Curriculum Units by Fellows of the National Initiative
2016 Volume VI: Making Sense of Evolution

Gotta Evolve 'Em All! Evolutionary Ideas for 1st Graders

Curriculum Unit 16.06.03, published September 2016
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Introduction

My students look out the window and see a variety of life. Birds flit from tree to tree, each bird and each tree different but closely connected. We talk about our pets: dogs, cats, guinea pigs, snakes. We look at the animals in our classroom: snails, guppies, millipedes, pill bugs, students, teacher, and the spiders and flies who routinely visit us. Why are there so many different kinds of plants and animals not only in the world around us but also just in our range of vision?

Evolution and first grade, not necessarily two things that one thinks will go well together. Building upon our present Science curriculum, I see a natural extension of our learning. I currently teach a Science unit for 1st grade on organisms and we learn about living and nonliving things. One of the concepts that we learn is that individuals change over time. We get taller; our features may change; depending on our species we may, through metamorphosis, change into an adult that looks totally different than we did as a juvenile. Changes in an individual are all seen in a lifetime. Nonliving things do none of those things, at least not unless they are acted upon. What I want to explore with my students is how and why does a species change over a longer period of time such as generations? The majority of students have not been exposed to this idea. I will “hook” the students with a discussion of evolution featuring Pokémon. We will discuss natural selection and adaptation and adapt Mr. Potato Head or another character to his changing environment. We will discuss how we know that whales evolved from land animals and how their ancestors' bodies changed to what we see today and then we will move on to birds and how they evolved from dinosaurs and how that happened. Finally, we will evolve our Pokémon according to the rules of natural selection.

Background

The elementary school where I teach, Kathleen H. Wilbur Elementary School in Bear Delaware, is comprised of many different kinds of students with a variety of beliefs and experiences. Our school has approximately 1200 students from Kindergarten through 5th grade and pulls from a wide geographic area in the Colonial School District. There are nine 1st grade classrooms grouped together in three clusters of three rooms. This year I will have up to 25 students from Hispanic, African, Caribbean, Asian and Middle Eastern cultures as well as students whose families are from the United States. My classes, historically, have been around 50% African American, 30% White and 20% other ethnicities and are usually a close split between boys and girls. Socio-economically, my class will also be diverse with all economic classes represented from students living in "McMansions" to students who are homeless. My school is a Title 1 school and qualifies for free lunch for all students.

Most of my students' life experiences are very basic. They rarely get out of their neighborhood and most do not play outside except at recess. We live about one hour from the ocean yet many of my students have never seen it, yet alone gone swimming in it. The sum total travel experience of many students is the shopping trip to Walmart and the weekly attendance at their family's house of worship. Most experiences are virtual through TV, movies, and video games. Many students will be familiar with the word "evolution" through popular culture mediums such as Pokémon and other video games, movies, and television shows such as X-Men and Spiderman where characters are said to evolve. Some students will have background knowledge of dinosaurs through the Jurassic Park movies but others will have only a vague idea of what dinosaurs were and when they lived.

Our grade level teaches Math and Language Arts four days a week. Science, in rotation with Social Studies, is taught one day a week for the whole day rather than daily in 50 minute blocks. This allows for deeper conversation and experimentation with the concepts we discuss. Language Arts and Math concepts are integrated into the instruction on those days, where appropriate.

Rationale

Over the past 8 years of teaching 1st grade science, I have noticed an interesting trend. At the beginning of a unit, many things that can be explained by my students scientifically are usually explained by them theologically. Why does it rain? God makes it rain. After learning about the water cycle, students are much more likely to bring up evaporation, condensation, and precipitation rather than God's will as the reason for a day's indoor recess. When we talk about organisms, many students are likely to say that animals are the way they are because that is the way God made them. While being sensitive to the students' varied religious beliefs, we will explore the scientific reasons that organisms are the way they are today and how these organisms have changed over time.

