Evolution: Pokémon v. Bizarre Real Animals

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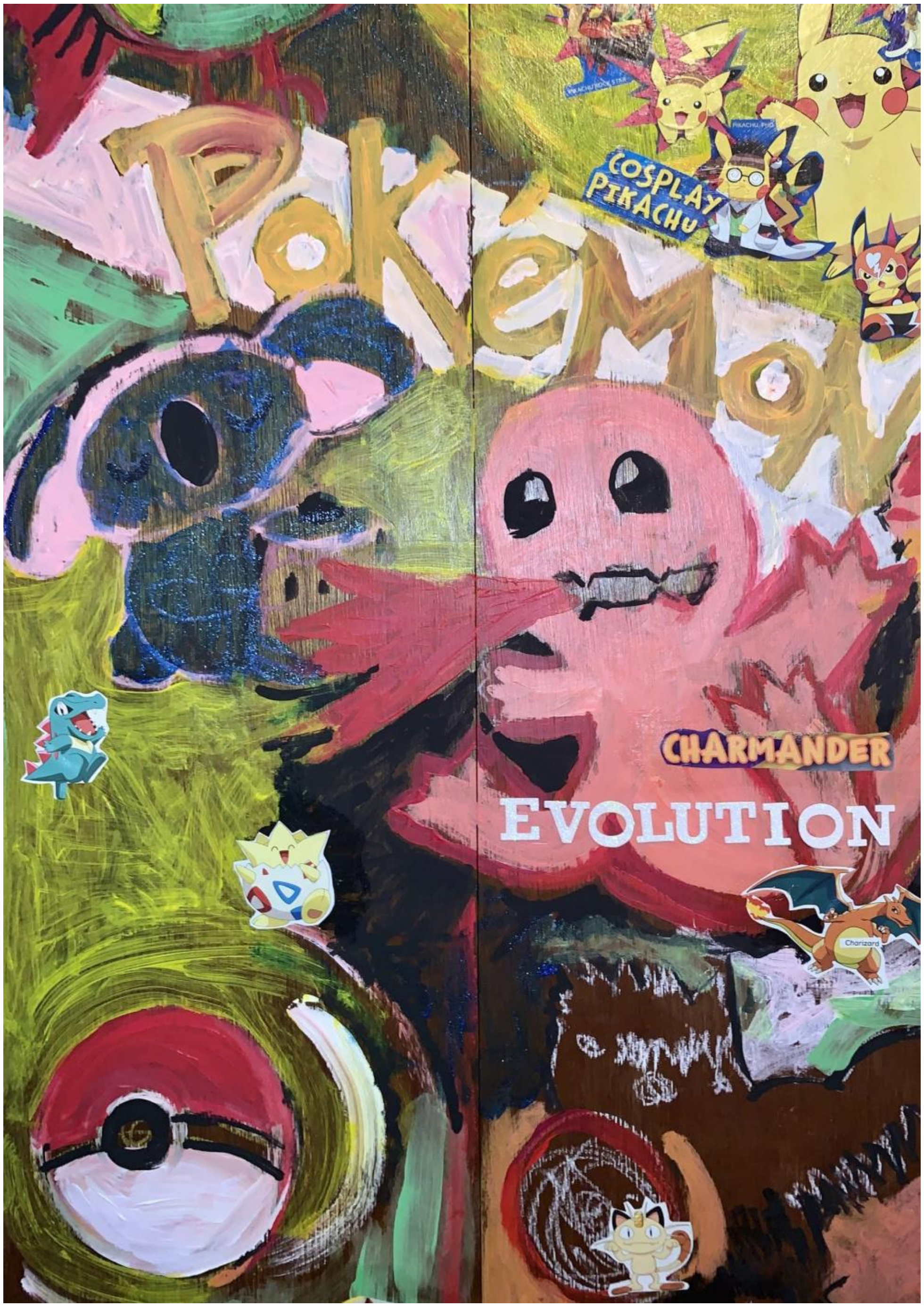
Introduction

My curriculum unit uses the popular appeal of Pokémon and bizarre real animals to address problems and pitfalls relating to the lack of understanding about evolution in our schools as well as the general public. It will center on using the strategies of Pokémon trading cards to hook student interest, debunk common misconceptions, and build a foundational understanding about evolutionary biology. If this unit can propel a few more American students to love and want to pursue science in high school, college or as a career, I am satisfied. The ability to articulate and discuss basic scientific concepts at an early age will prepare students to think critically about the future of our environment. It will guide them to search for evidences and create solutions to world problems such as a pandemic (e.g. COVID-19), disease-causing genes (e.g. Sickle cells), the inevitable reality of human and animal extinction (16,306 endangered species are threatened in 2019),[1] and the depletion of natural resources leading to climate change and world hunger.

Face the Controversy… Face Your Fear

In America, talking about "evolution" is a cultural taboo. Let's say it is a topic to avoid when meeting for the first time. Most people shy away from polarizing subjects like God, Santa Claus, sexuality, racism and other "uncomfortable" topics, especially when a disagreement is written on the horizon. There are many justifiable reasons: "I don't want to offend someone's feelings," or "I hate people who think like that," or "I don't want to lose my mind/job/friendship/marriage." You get the idea. In the classroom, teachers are expected to remain apolitical, disengaged, neutral and poker-face about controversial issues. The battle between scientists and creationists has been heated ever since Charles Darwin published his book *On the Origin of Species* in 1859, and has resurfaced with court cases like the Scopes Monkey Trial in 1925, and public debates like the 3-hour standoff between Bill Nye and Ken Ham in 2014.

