce the chances of mutation. Whenever a cell is getting ready to reproduce, the chromosomes which house the DNA strands create two identical copies of the DNA molecules. One stays in the original cell and one moves to the daughter cell. This process has many regulators but it does make errors from time to time. This rare error is where variation in living organisms begins. The changes in the DNA are mostly unnoticed, unhelpful, or harmful to the organism. The changes in the DNA can sometimes result in variation in physical traits. Certain parts of the DNA strand control for different structures, cellular operations, etc. These "parts" scientists refer to as genes. Genes are defined or described as certain locations on the DNA strand. They are marked by start and stop codons. Genes will look similar across many species. Within a single species, specific genes will still have some variety which result in variation in the organisms. These different variations of a gene are referred to as alleles. And alleles are a particular form of a gene that is usually distinguished from other alleles by its effect on phenotype (the observable traits or characteristics of an individual that are dependent on an allele.) All of this genetic information is critical in understanding, observing, and following evolutionary change.

Understanding the mechanics of genetics allows one to observe the relationship between changes in individuals that create variation and the change in populations that is evolution. While all genetic change happens randomly, the ways in which populations change can be described in several different ways. Genetic Drift is when allele frequency changes due to random combining of alleles and then some random forces that define allele survival. Genetic drift is not dependent on the environmental fitness of the individual. It is variation controlled by random variation and mathematical probability. Some traits that are neither detrimental nor helpful are passed down from generation to generation due to mathematical probability. Genetic migration is when allele frequency changes due to new genetic material being introduced into one population from another population. It is natural selection that is the only manner of change that is due to influences from the environment. In this situation, the frequency of alleles within a population increase or decrease due to the traits' benefit or detriment to the individual within a specific environment. Natural selection is the change in a population as a result of fitness of character. Better fitness in individuals of a certain phenotype will result in their having more babies, therefore producing more individuals like itself. And this phenotype will increase in numbers. Natural selection is the only evolutionary force that causes the evolution of **adaptive** features of organisms. Here, the environment chooses between phenotypic variations.

Phylogenetic trees are one of the most common ways students learn about evolution but, beware, there are many opportunities for students to misinterpret what our fossil records have taught us about evolution. Many children (and adults) have images stored in their memories of this "tree of life." They access these images when trying to imagine how organisms around the world and throughout time are related. These relations and the conclusions we draw from these relations are not as simple and direct as many people believe. Here are some evolutionary concepts that need to be taught explicitly… Most species go extinct. There is not a goal to evolution. Homo sapiens are not the final step or inevitable goal of evolution. Similarities in phylogeny do not necessarily indicate ancestral relation.

The expanse of geologic time and the vast number of individuals and species that have existed on our planet are challenging concepts for people to hold in their minds. This challenge makes it easy for confusion, disbelief or even denial about the information held in a phylogenetic tree to reify. The phylogenetic tree is a hypothesis of what organisms on our planet may have looked like. At first, it was based on observable traits and common characteristics, and later on genetic information and DNA analysis. Most of the evidence scientists use to create this ancestral tree comes from our fossil record. It is miraculous that fossils have formed and even more impressive when we find one. Obviously, our body of evidence to create this tree is shoddy. It turns out most species that ever lived are now extinct. Some proposals suggest that nearly 99.9999999999% of species that ever lived are now extinct! So even though there is much detail missing from our working trees, they do present a convincing argument that there is descent with modification as Darwin proposed. The tree of life was the one illustration in the Origin of Species in 1837. In an illustration of a phylogenetic tree, time is a variable from bottom to top, either moving back or forward in time. Whichever way it is illustrated, as time moves forward one can see that variation increases.

Phylogenetic trees are a work still in action. We are continuing to gather new fossil evidence and we continue to apply DNA analysis in order to refine our understanding of relation and ancestry between species. Without strong guidance, students might imagine that evolution occurred but is no longer *occurring*. Students might think-- Humans were achieved. The tree is done growing. They cannot see new species developing. Students must be dissuaded from depending on teleological thinking when looking at evolution. Using trees can easily reinforce this perception. Speciation events, when ancestral lines diverge and new species are established, are only observed occurrences. They are not planned, ordered, or presumed. We must remind ourselves (and our students) that as logical as nature seems, or how smart a hummingbird's beak appears, their appearance relies primarily on chance. Extinction does not occur from bad design or stupidity in the species but instead with its timely ill fitting with its environment. What works well in one time or place might not work well in a different time or place. Evolution is incremental change that is based on randomness and has an efficiency that maintains nearly 100% of an species' original DNA even as it changes into a separate species. A phylogenetic tree is best read from top to bottom or bottom to top, it can be misleading to read it left to right. To see closeness or genetic relation between two species, one MUST follow the lines. The horizontal lines are often meaningless but the length of connection that represents the passage of time are critical to show relationships.