Objective

This is a unit for 1st and 2nd grade classrooms and will address the Next Generation Science Standards 1-LS3-1 Heredity: Inheritance and Variation of Traits, 2-LS4-1 Biological Evolution, and the Common Core State Standards for Speaking and Listening and for Writing. My ultimate goal is for students to be exposed to the ideas that evolution does not happen in a generation or two nor do adaptations spring forth all at once as they did when Peter Parker was bitten by the radioactive spider and became Spiderman; it takes many, many generations to occur. To do this we will discuss the basics of natural selection and how this process contributes to evolution. We will discuss how Pokémon “evolve”. We will investigate how whales evolved from land animals, who themselves had evolved from water animals, and how their bodies adapted to their environment. We will then discuss how birds evolved from dinosaurs. We will revisit Pokémon and discuss how they don’t really evolve. For our culminating activity, students will choose a Pokémon (or other organism), design adaptations that their creatures will evolve, and will identify why those adaptations were key to the survival of the species. Students will also provide transitional forms to show how their creature changed over time.

It is important to note that this unit is not designed to prove the truth of evolution nor to counter claims based on religious beliefs or “Intelligent Design”, it is intended only to give students information, based on scientific fact, as to how evolution occurs in the natural world. If students are playing Pokémon Go and watching the shows and movies that use the words evolution and evolve, they need to understand that the pop cultural definition of evolution is not the same as the scientific fact.

Concepts

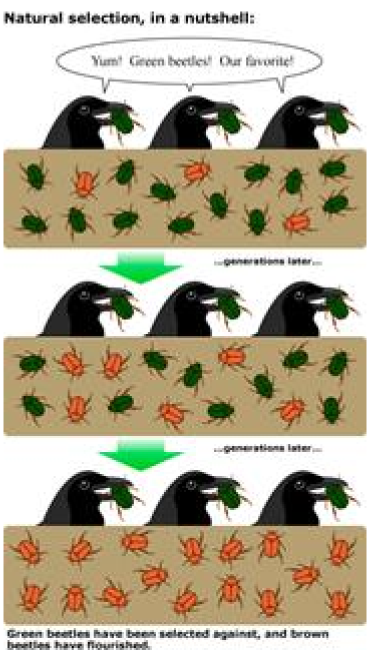
Evolution

Evolution. Charles Darwin. Survival of the fittest. Only the strong survive. We all know what evolution is, or at least we think we know. Oh, and it is *only* a theory. Charles Darwin published his theory for how natural selection drives evolution in 1859 and there has been much scholarship on it ever since. Instead of going back to Darwin’s work “On the Origin of Species” we will use noted University of Chicago professor Jerry Coyne’s definition of evolution: the theory of evolution can be summarized as so, “Life on earth evolved gradually beginning with one primitive species - perhaps a self-replicating molecule - that lived more than 3.5 billion years ago; it branched out over time, throwing off many new and diverse species; and the mechanism for most (but not all) of evolutionary change is natural selection.”[1] Organisms change over time. Not just in our lifetimes as we are born, grow and die, but over generations as we, as a species, adapt to our surroundings. Organisms cannot decide to evolve nor does evolution involve any effort on the part of the organisms. How and why does evolution occur?

Natural Selection

The major engine of evolution is natural selection, “A process in nature in which organisms possessing certain genotypic characteristics that make them better adjusted to an environment tend to survive, reproduce, increase in number or frequency, and therefore, are able to transmit and perpetuate their essential genotypic qualities to succeeding generations.”[2]

The website Understanding Evolution from the University of California has a simple illustration of natural selection. Imagine there is a population of beetles some brown and some green. The green ones get eaten by birds because they are more readily seen. More brown ones will survive to reproduce thereby creating more brown beetles because color is hereditary. Over time, the green beetles will disappear and only brown ones will remain.[3]



We hear the phrase “survival of the fittest” and we assume that the fittest is the strongest, but fitness is not necessarily physical. The Understanding Evolution site defines fitness as: “Fitness is a handy concept because it lumps everything that matters to natural selection (survival, mate-finding, reproduction) into one idea. The fittest individual is not necessarily the strongest, fastest, or biggest. A genotype's fitness includes its ability to survive, find a mate, produce offspring — and ultimately leave its genes in the next generation.”[4] (A genotype, in case you were wondering, is the genes that make up an organism, the genes that cause all of an organism’s traits). Do students see “survival of the fittest” in their lives?