So, did life evolve over billions of years OR was it created instantaneously by God? The scientific evidence is clear: life evolved from single-celled organisms about 3.7 billion years ago.[2] I agree that teachers should not indoctrinate students, but if students are not given opportunities to talk about confusing issues like evolution, when are they going to construct their own beliefs? In 2017, the *New York Times Magazine* released statistics illustrating the racial inequality of American school.[3] While our student population is becoming more diverse, our schools are becoming more racially segregated and disproportionately funded. In major cities like New York City and Washington, D.C., 90 to 80 percent of African American students attended highly segregated schools with less than 10 to 20 percent of white students.[4] In addition, the recent COVID-19 pandemics have forced world leaders to face a long-standing problem of digital accessibility and educational equity for all students. It's more critical than ever before that teachers get public support to cultivate a safe space for open dialogue, allowing controversial topics like evolution to challenge misconceptions as well as biases and prejudices. In a democratic society, controversy welcomes diversity, and the freedom to dissent or consent. A few words of caution to teachers: Do your homework in order to do your best to communicate with your administrators and parents PRIOR to conducting difficult discussions of any controversial issues with your students.



My artwork in collaboration with my 8 years old nephew, Ethan Yau.
[I promise him that I will give him credits.] Depicting some of his Pokémon (pocket monsters): Charmander, Bellsprout, Electrode, and Pikachu. Materials: Foldable wood panels, acrylic paints, stickers, and glue. 23 ½” by 65” in dimension.

Rationale

Believe or Not, Evolution Happened and Is Still Happening!

A 2019 Gallup's poll asked Americans this question: "Which of the following statements comes closest to your views on the origin and development of human beings."[5] 40% of people surveyed believe in *creationism* (God created human beings pretty much in their present form within the last 10,000 years), 33% believe in *intelligent design* (God guided this process), 22% believe *evolutionary biology* (God has no part in this process), and 5% has no opinions.[6] In other words, out of 10 Americans: about 1 person has no opinion, 2 people believe in evolution WITHOUT god's design, 3 people believe in evolution WITH god's intelligent design, and 4 people reject evolution. Thus, more and more Americans believe that humans evolved over millions of years.

Problem Statement #1:

How to use Pokémon to develop scientific thinking in children of all gender? Every year (for the last 10 years as a 5th grade teacher and this year as a 4th grade teacher), I had confiscated at least one stack of rubber banded Pokémon cards from one of my male students. I've yet to see a girl obsessed with Pokémon; this gender disparity is a sad symptom of the unspoken bias and stereotypes that girls can't play a boy's game, girls don't like math and science, girls are not good at lifting weights, building houses, engineering cars, and so on.

Anyway, back to the confiscated cards – often in the hundreds. I put these cards on top of my desk or inside a drawer with the promise: "Don't worry. I don't want them. I don't need them. I will return them to your parents during report card conferences." I had boys who begged me for forgiveness ("Please don't tell my parents."), negotiated deals ("I will be SO GOOD for the rest of the year."), sobbed crocodile tears (Ok, a few tears might have been sincere.), cursed me with expletives under their breath, stumped their feet with anger, and clenched their fists about to explode like those home-made volcano projects. *Oh boy, the drama!* Like sharks, some circled with eyes lurking around my teacher desk waiting for me to cave in or just too busy to notice their next move. One year a Pokémon super-fan "stole back" his cards as the class was transitioning for recess and lunch.

Most schools ban Pokémon trading cards for good reasons. Principals, teachers and parents often viewed these cards as a nuisance and a distraction from "real" learning. The trading cards also magnify the ugly issues of class (the haves and have nots), stealing, addiction, and bullying. How can adults relate to something that they don't understand? With the 2019 release of the movie *Detective Pikachu* and two new Nintendo games, the Pokémon obsession has returned, faded away, and returned again. In February 2020, over the course of a week, my principal, Pauline Cheung, who is more progressive and open-minded than most principals I know, had to make multiple announcements that Pokémon cards are not allowed in school. One time she added: "Unless your teacher asked you to bring them…but I'm not aware of any teacher doing that." In July, I texted her asking for her permission to include her name on this unit, and she immediately replied: "That's fine. Ha, ha! I will definitely enjoy reading it, thank you for doing this work!" About two years ago, I began a journey to understand the appeal of Pokémon. My then-five years old nephew started his collection of trading cards, toys, books, backpacks and t-shirts. The

Pokémon franchise is a money-making machine. Last summer during a two-week intensive teacher development with the Yale National Initiative in New Haven, I got even more intrigued when a fellow teacher, Simon Edgett who wrote an essay about his love of the augmented reality game Pokémon GO. I was sold that Pokémon does have important educational values. The game Pokémon GO has a bad rap among teachers. Despite its low status as an educational tool, teachers have taught lessons on civic landmarks (where PokéStops tend to be located), urban development, neighborhood history, and other academic topics. I will never forget my own awakening of the potential of Pokémon as a teaching tool when my then-6 years old nephew asked me how to spell "Charmander"- so he can "research" on my laptop. At that time, I didn't know that Charmander was a nonsense word (a portmanteau) like jabberwocky, frenemy, sheeple and turducken. After some back and forward of me saying: "What did you say? Spell what? Say it again. I don't know what you are saying," my precocious nephew finally gave up with "You should know how to spell it. You are a teacher!"

Gradually, I figured out that Charmander, known as "Lizard Pokémon", Hitokage (ヒトカゲ) in Japan, is a made-up word from *char* (meaning fire) and *salamander*. Charmander was introduced in Generation 1 with the National Number 004, the fourth Pokémon. In the internet, there are pages and pages of Pokédex (index) data about Charmander: type = Fire, species = Lizard, height = 0.6 meter (2 inches), weight = 8.5 kg (18.7 lbs.), abilities = Blaze and Solar Power, local numbers (004, 229, 234, 083, 378), egg groups: dragon and monster, gender (87.5% male and 12.5% female), egg cycles is 20 which requires 4,884 to 5,140 steps.[7] The information on Charmander alone is overwhelming and amazingly sophisticated.