Early models of the phylogenetic tree depended on observation of physical characteristics. Scientists observed fossil records noticing similarities and differences between specimens. There were noticeable incremental differences in bone structures of organisms. These slight additions and changes to structure and the age of fossils can then be synthesised to suggest ancestry. It is unavoidable to see the similarity of arm bones in many vertebrate animals. But this physical observation can also be misleading. The wings of a bird and the wings of a bat might look similar and function similarly but they are not genetically related. These convergent traits (physical or functional similarities in organisms that are not genetically related) can be misinterpreted as shared heredity by students of evolution. It can be hard to imagine the independent evolution of similar traits. Studying The tree of life, comparing the location of homologous traits (traits in different species that share a common ancestor) can again illuminate the randomness in evolution and the surety of genetic lineages. It then illustrates the clade (a taxon that consists of all the descendants of a common ancestor). If we are looking for what looks sensible or what is logical we could miss what really happened and lose an opportunity to embrace the randomness and variation that is evolution.

Strategies-

Young children are natural observers but they still need to be taught how to observe scientifically; to think about what they see and not to see what they think they see. Students need to practice applying analytical thinking before drawing a conclusion based on intuitive self-centered logic. Activities, conversations, and investigations designed by the teacher have to be considered carefully to ensure that misconceptions can be avoided and that the teaching point is clear. Using a KWL chart to assess what children think they know before starting to teach on a subject is useful. Teachers must be prepared to UNteach that which is erroneous or detrimental from developing concepts based on scientific rational thinking and observation.

Lessons and Activities

1) **Variation is variation**

Connect to prior learning of the Fall curricular unit- “We are different, we are the same.”

Show, post, or display collection of images that show variation within a species.
Create a set of images that show variations within species- pigeons, dogs, plants, etc. invite the children to talk about what they notice: not all pigeons look the same, not all humpback whales look the same, not all mayapples look the same. They might notice features, colors, sizes etc.

Look at <u>Animal Faces</u> by Akira Satoh.
“In this book, you will be looking at photographs of animal faces, which for a particular species of animal you might expect to look very much alike. But in fact, for each of the 24 species of animals included in this book, each one of the 21 photos for that animal show a different face.It is up to you to discover how they all differ from each other.” Amazon description

What do we observe?
Teacher will color copy a few, select pages from the book. Make 2 copies. One copy leave as an intact array. The other cut into individual cards. Disperse these cards to the children in the class individually or in thinking partnerships.
Pick one face (a cut card) then try and find the one in the array that matches the face you studied. How did you recognize it? Notice the differences in the individuals- broader brows, longer noses, hair growth patterns, coloration, etc. Chart the descriptive words the children use.

Follow up activities, can be done at other times (reading, writing, etc

After reading appropriate Jane Goodall biographies, find and read Jane Goodall’s descriptions of individual chimpanzees (reference). How did she tell them apart? Fifi, Flo, Mr. McGregor, David Greybeard. Notice their individual differences. Discuss how her methods as a scientist were controversial but also lead to great breakthroughs in primatology.

Look at your school’s “Staff School Picture.” Focus on one attribute- hair, eyes, nose, mouth.. Etc. Look at all the variation. Can we find similarities? Create “traits”. ie hair color, length, texture, eye color, eye shape, lips size and balance etc. Try to create continuums rather than polarity in these differences.
Create student pairs and use a mirror to describe variations between each other- shared or differing. Return to the whole group to chart traits and variations that are observable amongst our class. Record their statements about variation between individuals of a species.

2) Heritable Trait Tree, Traits are heritable

Revisit family trees (we made family trees and shared them in the fall as we learned "family vocabulary"). Share mine. Use drawings or photos to represent my family including children, parents (and Grandparents?) Look for observable traits that are inherited. Look for William Wegman's Family overlays. These pictures can help make connections to previous lesson on school population traits.

Label the parts of a family tree, parents, grandparents, offspring, siblings, generations

What do we notice? Are there some traits that are shared? Between siblings? Across generations?

Extension activity- Invite families (parents) to share pictures of what they looked like when they were your students' age. Bring these photos into class and display them in an array. Invite children to look for resemblances between the pictures and their classmates. Discuss which pictures are whose parents and what evidence can the students can present to back up their predictions.

Goat Project visit our school or we can take a field trip to Philadelphia Goat Project.
Observe goats. Photograph individuals. Collect and chart observations of variation. Collect data on family trees from the staff. Make familial connections that show heritable traits.

<u>Heritable Trait tree</u>

Use Goat families to create family trees. These family trees will focus on fur coloration and ear attributes and beards. Model for the students what this goat family tree will look like.

Nigerian Dwarf goats have three major hide color variations: Black chocolate, gold and spotted with those two colors. They also tend to have short, erect ears
Nubian Goats tend to be red, black, or white spotted. Nubians have big floppy ears.