And what causes these genetic differences between individuals? The cause is mutation, defined by the Understanding Evolution site as, “a sudden departure from the parent type in one or more heritable characteristics, caused by a change in a gene or a chromosome.”[5] Most mutations are either harmful or neutral, but on rare occasions, a mutation might prove useful or beneficial to the organism. If the mutation is beneficial, as the organism reproduces the trait will become more prevalent in the next generation and eventually spread throughout the population. We call this beneficial mutation that has spread to become a typical part of the species an adaptation. It is important to remember that mutations are changes in traits that already exist in the species; they almost never create brand new features. If your species has four appendages, two can evolve into wings but you cannot grow a set of wings where appendages are not present already. You cannot have six limbs; your developmental plan limits your appendages to four.[6] The bottom line? All evolution starts with mutation of preexisting features.

Adaptations can be structural or behavioral. An example of a structural adaptation is how the beaks of some bird populations elongated over time, allowing better retrieval of flower nectar in response to living in an environment with this food resource. A behavioral adaptation is the way an organism acts in response to its environment in order to survive. A behavioral adaptation would include how some animals (whales, caribou, wildebeests, etc.) migrate every year in search of food or to birth their young in an environment with more abundant food.

Some adaptations are called exaptations: adaptations that evolved for one purpose but are used for another. This idea was put forward in 1982 by noted paleontologists Stephen Jay Gould and Elizabeth Vrba in the journal Paleobiology. We cannot necessarily tell why a feature was adapted just by looking at how it is used today. An example of an exaptation is the feather, which evolved on dinosaurs most likely for insulation and warmth but is now beneficial for flight.[7]

Other adaptations become vestigial: "(of certain organs or parts of organisms) having attained a simple structure and reduced size and function during the evolution of the species."[8] These vestigial adaptations are no longer beneficial but are not detrimental to the organism, either. Among vestigial traits that we have as humans are our appendix, our coccyx or tailbone, the Arrector Pili or goosebumps and wisdom teeth. In whales, you can see vestigial hind legs that are no longer connected to the spine and flightless birds such as the kiwi still have small wings.

Common Ancestor

Natural selection means that all living things (except maybe viruses but that is for another unit) share a common ancestor, even though we do not currently share any obvious traits with them. How is this possible? The evolutionary biologist John Maynard Smith used a word game to help describe how this works, going from "word" to "gene" in four mutational steps. We can use this example of transitioning between words to show how a variety of species can come from a common ancestor with this simplified form.

1. lamp -> lame -> came -> cane -> cone
2. lamp -> lame -> lime -> time -> tire

If we take the word "lamp" and change the p to an e (like a mutation of the genetic code) we get "lame". Then the word mutates again to "came". A further mutation takes us to "cane" and finally to "cone". We have mutated the word lamp to cone. None of the letters remain the same but it is still a word. The word correlates to an organism (and the fact that it is a word and not a nonsense word means it is viable) and the letters to DNA. If, instead, we change the word "lame" to "lime" and then continue to mutate and evolve to "tire" (as in example 2), the closest common ancestor to tire and cone is lame but they still come from the word lamp. So whatever single cell organism that started the whole process (lamp in this example) used the same building blocks in its DNA as modern organisms (cone and tire) and, over almost 4 billion years, life has slowly evolved into the variety of species we have today.

Theory

We should also discuss what a theory is. In our everyday usage, a theory is an idea or a guess about what we might think about something. A scientific theory is different, it is "a coherent group of propositions formulated to explain a group of facts or phenomena in the natural world and repeatedly confirmed through experiment or observation."[9] A scientific theory is not a "guess", it is a collection of facts. The ideas that underlie these facts are tested through observation and experimentation.

Facts are introduced in 1st grade through our Reading and Writing curriculum. We learn about "Fact and Opinion" but, unfortunately, many students see fact and opinion as a dichotomy. Something is either a fact or an opinion. When they come up against a "fact" that is not true they have a problem identifying it. I will make sure that when we are discussing facts that I stress that facts are true, that they are observed and/or proven. Information is not a fact just because it is not an opinion. It is a fact if it is true. We can receive information that is not an opinion but is also not a fact, either.