To adults these stats may seem frivolous and worthless, but I would argue that when children have mastered this labyrinth of rich vocabulary and complex classification system, they are also mastering critical and creative thinking. YET much of this information is based on a lot of scientific misconceptions about evolution. Just imagine how much knowledge children would have gained, if they are aware of these misconceptions. For example, if Charmander is a salamander, then it is an amphibian, and not a lizard as the Pokémon stats claimed.[8] The glossary for Charmander includes the following imaginative terms: attack, breeding, defense, egg cycle, egg group, entries (in a multitude of colors), Friendship or Happiness, Generations (a total of 10 generations and 890 Pokémon with more coming in November 2020), max., min., Magnetic Field, speed, sprites, yield, base, and growth rate.[9] On a separate catalog, "moves" are differentiated with adjectives such as: scratch, growl, ember, smokescreen, dragon rage, slash, flamethrower, rest, protect, substitute, reflect, dig, facade, seismic toss, rock slide, thunder punch, toxic, and outrage.[10]

I've witnessed my students code-switched into the Pokémon world lexicon; they understand that most adults have no clue what they are talking about. Try to figure out the following questions asked by fans: How could I chain breed "thunder punch" onto my Charmander? [11] How can I get Charmander in platinum? What is a good Little Cup moveset for Charmander? What location number was Ash's Charmander caught? Why did my Charmander get inferno if it's not an egg move?[12] Such complexity and sophistication for a "child's game!"

Today I can envision using Pokémon to teach English language acquisition, math, art, science and other subjects. For ELA, the ability to read nonsense words is important for students because they need to be able to use good phonics skills to decode and blend unfamiliar words for the rest of our lives. According to research, "pseudo-word decoding is the best single predictor of word identification" and the "most reliable indicator of reading disabilities."[13] There are a lot of nonsense words in the Pokémon universe. For Math, kids can practice calculation on how to "evolve" a Pokémon to the next level with the number of points, steps, etc. For Art, there are endless illustrations of Pokémon to study and emulate as a way to observe and analyze the physical features of living things. For Science, I can see teaching students about classification, inheritable traits, artificial selection (breeding) and natural selection. Not surprisingly, some Pokémon characters are actually based on bizarre and real animals.

According to Stanford University's research study, published in the journal *Nature Human Behavior* (May, 2019), when kids are constantly exposed to images of Pokémon, their visual cortex forms a wrinkle to store memories of these pocket monsters.[14] I believe the same children who love Pokémon are more likely to become biologists, mathematicians, negotiators, artists and ultimately independent and creative thinkers. The mega-franchise with television shows, films, video games, anime series, books, toys, trading cards, augmented reality mobile game (Pokémon GO) and fan community have created a cultural phenomenon and an estimated earning of 59.1 billion U.S dollars since its inception in since 1996 (over 24 years),[15] Pokémon is not going away any time soon. It's time to adapt and take advantage of popular phenomena like Pokémon rather than be annoyed by them. We have to see the potential power to promote greater student engagement about science.

Problem Statement #2:

In America, we marginalize science education, and then turn around and use scientific content in standardized testing to measure proficiency in reading and writing. In my school district, both Science and Social Studies are often put on the back burners due to inefficient professional development, tenuous curriculum with muddled standards, and lack of instructional time and materials. Since only 4th and 8th grade students take the Pennsylvania state science standardized test, there is also a lack of accountability and motivation for administrators, teachers and students to put science knowledge as a priority. From the Scopes Trial to today's public denial of climate change by lobbyists, America's science education has suffered a massive attack by the forces of big businesses, religious groups and self-interested politicians. The marginalization of science education in America has created a shortage of young scientists, especially women scientists. Modern science and "controversial" topics like evolution and global warming are not being taught with a sense of urgency in our schools.[16] Needless to say, our future generations suffer the consequences as they face the probability of a human mass extinction. This unit guides students to use scientific thinking to look at living things with greater compassion, understanding, and compelling reasons to be advocates of biodiversity and our future survival.

When the Next Generation Science Standards (NGSS) was first introduced in 2013, only 6 states adopted it; much of resistance from both conservatives and liberals has a lot to do with the inclusion of climate change and evolution, and lack of federal fundings.[17] Today, only 20 states and the District of Columbia (representing an estimated 36% of U.S. students) have adopted the

Next Generation Science Standards; Pennsylvania has not kept up with this advancement.[18] The arguably outdated 4th grade PA science standards (2010) are organized into 4 categories: Nature of Science, Biological Science, Physical Sciences and, Earth & Space Sciences.

Most 4th grade standardized Reading tests are divided into 2 categories: fiction and nonfiction. A majority of the nonfiction passages are informational texts with complex concepts such as how the Assateague horses adapted to rough conditions in order to survive, factors that contribute to the germination of seeds, how polar bears "evolved" from the brown bears, how Emperor penguins take care of their offspring, the life cycle of frogs, and the migration of the monarch butterflies. The terms "adaptation" and "survival" often appear on my district's and state's reading standardized assessments. Students are expected to read a passage about a complex scientific topic, and then answer a set of multiple-choice questions about summaries, main ideas and supporting details; this myth that science is already contained in the Common Core State Standards, English Language Arts (CCSS, ELA) water down and even strips science education from our elementary school students.[19] Sadly, teachers are often mandated to teach reading skills (not content) during a 120 minutes literacy block. Due to the lack of instructional time and materials, science is often reduced into a 45 minutes block 3 to 5 times a week. Because of limited instruction time and the reading comprehension focus of standardized testing, most of the time a science lesson turns into a reading lesson. A 2014 study conducted by neuroscientists from MIT, Harvard and Brown University shows that students who improved the most on standardized tests, also have the least gain in critical thinking such as the ability to analyze materials, think logically and globally about solving real life problems.[20]

In this unit, I want to introduce students to some complex concepts about evolution with math games, hand-on activities, artificial breeding proposals, in-depth inquiry and discussion asking difficult questions and forming hypotheses.

Problem Statement #3:

So how should teachers create a 21st Century research environment that advances science knowledge about concepts like evolution in our students? As our environment changes, more and more animals are evolving and more of them are being discovered by scientists. Students are often not educated in depth about the effects of environmental change and its impact on their human lives, other living things and the future of our planet earth. According to a 2016 estimate, each year about 18,000 new species of animals, plants, fungi or microorganisms are being discovered by scientists and about 86% of existing species have yet to be identified.[21] Evolution has made some real animal stranger than fiction.