Mini Nubians are a cross between Nubian and Nigerian dwarf goats.
Create a theoretical heritable trait tree together. Students will generate traits with the roll of a die. Ears and coloration are the variables and are assigned numbers on the dice.
Red die: ears 1-2 floppy from the base of the ear. 3-4 floppy in the middle of the ear. 5-6 straight and erect ears.
Green die: coloration 1-2 Gold 3-4 spots of gold and black chocolate 5-6 Chocolate

Extensions:
Create robot or monster trees that have clear traits.

What did we learn from studying the goats and from studying our families?

Create "robot" family trees.

Present students (individually, in partnerships, or in teams) with robot family trees with missing characters (or missing links etc.).
Children can create drawings to represent robots with various missing traits within a created tree. The traits will be chosen by a roll of the die, each number representing a different trait. The robots could have antennae (straight, crooked, or spiral). They could have 1, 2, or 3 eyes.

3)Things that have more babies will have more things that look like them

Create a random environment generator… The changes in the environment affect survival. The organisms that survive have more babies and will produce more babies that look like it.

I draw a snake, you draw a snake (or fish, lizard, dog) they all look different. Which survive and which perish is due to environmental conditions. Children will each draw one or two of these animals. Tell the children to think about variation in a species. Be creative. Look at all the organisms and notice and discuss variation of traits among the creatures. Describe to the children in a dramatic voice an environmental change that occurs in the animals' habitat--torrential rains, invasion of predators, meteorite impact, etc. This change threatens ones with specific traits (skin color, size, spots, large or small ears etc.). Explain that the survivors will have more children that look like them, the dead ones won't. The next generation will be more of the same.

Hands on activity to model individuals' sensitivity to habitat.

Tell a story about Darwin's finches. Explaining that Darwin noticed that similar finches had different beaks that served different purposes.
Present children with a pile of spoons and a pile of chopsticks. Explain that these we will use like the finches use their beaks. We will use them to collect food. The more food you can get, the more you eat, the more likely your survival and reproduction. Disperse these tools amongst the students using a randomized choice maker (choose a number, roll a die, flip a chip etc). Remember to record which student uses which tool. Present a challenge- pick up as many marbles as you can. Notice which tools (beaks) work better. Invite the children to share what they noticed. Tomorrow do it again quickly with another food source or various food sources (marshmallows, cheerios, bagels, etc) or on a different surface (rug, tile, grass etc). Create a challenge that will provide an opportunity for the other "beaks" to find success and survive. Again, invite the children to share what they noticed.

Extensions to explore:
CONCEPTS:
All life evolved from shared ancestors over billions of years and is not designed is counterintuitive but not if we start early?
Fight teleology- that things are designed with a purpose

Talk about how scientists have changed their ideas based on observations just like we can!
Evidence of Evolution: common ancestors
-Arm bones similarities and differences
-Link Form to function bear's vs wolves' legs, snouts, and ears

Environment selects for fitness: Organisms fit their environment.

Urban wildlife (Some animals don't mind living with people. They can fulfill their needs in a human or even urban environment. Some are omnivores, some are carnivores, others are herbivores). Discuss the absence of predators. How do most people feel about having predators around that pose a risk to humans?

Tell the Story of Coyotes, how they are making a comeback.

Selective breeding: Humans can breed animals to enhance or decrease traits that they prefer fr a specific purpose.
Remember goats? Tell dachshund story- selective breeding to produce desired traits (beware- this may elicit ideas of etiology.)
Tell the sad story of the Dole Banana.

Show that variation can also be seen in plants-

-Flowers- using books and possible school campus and neighborhood flowers, notice and describe traits and variation among flowers. Read Reason for a Flower. Talk about why different flowers are (need to be) different. Focus on the relationships between plants and their environment and between plants and animals (pollinators)

How are these traits inherited? DNA.

Strawberry DNA extraction experiment to show DNA

Bibliography

https://www.nextgenscience.org/

https://evolution-institute.org/best-way-to-teach-evolution/

https://evolution.berkeley.edu/evolibrary/teach/index.php

https://evolution.berkeley.edu/evolibrary/teach/k2goals.php

https://whyy.pbslearningmedia.org/resource/nvev-sci-mission1/nova-evolution-lab-interactive-lesson-mission-1/

https://lsintspl3.wgbh.org/en-us/lesson/nved-il-evolab-m1/

https://www.nsta.org/about/positions/evolution.aspx

https://www.sensoryecology.com/games/

https://www.evolutionsociety.org/content/education/resources-for-teachers-and-students.html#eo1

https://miniaturedairygoats.net/mini-nubian/

Content Standards

SL.K.1

Participate in collaborative conversations with diverse partners about *kindergarten topics and texts* with peers and adults in small and larger groups.

SL.K.2

Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood.

K.MD.A.2

Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. *For example, directly compare the heights of two children and describe one child as taller/shorter*.

NGSS PRACTICES

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

CROSSCUTTING CONCEPTS OF THE NGSS FRAMEWORK

1. ***Patterns.* Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.**
6. ***Structure and function.* The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.**
7. ***Stability and change.* For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.**

Keywords
Kindergarten, Science, Evolution, Heredity, Traits, Variation,