David Young in The Discovery of Evolution states that the theory of evolution seeks to explain the large diversity of plants and animals on Earth and how this diversity came about, by providing accurate information on the changes in the history of life that account for the diversity. Inferences about what happened in the past are based on evidence that is found in the present, i.e. the fossil record. The process of natural selection is the mechanism that provides well-adapted organisms. Evidence for natural selection is seen in the processes of life that are being played out, in the natural world, at the present time.[10]

Time

Time is a big part of my students understanding of this process. In our organisms science unit, we see the life cycle, if we are lucky, of the guppy. This plays out in weeks as we get male and female guppies segregated from one another. We combine them in an aquarium and a few weeks later (if they aren't eaten by the adults!) we see smaller versions of the adults swimming around in the tank. Eventually, guppies die and we witness the life cycle from birth through adulthood to death. Children understand the concept of a year, we have 12 months, 365 days, 24 hours in a day, 60 minutes in an hour, and 60 seconds in a minute. They may not be able to tell time but they understand that it exists and moves forward, however slowly that may feel. When we talk about evolution, we will be talking about numbers that are beyond the comprehension of most 1st graders and quite possibly their teachers, as well.

There is a YouTube video (see references for a link to the video) that gives a physical representation of time using blocks. It starts with 1 block the size of a wooden toy block, then ten, then 100 organized in a flat just like in the base 10 blocks that we use in Math. It then starts adding more blocks to show larger and much larger numbers. One million blocks are the size of a house and one billion the size of an apartment building.

Fossils

If present day organisms (or, for that matter, extinct organisms) have evolved from early life forms we should see some proof of this in the fossil record. While we may have heard the term before, what exactly is a fossil and how do the remains of organisms become one?

Fossils "refer to the physical evidence of former life from a period of time prior to recorded human history. This prehistoric evidence includes the fossilized remains of living organisms, impressions and moulds of their physical form, and marks/traces created in the sediment by their activities."[11]

How are fossils made?

Over 99% of species that ever lived are extinct and very few are preserved as fossils and very few of those fossils are found.[12] Why is that? There are a variety of ways that fossils can be formed. Let's look at what happens when an animal dies and is turned into a fossil. Fossils are most easily formed using sediment and water, so if an animal dies and is quickly swept into a body of water before its carcass is scavenged, there is a better chance of getting a more complete fossil specimen. As the body sits on the bottom, the soft tissue of the body decomposes and the hard material, bone, shell, and/or teeth, is covered with mud and silt. Over time, the sediment that covers the bones hardens into sedimentary rock. As the now encased bones decay, the organic material in the bone is replaced by minerals in a process called petrification. Sometimes the bones decay completely away and the resulting void is filled with minerals creating a stone replica of the bone. As the earth changes, the layer of rock gets buried deeper and deeper but then tectonic activity and environmental activity such as rain, wind, and ice change the landscape again and the fossil rises to the surface and it is exposed such that an observant individual can find it.[13]

In order to become fossilized, animals must die in a watery environment and become buried in the mud and silt. Because of this requirement most land creatures never get the chance to become fossilized unless they die next to or within a lake, stream or ocean. Animals also need bone or other hard material in order to make a fossil, which is why there are few fossils of soft-bodied creatures such as jellyfish.

Where are fossils found?

There are three kinds of rock that are found on the earth's surface. These rocks are igneous rocks, which cool from a molten state such as volcanic rocks; metamorphic rocks, which have been changed due to temperature or pressure such as marble; and sedimentary rocks, which are formed through an accumulation of cementing of mineral grains or by chemical precipitation at the Earth's surface.[14] The first two rock types are not formed by processes that are favorable to preserving fossils. Fossils are much more likely to be found in sedimentary rocks.

What can be made into a fossil?

Bones are not the only items that can become fossils. Eggs, footprints, skin and feather impressions, and feces also can become fossils although all these are rarer owing to their more delicate nature. Impressions made by plant material such as stems and leaves can also be fossilized.