At the end of this unit, as a cumulative activity, students will research some of these "unbelievable" animals and investigate essential evolutionary questions such as: why do these bizarre animals exist and what environmental changes are contributing to their livelihood? As technology advances, accessibility to information about these new animal discoveries is easily available. Apps such as Google Docs and other platforms allow students to post and share their knowledge worldwide. Educational programs such as Skype-a-Scientist have made scientists across the globe available for face to face interviews. Technological advances and crises like the COVID-19 pandemic are drifting the traditional classrooms into a 21st Century global classroom of shared knowledge through synchronous and asynchronous instruction that can defy language and distance barriers.

School Demographics

My school demographics are highly diverse in their ethnic, cultural and language backgrounds. The languages spoken by this diverse group of multilingual students, teachers, administrators, parents and other community members had included: Arabic, Burmese, Chinese (Cantonese and Mandarin), French, Hindi, Italian, Khmer, Korean, Laos, Malays Nepali, Spanish, Swahili, Turkish, Vietnamese, and indigenous languages. For 2020, the student body is approximately 41% Asian, 32% Hispanic, 13% White, 9% Black, and 5% Multi-Racial.[22] About 50% are English Language Learners (ELL), about 10% were exited out of ELL service, and 20% are children of immigrants who were born in the United States (but never received ELL service, even though a language other than English is primarily spoken at home). That means a total of 80% are recent immigrants or children of immigrants.

I feel that I have a huge responsibility to teach my students in a culturally responsive way that is compatible with – as well challenging to – how their brains function in a language other than English. I believe it is important to teach science without marginalizing diverse learners. As teachers, we often underestimate our students, especially ELL and Special Education learners, by giving them below grade level work. When a struggling reader is able to read text two or three years below grade level, it is not time to "just" cheer and celebrate, it's time to set higher goals. As teachers, we don't want to promote a false sense of accomplishment that may cripple the growth of all learners, and shield them away from controversial topics such as evolution.

Content Objectives

Misconceptions: Why Pokémon gets it all WRONG about evolution

From my teaching experience, most children's first exposure to the word "evolution" came from playing Pokémon trading cards OR from a kindergarten science lesson about the life cycle of a butterfly. When I asked my students to define evolution? The most common misconception is derived from that butterfly lesson. The life cycle from egg to larva (caterpillar) to pupa to butterfly is called metamorphosis, NOT evolution. When an individual Pokémon such as Charmander (#004) "evolves" at level 16 into Charmeleon (#005) which in turn can "evolve" at level 36 into Charizard (#006), that is NOT evolution.

IMPORTANT: In our Teachers Institute of Philadelphia (TIP) seminar, the term "biological evolution" is defined as **"the change in allele frequencies in a population over time."** Post this definition in your classroom and have your students memorize it. Refer to this definition often as you debunk misconceptions, unpack concepts and build better scientific understanding.

Let's break this definition down to debunk 6 common misconceptions about evolution.[23]

1) Evolution does NOT happen in one's lifetime. No living thing is like Spiderman whose mutated genes gave him extra superpower when he was a young man. Humans are born with a set of given genes (all the superpowers are given during reproduction).

2) "Over time" does NOT always mean a long time, like a thousand years. Yes, evolution can occur slowly and gradually, but it can also happen quickly. In the modern era, rapid evolutions may have a lot to do with harmful human activities such water pollution, fossil fuel emission, and deforestation. For example, over the past 50 years, a fish species evolved to have resistance to toxins in the Hudson River. Another more current example is that SAR-CoV-2 or COVID-19 seems to have about 25 mutations per year, whereas the seasonal flu has 50 mutations per year.[24] That's why your doctor wants you to get a new flu shot at least once a year.

3) Natural Selection means "survival of the fittest." That's NOT necessarily true. The phrase "survival of the fittest" is very misleading. Natural selection does NOT always mean the fittest, the strongest and the healthiest will survive, but rather that those who successfully reproduce more offspring than other species or other variants of a species will survive. For example, the dinosaurs did not become extinct because they were not "fit," strong, and healthy. Dinosaurs were not able to adapt, reproduce, and survive the volcanic eruptions, climate change, and sea level changes. Even though about 50% of animals and plants died out, birds and lizards (distant relatives of dinosaurs) fit better to the changed environment and survive the mass extinction of creatures 65 million years old.[25]

4) All mutation is bad. NOT necessarily true. Mutational effects can be neutral, beneficial, or harmful, depending on their context, location or environment. Mutation occurs when a gene is incorrectly copied during reproduction. Examples of beneficial mutations include: HIV resistance and seedless fruits. Examples of harmful mutations include: diseases and birth defects. A mutation is neutral when it has no selective advantages or disadvantages and some examples are attached and detached earlobes, hair and eye colors.

5) Genetic drift is like natural selection. YES and NO. Both genetic drift and natural selection are processes of evolution where there is a change in allele frequencies over time. The distinction is in genetic drift, the change of allele frequencies is due to **chance**, whereas natural selection allele frequencies favor the most adaptive traits to be passed on to more offspring, **not so random**.

6) Evolution does not claim humans evolve directly from monkeys. Evolution is as "true" as dinosaurs, the sun, man landing on the moon, gravity, atoms and quantum physics. No argument: you look like your father and/or your mother. Evolution is also a gradual process. Fossils such as those of birds have shown the evolution of birds began during the Jurassic Period (199.6 to 145.5 million years ago). We have evidence to support the claim that the earliest birds evolved from a clade of theropod dinosaurs.[26]

Alleles, RNA, DNA, Genes and the Punnett Square[27]

In human beings, genetic information is stored in 23 chromosomes; each chromosome comes in pairs (one from the mother and one from the father). Genes are made up of DNA, a series of building blocks with stored instructions that tell cells how to behave. In general, DNA stores the genetic information, whereas RNA uses the information to help cells produce proteins. An allele is one variant form of a given gene that occupies a specific place on a chromosome. An allele can be one of two or more versions of a gene. An allele can be dominant, recessive, or co-dominant. The Punnett Square is a square diagram to predict the probability of an offspring having a particular genotype. For example, if "A" stands for an allele (brown eyes) and "a" stands for an allele (blue eyes), then a mating between two heterozygotes (Aa and Aa) can result in three genotypes: AA, Aa, and aa where the probability is 25% AA, 50% Aa and 25% aa. In an equation using fractions, the Punnett Square can be represented with AA x aa = ¼ AA + ½ Aa + ¼ aa. If the allele "A" is dominant and the allele "a" is recessive, then 75% (AA and Aa) of the offspring will have brown eyes and 25% (aa) of the offspring will have blue eyes.