The time it takes to fossilize a bone is not well established. Paleontologists, people who collect and study fossils, generally agree that it takes at least 10,000 years and usually much more for bone to turn to a fossil.[15]

As the conditions to create fossils are not easily attained, it is highly unlikely that all the transitional forms from ancestor to descendant will be found. But there is enough evidence in the fossil record to show how certain species alive today evolved.

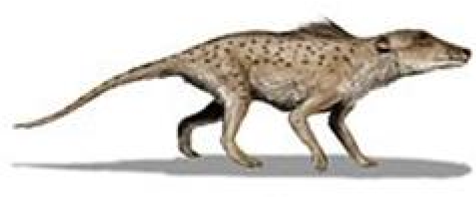
Transitional Forms

As was noted earlier, if modern organisms evolved from earlier organisms we should find fossils showing the transitions in the organisms as they adapted to their environment. If we get to point z from point a, there should be points b through y in between. Scientists have been discovering these transitional forms - "fossils or organisms that show the intermediate states between an ancestral form and that of its descendants"[16] connecting the dots to present day organisms from their earlier ancestors. We have seen how hard it is to create fossils so we cannot expect to have every transitional form from point a to point z. Scientists can infer what occurred using the fossils that have been found and the traits they show as points along a continuum. As evolutionary biologist Neil Shubin explains in the first chapter of his book Your Inner Fish, using what is known about geology, scientists at least have an idea of where to look in the world for other forms that predate or postdate those that have already been discovered. We will look at two species where we can see transitional forms today, whales and birds.

Why Whales?

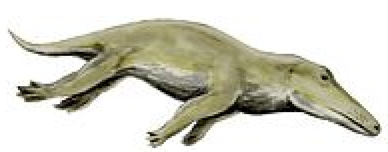
Whales are mammals that live in the ocean. If you look at a whale skeleton you will find vestigial hind legs. These vestigial rear legs are evidence that whales evolved from land animals. But locomotion from legs to flukes is not the only thing that evolved. How do we know what has evolved? We have transitional forms.

In 1978, paleontologist Phil Gingerich found a 52 million year old skull, dubbed Pakicetus, which showed characteristics shared by both wolf sized carnivore land animals and Archaeocetus, the oldest known whale. These characteristics were related to hearing and the difference between directional hearing underwater by whales and the hearing associated with land animals. Pakicetus had an ear region that was the intermediate between the two. This ear region is evidence that Pakicetus was semi-aquatic.

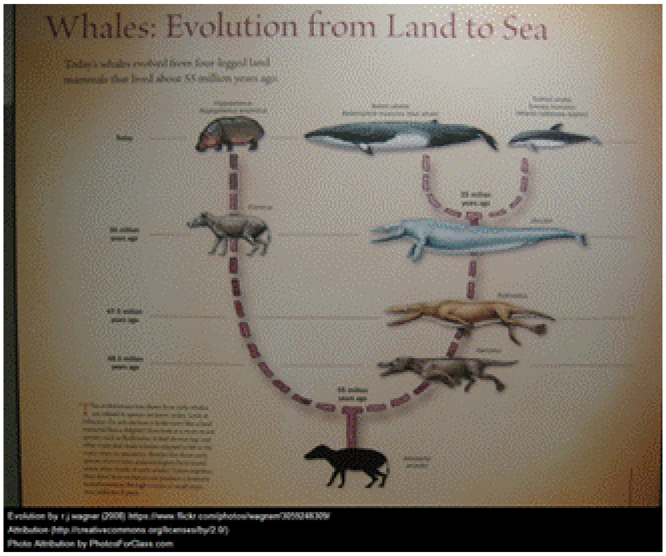


Pakicetus courtesy of Nobu Tamura http://sinops.blogspot.com

Using a variety of scientific methods, scientists have been able to trace the evolution of Pakicetus from a semi-aquatic animal to Ambulocetus, which spent more time in estuaries comprised of a mix of fresh and saltwater, then to ancestors who moved to more of a marine environment and finally to the whales we have today. As these animals moved to saltwater, other changes occurred.



Ambulocetus courtesy of Nobu Tamura http://blogspot.com



When we look at a whale we notice that it has a blowhole at the top of its head. This blowhole has evolved from nostrils that were found at the front of the skull.[17] As the ancestors of the whale transitioned to a more aquatic life, it became more useful to have their nostrils towards on top of their heads rather than in front of their skull.

Individuals who did not need to raise their head to breathe expended less energy, it also took less time to breathe and therefore an organism would spend less time at the surface where there may have been predators lurking. These individuals would have been more fit for their environment and would have reproduced more than individuals with nostrils at the front of their skull, explaining why this trait (and others) was passed on to future generations. (See reference section for web addresses for illustrations of these concepts.)

Dinosaurs to Birds

Archaeopteryx courtesy of H. Raab

When I was a child, dinosaurs fired my imagination. My favorite was Triceratops, with its three horns and a big armored plate around his head. Dinosaurs were seen in books, at museums - if you were lucky enough to live near one, or as pets on animated TV series The Flintstones. Students now have seen them in the Jurassic Park films and maybe as Jack and Annie have a run in with them in The Magic Tree House TV series. My students are not very interested in them; my non-fiction books go unread and in 10 years of teaching I have had not one “expert” on the field in my class. I hope to change that by just looking out the window and talking about the familiar animals flying in the sky.

In 1860 and 1861, first a feather and then a specimen of what was soon called Archaeopteryx, was found in limestone deposits (sedimentary rock) near Solnhofen, Germany. All together 12 specimens have been found, the most recent in 2010. This creature lived in the late Jurassic Period around 150 million years ago. Archaeopteryx is an important fossil because it shows a transitional form between the theropod dinosaur and birds of today. According to the University of California at Berkeley, "Unlike all living birds, Archaeopteryx had a full set of teeth, a rather flat sternum ("breastbone"), a long, bony tail, gastralia ("belly ribs"), and three claws on the wing which could have still been used to grasp prey (or maybe trees). However, its feathers, wings, furcula ("wishbone") and reduced fingers are all characteristics of modern birds."[18] The only obvious feature possessed by Archaeopteryx and not present in theropod dinosaurs was flight feathers. Spencer Lucas, in Dinosaurs: The Textbook, states, "To call Archaeopteryx a "feathered dinosaur", in other words, to recognize it as an animal with essentially theropod skeleton and avian flight feathers is a reasonable conclusion".[19]

We should discuss a bit of what a theropod dinosaur is. The theropod (meaning "beast-footed") dinosaurs are a diverse group of bipedal dinosaurs which include such heavy hitters as Tyrannosaurus rex and Velociraptor. According to the University of California at Berkeley, "Recent studies have conclusively shown that birds are actually the descendants of small nonflying theropods. Thus when people say that dinosaurs are extinct, they are technically not correct."[20]

In 1998, fossil finds in Northeastern China made headlines. A Chinese farmer had found fossilized evidence of early birds. These finds continued as the shale and limestone prehistoric lake beds were scoured for fossils. Fossils for Sinornis, a sparrow sized early bird, were found and showed that it still had teeth, a clawed hand, and limited fused bones like its theropod fore-bearers but it flew and perched much like a modern bird. Confusciusornis was discovered and became the earliest known example of a toothless bird but it still had a clawed hand and other dinosaur features.[21] As the generations progressed, more birdlike adaptations replaced dinosaur systems so the teeth disappeared, the hand or claw went away, bones become more hollow and lighter and they fused together to make flight more efficient. The breastbone and musculature changed and so did arm length as the major method of locomotion changed from running to flying. Feather length and symmetry changed as natural selection favored the traits that were better for flight and thereby survival. Some features, such as the wishbone and the s-curved neck and long shoulder bones, remained from the theropods giving clues to the ancient ancestry of our modern birds.

Sinornis courtesy of Pavel.Riha.CB

Adding to the proof for the relationship between theropods and birds is the connection found between Tyrannosaurus rex and the modern chicken. In 2003, a 68-million-year old Tyrannosaurus thigh bone was discovered in Montana. What was special about this bone was that it still had collagen in it. After analysis, scientists determined that the collagen make-up in the T-Rex bone is almost identical to that of the modern chicken.