	T	t
T	TT 25%	Tt 25%
t	Tt 25%	tt 25%

Above is a Punnett Square of two heterozygotes (Tt and Tt) resulting in three genotypes: TT (25%), Tt (50%), and tt (25%). If "T" stands for the dominant trait (tall plants) and "t" stands for the recessive trait (short plants), then the probability of "tall plants: will be 75% (TT and Tt) and the probability for "short plants" will be 25% (tt).

Natural Selection: Directional, Stabilizing and Diversifying[28]

Natural selection can take 3 basic forms: directional, stabilizing and diversifying. Environment is a crucial factor in determining the type of survival for a given species. The evolution of the peppered moth is a classic example of *directional natural selection*. During the Industrial

Revolution, the allele frequency of the dark-colored moth population increased because birds could easily catch white colored moths on birth trees covered with polluted soot. In 1848, the dark-colored moths had survived better in an industrial city like Manchester, England.[29] The experiments of Bernard Kettlewell (1953 and 1956) supported the story that a light-colored moth camouflaged in a clean environment like Dorset as opposed to the dark color moth which camouflaged its body better in a polluted environment like Birmingham.[30] This selective survival was due to birds which easily caught dark moths on clean trees, and white moths on trees darkened with soot. This type of natural selection caused the allele frequency of a trait to change over time in the direction of the phenotype that will best survive in a changing environment. The increase in population does not depend on whether the allele is dominant or recessive.

On the other hand, natural selection can also occur with or without environment changes. For instance, penguins can only raise one chick at a time because of the size and the amount of food both parents can provide. This type of natural selection is called *stabilizing selection*, which pushes the population toward the average trait rather than the extremes. Environment changes will not necessarily increase or decrease the number of chicks a penguin can raise. Except for emperor and the king penguins, most penguins raise one egg at a time, a stabilized condition.[31]

Finally, *diversifying or disruptive selection* pushes the population toward the extremes of the given traits. As the variance of a trait increases, the population is divided into two distinct groups. Let's suppose that if there are three variants of fur colors in rabbits: black, gray and white. The black rabbits can hide under black rocks from predators. The white rabbits can hide under white rocks. The gray rabbits will stand out in an environment of black rocks as well as in an environment of white rocks. Because of this, the population of gray rabbits will naturally decrease while both the populations of black and white rabbits will continue to increase. As a result, the color trait will diversify into the extremes (black and white). Evolution helps scientists to make good reasonable predictions. For example, horses have only one (1) toe/hoof on each foot, but thousands of years ago, horses had 5 toes inside each hoof. Scientists figured out that the reason modern horses have only one hoof may have to do with the fact that one toe makes it easier for grazing on grassland.[32] As animals adapt to their new environments, the those with most beneficial traits will survive and reproduce more offspring.

Standardized testing companies often use the following terms related to natural selection: adaptation, survival, migration, "traits v. features v. characteristics," inherit, instinct, etc. At the elementary level, environmental adaptation can be categorized into 3 basic types: behavioral, physiological and structural.[33] An organism behaves in ways to help it survive and reproduce. For example, wolves hunt in packs rather than going solo. An organism can go through a physical change to help it survive and reproduce. Another example is how peppered moths evolved their color to avoid being eaten by predators. Similarly, an organism's structure can evolve to help it to survive and reproduce, such as wings for flying or fins for swimming.

Artificial (Selective) Selection

Unlike other living things, humans have the power to engineer rapid evolutionary changes in other species. This process is called artificial selection or selection. Humans can breed plants like corn and animals like dogs to get the desired traits. Corn (maize) was domesticated in Mexico about 10,000 years ago by indigenous people.[34] Human has continued to genetically modify maize and other crops to yield favorable traits such as pest resistance. Today corn crops can be categorized into four basic types: dent, flint, sweet and popcorn.[35] About 8,000 years ago, cats most likely hung around farms and established a mutually beneficial relationship as rodent patrol, and as of 2019, the International Cat Association (TICA) recognized 71 breeds of cats.[36] Dogs were believed to be domesticated about 15,000 years ago in Europe or 12,500 years ago in Central Asia or China, and today the Fédération cynologique internationale (FCI) or World Canine Organization recognized 340 breeds of dogs.[37] Cats and dogs cannot have offspring together because they belong to different genus and different species. The eggs of a cat and the sperms of a dog are incompatible.

Speciation: Natural or Artificial Selection

Speciation (one species split into two or more species naturally or artificially) occurs with bears, monkeys and countless numbers of other animals. With the advent of genetics, all lives can be traced back to a common ancestry. There is an abundance of evidence that explains natural selection where organisms that are better adapted to their environment will produce more offspring. The theory of natural selection was extensively documented by Charles Darwin in his book *On the Origin of Species* (1859) with drawings and observations of creatures in the Galapagos Islands, located 906 km (563 miles) west of the Republic Ecuador.[38] A large number of endemic species such as marine iguanas, pink-land iguanas, giant tortoises, blue-footed booby, and magnificent frigate birds continue to evolve in the Galapagos Islands.[39]

Speciation is the process by which the original population evolves (through mutation) over time into two or more distinct species that now can no longer reproduce with each other. A great example of natural (allopatric) speciation is the Galápagos finches. Because the original population of finches got isolated from each other by the ocean (a physical barrier), over time different species of these birds evolve and live on different islands.[40] Similarly, artificial speciation is also possible through laboratory experiments and agriculture husbandry. For example, fruit fly is a great example of artificial speciation because scientists can easily mutate its genes. Furthermore, the fruit fly is small but large enough to be easily observed under a microscope, can reproduced in the millions and quickly (a new generation every 10 to 14 day at 25˚C or 5-6 weeks at 18˚C), and has 75% of the same genes that cause human diseases.[41]