Pokémon

To illustrate what evolution is and what it is not, we will reference the popular game of Pokémon. As I am writing this unit in 2016, there is an international craze for the app Pokémon Go. Many people, from children to adults, are obsessed with capturing Pokémon in their houses, neighborhoods, and city streets. For those reading this after the craze has died down, I will explain the premise of Pokémon.

Pokémon are imaginary creatures which are said to evolve. Players capture their Pokémon with Pokéballs and hold them and, over time, through various ways like gaining experience or trading items they "evolve" new features and skills that help them to battle. Each iteration grows larger and changes features until the "cute" little lizard like creature, Charmander becomes a larger more dangerous Charmeleon and then, later, a large flying dragon, Charizard.[22] Although this change is called evolution and our students will likely have referenced Pokémon when first discussing evolution, the creatures have not evolved. Evolutionary biologist Richard Lenski in How Evolution Shapes Our Lives defines evolution as "the process by which life changes from one generation to the next and from one geological epoch to another."[23] Pokémon do not change generationally, they only change as individuals. In evolution, wings will not immediately sprout where none were before. The changes in Charmander and other Pokémon are not caused by mutation, and natural selection does not come into play. The characters undergo a change that is more akin to what happens in a life cycle, many undergoing metamorphoses which my students will study in 2nd grade.

In evolution, traits are passed on to offspring through heredity. Most Pokémon do breed and must be of compatible types but not necessarily of the same species. If two compatible Pokémon breed, the offspring, hatched from an egg, is the same species as the mother. The mother does not pass her physical traits down to the offspring. A Charizard's offspring would be a Charmander who then would change, if experience is gained, but does not benefit from the physical changes of its parents. Of course, Pokémon being a game and not real life there are all sorts of scenarios that play out when they breed including producing different Pokémon types and inheriting knowledge and stats. For the purpose of illustrating what evolution is and is not, the fact that Pokémon do not keep their physical changes will suffice.

Teaching Strategies

This will be a hands-on unit where students will create adapted organisms and manipulate pictures to show understanding of the concepts. Students will work individually and cooperatively in pairs and table groups to accomplish this.

Students have partners based upon reading level where those that are strong readers partner with less skilled readers and non or struggling readers partner with medium leveled readers. As reading is not a requirement for this unit, partnering in the classroom will change based upon other factors such as enthusiasm and possession of background knowledge. Table groups will stay the same.

Rigor, Relevance, and Relationships are essential to the culture at Wilbur Elementary. This unit will be relevant to students because it includes Pokémon, which are part of the popular culture, and references animals that students are familiar with in birds. I hope to also excite their imagination with our discussion on natural selection, adaptations, and transitional forms. I will include activities for all quadrants of the Rigor Relevance framework, Acquisition, Application, Assimilation, and Adaptation but will focus on Quad D, creating, evaluating, and analyzing which will increase the rigor of the unit through classroom discussion, error analysis, and hands-on experiences.

Our school subscribes to the Kagan Structures model of classroom engagement. Strategies stress equal participation and accountability by all partners. As I don't want this to be an advertisement for the program, I will just say that it is important that all students have an equal voice in the discussions and equal participation in the activities and that during instruction and activities these should be closely monitored through whichever model works best in your classroom.

Classroom Activities

The first activity should be a crowd pleaser for the students. Before the beginning of the unit, I will feature some Pokémon books in my classroom library to help all students acquire background knowledge. There are many of these books available in reading level 1 and 2 from Scholastic books. I will have Pokémon cards and Pokémon Go available for use during recess. I will also feature books on dinosaurs, birds, and whales.

In the first class period students will have scraps of paper and I will give them one minute to write down all the different Pokémon characters they know. After writing a name they will place the paper in the center of their table group. When finished, students will sort the papers according to their own criteria. I will suggest that Pokémon who evolve from other Pokémon should be a way that they could sort, but they are free to sort by color, fighting style, etc. We will look at how students have sorted their identified Pokémon and I will write on the board some of the Pokémon "family trees". We will discuss what evolving a Pokémon means in the context of the Pokémon universe and how does a Pokémon get to the next level. The "experts" in the class will lead the way. We will find the appropriate cards and see how the Pokémon evolve and what it takes to evolve them. Is it something internal such as age or something external such as experience or possession of certain items? Using cards, books, and prior knowledge, students will draw their favorite Pokémon and write about the changes that take place when it evolves.