Pokémon Trading Cards

Each pack of 11 Pokémon cards retailed for about $3.99 and had one random “Rare” or “Holographic card.” Children collect them because of one big reason: it is never boring and new Pokémon creations are incessant as long as the enterprise is profitable. The design teams behind it all keep coming up with new ideas and integrating new technology, such as 2016 releasing Pokémon Go on smartphones. The 2019 World Championships took place in Washington, D.C., with more than 7,000 competitors from all over the world flying in to compete for over $500,000 in cash, scholarships, and other prizes.[42] The 2020 World Championships will be held in London, England. According to data from Sensor Tower (2019), mobile users spent nearly $2.45 billion with 550 million downloads globally.[43] As long as the Pokémon team continues to re-invent ways to market Pokémon to the next generation, the franchise will stay relevant.

Pokémon are creatures of all shapes and sizes who live in the wild or alongside humans. For the most part, Pokémon do not speak except to utter their names. Pokémon are raised and commanded by their owners (called “Trainers”). During their adventures, Pokémon grow and become more experienced and even, on occasion, evolve into stronger Pokémon. There are currently more than 800 creatures that inhabit the Pokémon universe. In a Pokémon trading card game, players build decks of Pokémon to play against each other and battle to see who is the best trainer. Each year four new sets of cards are released by the Pokémon Company International. What are the different types of Pokémon cards? In the Pokémon universe, there are three different categories of cards that you’ll find in any given deck: Character cards, Energy cards and Trainer cards. Each character card has a type such as Fire, Water, Psychic, Metal or Dragon. Each Pokémon card will also indicate how “evolved” the character is—whether it’s in its basic form, Stage One form or Stage Two form. Those shiny cards your kids probably want most are the Legendary Pokémon. They don’t evolve and are some of the most powerful cards in the trading card game, and they’re also only found in booster packs. Energy Cards are needed to power a Pokémon. Trainer cards are used for the items, supporters and stadiums you can use during a battle. Pokémon EX cards and GX cards are highly coveted because they are more powerful and have cooler illustrations, sometimes they are shiny or holographic.

How to play the Pokémon trading card game off or online?

There are a few virtual tutorials online that can explain how to play the Pokémon trading card game. Another way to learn is with a Trainer Kit that will instruct two players step by step. Check out the links and video below:

http://www.Pokémon.com/us/Pokémon-tcg/play-online/
https://www.youtube.com/watch?v=7qPxe0eYaSE
https://www.youtube.com/watch?v=FDqDvvJyY2w
https://www.youtube.com/watch?v=WMJnJVW5dNU
https://www.youtube.com/watch?v=3tjqcRNYufw
https://www.youtube.com/watch?v=DSfBJ-EeFhc

Teaching Strategies

1. Assign Research about an animal and its environment (allows 4 to 6 weeks)
2. Survey and Pre-Assessment
3. Debunk misconceptions by discussing how to play Pokémon
4. Post Vocabulary word on wall or have student keep a science notebook
5. Play a card and math game by selecting inheritable traits
6. Use LEGO blocks to teach the Punnett Square and multiplication using an area model
7. Play a word game with Latin & Greek prefix, root and suffix
8. Play an environment for a Pokémon based on animal traits.
9. Present research projects
10. Complete Post-Assessment with Items from the Pennsylvania PSSA Standardized Test
11. Visit interactive sites http://interactivesites.weebly.com/animal-adaptations.html
12. Optional ELA Connection: The book *Love That Dog* by Sharon Creech and *The Tyger* by William Blake.

Classroom Activities

Hook and engage students: Present this science unit as an investigation with two main purposes: 1) Students will be convinced that Pokémon got all the science WRONG about evolution IOT to explain at least three misconceptions; 2) Each student will become a research expert about one of the world's most bizarre animals. Show 10 minutes of the following YouTube video. https://www.telegraph.co.uk/travel/safaris-and-wildlife/The-worlds-weirdest-animals-and-where-to-see-them/

Research Project Assignment:

Pass out a Master sign-up sheet with names of bizarre animals (see list below). I prefer to assign each student a different animal from each other; it would allow students to teach each other what each person had learned. Allow three to six weeks for students to support each other with their research, reading and writing. Distribute an assignment sheet with the following instructions:

Step 1: Choose one to three unbelievable animals to browse on the internet for a day.
Step 2: Narrow your choice to one final choice and continue to research by the end of the week.
Step 3: Use a top-down web or other graphic organizer to take notes
Step 4: Write an essay about your animal and its environment
Step 5: Construct a model of your animal and its environment
Step 6: Create your own Pokémon character and write a backstory.

List of Unbelievable, Bizarre, Weird, and Rare Animals:

1) Sloane's viperfish (Chauliodus sloani), Reykjavik deep sea, Iceland
2) Bald uakari (Cacajao calvus), Brazil's rain forest
3) Mata mata (Chelus fimbriate), South America's slow-moving streams and pools
4) Toktokkies (Onymacris unguicularis), Namib desert
5) Axolotl (Ambystoma mexicanum), Lake Xochimilco, Mexico City
6) Deer-pigs (Babyrousinae babyrussa), Adudu Nantu and Tangkoko nature reserve, Indonesia
7) Treehoppers (Ceresa taurina), every continent except Antarctica
8) Puss moth larva (Cerura vinula), woods, parks and gardens of Europe and Asia
9) Philippine pangolin (Manis culionensis), Palawan province of the Philippines
10) Shoebill (Balaeniceps rex), wetlands of Great Bangweulu Basin, Zambia
11) Poodle Moth (species to be determined), Venezuela
12) Blue dragon (Glaucus atlanticus), warm water of the ocean
13) Macropinna microstoma, depth between 2,000 feet to 2600 feet
14) Lowland streaked tenrec (Hemicentetes semispinosus), Madagascar, Africa
15) Red-lipped batfish (Ogcocephalus darwini), Galapagos Islands
16) Blue parrotfish (Scarus coeruleus), the Caribbean Sea
17) Glass frog (Hyalinobatrachium ruedai), South America
18) Fossa (Cryptoprocta ferox), Madagascar
19) Japanese spider crab (Macrocheira kaempferi), Japan
20) Leafy seadragon (Conservation status), Australia