Another activity we will do will help students understand adaptation and why there is a vast array of life on earth. Using Mr. Potato Head, we will talk about how we can change him. We can't add extra arms or feet; we can only put different appendages in the holes that he has. When we look at the pieces he comes with, can any of those help him adapt to a new environment? What if his habitat became covered in water, what might be a useful adaptation that would help him survive? Could he grow fins? How about flippers? Gills? Why or why not? What if we had another scenario where there were dangerous predators that walked on the ground and swam in the water, what adaptations could he have that would help him survive? Could wings sprout from his back? How could they evolve? Did everyone's potato evolve the same way? Is there only one adaptation the potato could have to help him survive or could there be more than one? Could he evolve to fly or, instead, evolve to climb trees to survive? We will take a paper doll of a potato-like creature and add features to it that will help it survive in different scenarios. Is there more than one way to adapt to survive? Students will choose a scenario, adapt their potato to survive in it, and write about their ideas. Finally, we will compare how and why their potato adapted as compared to what Pokémon undergo. Do Pokémon adapt to survive? How is their evolution different?

Another activity will help students understand that evolution does not happen all at one time, and instead that it takes many generations to occur. We will look out of the window and discuss what we know about birds. I will then show the video from the American Museum of Natural History that shows the transition from dinosaur to birds (see resource section). We will talk about what we know about birds and dinosaurs, what is the same and what is different. Due to our students' limited knowledge, I would not expect to have much information in the "same" category. So how is it possible that birds evolved from dinosaurs? We will access the American Museum of Natural History's exhibition "Dinosaurs Among Us" online and read about and see illustrations of how birds evolved from dinosaurs (see reference section). We will talk about transitional forms and about how it took millions of years for theropods to evolve into the birds we see today. If possible, I will ask the art teacher (or someone else with artistic skills I do not possess) to draw how a theropod dinosaur could evolve into a bird including three or four transitional forms. Students, in pairs, will then sort the forms from dinosaur to bird deciding which transitional form goes where on the continuum and citing a reason for their placement of it. How would each transitional form help the organisms to survive? These artistic renderings are only to help students to understand that the change from arms to wings and other adaptations such as a toothed beak to toothless one do not occur in an individual or in just one generation but rather that they take many generations to occur.

Our culminating activity comes back to Pokémon and evolution. Students should now understand that what Pokémon do is not true evolution. Students will discuss why their change is not evolution. If Pokémon were to evolve, what would need to happen? Students will choose their favorite Pokémon or another organism and create a scenario as to how the environment has changed. Students will then draw a picture of how their creature has evolved to adapt to its environment. They will write about how the adaptation(s) help it survive. Students will then draw two transitional forms that show how their creature has evolved over time.

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Resources for Teachers

http://www.telegraph.co.uk/news/science/dinosaurs/11122181/Graphic-How-Tyrannosaurus-rex-evolved-into-modern-bird.html

Dinosaurs Among Us from American Museum of Natural History

http://www.amnh.org/exhibitions/dinosaurs-among-us

Overview of exhibition

https://www.youtube.com/watch?v=y24Q4BxzVu0

Video showing transformation from dinosaurs to birds

https://www.youtube.com/watch?v=XAzGC89n0S4

Graphics for whale evolution

http://evolution.berkeley.edu/evolibrary/images/evograms/whale_evo.jpg

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Numbers

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Similarities between birds and dinosaurs

http://www.wbu.com/chipperwoods/photos/dinos.htm

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Appendix

This curriculum unit will target the Next Generation Science Standards for 2nd grade 2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats. We will be learning about how adaptations by organisms contributed to the variety of life found on the planet. It will also target NGSS for 1st grade 1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. This is an important concept because organisms that reproduce sexually are not exact copies of their parents and this allows for mutations that can give an individual an advantage in survival to reproductive maturity.

The Common Core State Standards for speaking and listening as well as writing will be addressed as students discuss their ideas with their peers and teacher and explain their thinking in the choice of adaptations for particular environments via discussion and writing.