21) Halitrephes jelly (Halitrephes maasi), deep sea, 5000 feet
22) Okapi (Okapia johnstoni), Democratic Republic of the Congo
23) Star-nosed mole (Condylura cristata), North America
24) Golden tortoise beetle (Metriona Fabricius), native of the Americas
25) Gobi jerboa (Allactaga bullata), China and Mongolia26) Frogmouth, Sri Lanka
26) Sundra flying lemur, (Galeopterus variegatus), Malaya
27) Long-wattled umbrellabird (Cephalopterus penduliger), Colombia
28) Gerenukm (Litocranius walleri), Africa
29) Snub-nosed monkey (Rhinopithecus), Asia
30) Thorn bug (Umbonia spinosa), South America
31) Sparklemuffin (Maratus jactatus), woodland forest of Australia
32) Jabiru stork (Jabiru mycteria), Belize
34) Southern cassowary (Casuarius casuarius), Australia
35) Black snub-nosed monkey (Rhinopithecus strykeri), Myanmar
36) Angora (11 distinct breed), English, French, Giant, Satin
37) Walking stick (Leptynia hispanica), Asia, South America, and Australia
38) Mangalica pigs ("pig in sheep clothing"), Hungary

Give Pre-Assessment: Ask students to check "True or False" for each statement. Below is a short list of sample statements.

True	False	Statements
		Evolution is a theory
		Evolution is random.
		Evolution means species will evolve with better traits.
		Individual organisms can evolve during their lifespan
		Evolution takes a long time.
		Humans can influence evolution.
		Environment will always change how a species evolves.
		Species are easy to separate into distinct categories.[28]

Lesson 1: Introduction and Vocabulary

Show one or both of the following videos: A 91-Year-Old guess the names of Pokémon https://www.youtube.com/watch?v=i4PKHk0LL4Q
A 5-Year-Old guess names of Pokémon https://www.youtube.com/watch?v=4s8Kptm6L4I
Ask guiding questions: How do Pokémon get their names? Does anyone play the Pokémon and explain the basic rules? Set up a word wall and/or student science notebook. Have students "Think, Pair and Share" the following words: evolution, natural selection, adaption, survival,

environment, artificial selection, mutation, genetic drift, speciation, allele, DNA, RNA, gene, dominant, recessive, Punnett Square.

Lesson 2: Debunk Misconceptions about Evolution

Discuss the results of pre-assessment. How many people check True? How many people check False? Why? What is evolution? What is not evolution? Compare a few variable traits of Pokémon and ask why they exist.

Lesson 3: Explain the Difference between Natural or Artificial Selection.

Show pictures of hybrid animals listed below to discuss natural selection. Have each student pick two Pokémon using a deck of Pokémon trading cards or just have students research on the internet. Ask students to create a new Signature Pokémon by comparing the best traits from the two parent Pokémon. Below is a short list of hybrid animals:

1) Liger (Lion and Tiger, 9 feet, 2000 pounds)
2) Tagon (India gifted to England)
3) Killer Bees [DB5] (African and European bees, caused the death of 400 people)
4) Cama (Camel and lama)
5) Sterile Pink Bollworm (Cotton Crops, 1968)
6) Zorse (horse and zebra)
7) Savannah cat (tallest domesticated)
8) Enviro Pig [DB6] (less phosphorus waste)
9) Wholphin (Whale and Dolphin)
10) Alligator Turtle (175 pounds)

Lesson 4: Punnett Square Math Game and Genetic Drift Card Game

After discussion, demonstrate how to make a Punnett Square. Choose two different colors of LEGO pieces or Uniflex cubes. Decide what variant each color represents. For example, brown cube for brown eyes, and blue cube for blue eyes. The Punnett Square is similar to an area model. Draw a Punnett Square on your SmartBoard or chart paper to explain the probability of offspring with different genotypes. Refer to the previous Punnett Square with two heterozygotes (Tt and Tt) as the parents where the letter "T" stands for the "tall allele" and the letter "t" stands for the "short allele." Teachers can relate percentages, fractions and other math concepts to illustrate the possible outcome of offspring. Similar algebra problem using fractions: $(\frac{1}{2}T + \frac{1}{2}t) \times (\frac{1}{2}T + \frac{1}{2}t) = \frac{1}{4}TT + \frac{1}{2}Tt$ and $\frac{1}{4}tt$.

Once students are familiar with using the Punnett Square, teach students how to play a simple "genetic drift card game" to show evolution by chance. Use a deck of playing cards (52) and deal each student two cards. You may need two decks to have enough for all of your students. Choose a trait. For example: Red cards stand for short alleles (recessive). Black cards stand for tall alleles (dominant). BB (2 black cards) are tall people. Br (one black and one red card) are tall people. rr (2 red cards) are short people. After everyone has two cards, tell students if they have the tall alleles combination (BB or Br), then move to the right side of the classroom, If they are short alleles combination (rr), then move to the left side of the classroom. Record the number of tall v. short people on a T-Chart. Collect all the cards and repeat at least 2 more times. Then have students to discuss the results and generate a list of questions.

Challenge #1: Once students understand the card game, increase the complexity to four allele traits. For example: Clubs (♣) stands for short, Diamonds (♦) stands for tall, Hearts (♥) stands for blue eyes (recessive allele) and Spades (♠) stands for brown eyes (dominant allele). The only difference is this time each person has four cards to figure out what are their two traits.

Challenge #2: Put an empty tray or box in the middle of the room. Deal two cards per student. Instruct students to randomly get rid of one card and put it inside the tray or box and then randomly find a partner. Now two people make one offspring. Record the number of tall v. short people on a T-Chart. Discuss results and ask new questions.

Lesson 5: Re-Name Your Pokémon.

This word game can become a Science center activity. Give each student a Pokémon trading card. Have students research online for the possible scientific name and write the reason(s) behind the name. Scaffold students with the link of Latin and Greek prefixes, roots, suffixes: https://www.rtsd.org/cms/lib/PA01000218/Centricity/Domain/933/Prefix%20Suffix%20Information.pdf.

Challenge students to come up with a better name that incorporates Latin and/or Greek prefixes, roots and suffixes. Below is a list of Pokémon based on an actual animal derived from these two links https://guff.com/Pokémon-that-were-actually-inspired-by-real-world-animals and https://www.zsl.org/blogs/conservation/22-Pokémon-inspired-by-rare-edge-species

1) Articuno and Kagu (Rhynochetos jubatus)
2) Bulbasaur and Bullock’s False Toad (Telmatobufo bullocki)
3) Caterpie and Eastern tiger swallowtail caterpillar
4) Chansey and Olm (Proteus anguinus)
5) Chatots and yellow collared lovebirds
6) Charmander and Chinese Giant Salamander (Andrias davidianus)
7) Dewgong and Dugong (Dugong dugon)
8) Drowzee, Asian tapir, Malayan tapir (Tapirus indicus)
9) Farfetch’d and Sichuan Jay (Perisoreus internigrans)
10) Gorebyss and long-nosed chimaera
11) Krookodile and gharial
12) Luvdisc and kissing gourami
13) Magikarp and yelloweye rockfish
14) Mankey and Barbary Macaque (Macaca sylvanus)
15) Mudkip, Vaporeon and Axolotl (Ambystoma mexicanum)
16) Pikachu and IIi Pika (Ochotona iliensis)
17) Poliwrath and Purple frog (Nasikabatrachus sahyadrensis)
18) Poliwag and translucent tadpoles
19) Primeape and Red Slender Loris (Loris tardigradus)

20) Psyduck and Platypus (Ornithorhynchus anatinus)
21) Rattata and Large Rock Rat (Cremnomy elvira)
22) Rhydon and Jayan (Rhinoceros sondaicus)
23) Sandslash and Sunda Pangolin (Manis javanica)
24) Seel and Meditteranean Monk Seal (Monachus monachus)
25) Shellos and Chromodoris Lochi
26) Stunfisk and stargazer
27) Tauros and European Bison (Bison bonasus)
28) Victreebel and pitcher plant
29) Vileplume and stinking corpse lily (Rafflesia arnoldii)
30) Vulpix and California Channel Island Fox (Urocyon Littoralis)
31) Zubat and Cuban Greater Funnel-Eared Bat (Natalus primus)

Drawing Contest: Hold a class or school-wide competition to draw a new Pokémon trading card. Remind students to situate their Pokémon in an interesting scenery. Solicit ideas for prizes from students. Refer to this link for examples. https://pokejungle.net/2019/06/09/Pokémon-tcg-illustration-grand-prix-winners-revealed/

Post-Assessment: Use the same Pre-Assessment, but this time, after checking out the true or false statements, students have to write at least one sentence to explain their reasoning for one of the false statements.

Appendix on Implementing NGSS and District Standards

Next Generation Science Standards (NGSS) are K–12 science content standards that set high expectations for what students should know and be able to do. The NGSS were developed by 26 states to improve science education for all students on research-based data.

3-LS-4-2: Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. [Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals (e.g. dark-colored and light-colored moths) may be more likely to survive and therefore more likely to leave offspring.]

3-LS-4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Examples of evidence could include needs and characteristics of the organisms and habitats involved that students can address with their animal research project. The organisms and their habitat make up a system in which the parts depend on each other.]

3-LS3-1: Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. [Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans like tall plants and short plants.]

3-LS3-2: Use evidence to support the explanation that traits can be influenced by the environment. [Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight.]

Pennsylvania Science Standards

The following standards expect students to be able to identify and explain how adaptations help organisms to survive. S4.B.2.1.1 Identify characteristics for plant and animal survival in different environments (e.g., wetland, tundra, desert, prairie, deep ocean, forest). S4.B.2.1.2 Explain how specific adaptations can help a living organism survive (e.g., protective coloration, mimicry, leaf sizes and shapes, ability to catch or retain water). S4.B.2.2 Identify that characteristics are inherited and, thus, offspring closely resemble their parents. S4.B.2.2.1 Identify physical characteristics (e.g., height, hair color, eye color, attached earlobes, ability to roll tongue) that appear in both parents and could be passed onto offspring.

The following standards expect students to be able identify and describe living and nonliving things in the environment and their interaction. S4.B.3.1.1 Describe the living and nonliving components of a local ecosystem (e.g., lentic and lotic systems, forest, cornfield, grasslands, city park, playground). S4.B.3.1.2 Describe interactions between living and nonliving components (e.g. plants – water, soil, sunlight, carbon dioxide, temperature; animals – food, water, shelter, oxygen, temperature) of a local ecosystem.

The following standards expect students to be able to describe, explain, and predict change in natural or human-made systems and the possible effects of those changes on the environment. S4.B.3.2.1 Describe what happens to a living thing when its habitat is changed. S4.B.3.2.2 Describe and predict how changes in the environment (e.g., fire, pollution, flood, building dams) can affect systems. S4.B.3.2.3 Explain and predict how changes in seasons affect plants, animals, or daily human life (e.g., food availability, shelter, mobility).

ELA Common Cores Standards

Lesson 1 to make a Word Wall and Lesson 5 to rename your Pokémon will help teachers to address these standards. Phonics and Word Recognition (RF.4.3.A) Use combined knowledge of all letter-sound correspondences, syllabication patterns, and morphology (e.g., roots and affixes) to read accurately unfamiliar multisyllabic words in context and out of context. Key Ideas and Details (RI.4.3) Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

Math Common Cores Standards

Lesson 4 uses math games to teach students how to use models to represent multiplication and probability. 4.NBT.B.5 Multiply a whole number of up to 4 digits by a 1-digit whole number, and multiply two 2-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculation by using equations, arrays, and area models.

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