The Body Polygraph:
Applying the Polyvagal Theory to Media Skills Lesson Design

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This curriculum unit is recommended for:
Media & Information Skills and Science Grades 1-5

Keywords: Animal Classification, Bees, Coyotes, Frogs, Polyvagal Theory, Vagus Nerve, Wolves.

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit. (Insert a hyperlink to Appendix 1 where you've stated your unit's main standards. For directions on how to insert a hyperlink, see Fellows Handbook, p. 24.)

Synopsis: The goal of this curriculum unit is to apply some of the content learned in the How to Build a Human seminar which explores the social and cultural definitions of what it means to be human through the lens developmental biology. Some lessons will be directly related to K-4 science content, while the lessons for Grade 5 focuses on applying some of the teaching techniques and academic conversation protocols developed as a result of Stephen Porges' research on the vagus nerve. In his theory, Porges proposed the idea that the nervous system reacts to three states of perception, safety, danger and life-threat and that as signaling systems, social communication and the unmyelinated portion of the vagus nerve work together in mammalian animals to mediate sensory input and determine threat levels. He calls this complex adaptive mechanism, "neuroception". Neurobiologically informed lesson design include: "chunking" information, sensory activities to help students pair new information to old information, use of graphic-organizers to assist students comprehension, movement to refresh the brain, cognitive routines that promote active listening and reflection activities that help students to synthesize content or to self-regulate.

I plan to teach this unit during the coming year to 713 students in Grades 1-5.

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Introduction

I have to admit that today was a difficult day to hold back tears of frustration as I watched a young student struggle to pay attention to the assigned text. I had asked her to stop talking, told her to get off the top of the table, reseated her a couple of times. We both knew that she was intelligent, but today she couldn't track or comprehend the information in front of her. When I re-directed her to an online encyclopedia article with a lower reading level and less distracting animation, she began to cry. "Don't make me do stuff the other kids don't have to do!", she sobbed as I explained that in fairness, I had to give her the simpler assignment. What wasn't equal was indeed fair. It hurt all the same. When, in tears, she succeeded at demonstrating an understanding of the content, we exchanged shakey fist-bumps.

School/Student Demographics

I teach in a large urban school inside Charlotte's beltway where over 84% of the students live in poverty. [1] About 49% of the student population have lived in poverty for two or more generations, while the other half, roughly 48% are recent immigrants, who would be considered relatively poor when compared to their neighbors, living in trailer parks not far from newly built subdivisions. Winding Springs is a high poverty neighborhood school surrounded by more affluent housing developments. Wedged between two interstate highways and hemmed in by industrial businesses, this school serves households where the average household income ranges from $31,000-39,000, dropping more than 20% between the last two census counts. [2] New houses are being built on the other side of the rail line, unaffordable for many of the families crowded into nearby trailer parks. Immediately outside the beltway, income jumps dramatically -- to almost double that of the school's service area. Elsewhere in the county, only 18% of children live in poverty [3,] however within the public-school district, the poverty level is 54% [4] and at Winding Springs, the poverty level is 84%. At our school we have 25 homeless students, a rather high number for this district. The school population, whether from old established families or recent emigrants, Hispanic, African-American, Caucasian or Asian, share one characteristic, that of poverty. In spite of that, most students meet or exceed expected yearly academic growth, due not only to the rigor of instruction, but also because of the support of specialized staff and a strong school culture. In short, parts of the Winding Springs academic profile looks similar to schools in more moderately affluent areas of the county, in spite of the socio-economic profile of the students. Our students make tremendous growth, but many are not at "grade-level".

Rationale

There seems to be a correlation between poverty and lags in cognitive development and health issues.[5] Deficits in emotional intelligence appear as inappropriate impulsive behavior such as "acting out" in class. More troubling are the cognitive lapses--the differences in key areas of brain processing: language, memory, working memory, spatial cognition, cognitive control, visual cognition, and reward processing.[6]

In search of understanding, I turned to the work of Stephen Porges, a professor of psychiatry. In 1994, Stephen Porges posited a theory that linked vagus nerve reactions to PTSD responses. The vagus nerve, cranial nerve X, is a long, paired nerve that runs from the brain to the colon. The vagus nerve is part of the autonomic nervous system as well as the major nerve of the parasympathetic nervous system, serving as both a motor pathway and a sensory pathway[7], serving the heart and the digestive/excretory system, as well as the muscles in the face. According to Porges, neural regulation of the heart in mammalian species not only is linked to the neural control of head and face muscles, but is also, evolutionarily speaking, linked to facial expression, supporting social behavior and vocal communication. In short, the neural pathways that support health are the same ones that provide social communication.[8] In his theory, Porges proposed the idea that the nervous system reacts to three states of perception, safety, danger and life-threat and that as signaling systems, social communication and the unmyelinated portion of the vagus nerve work together in mammalian animals to mediate sensory input and determine threat levels. He calls this complex adaptive mechanism, neuroception.

The vagus nerve links the brain to our organs, part of the parasympathetic nervous system a phylogenetically older system that we share with lower order animals such as reptiles, and normally, the vagus nerve serves to inhibit and calm the heart. However, according to Porges, sometimes when under stress the unmyelinated portion of the vagus nerve activates, suppressing heart-rate, inhibiting breathing and causing disassociation.[9] He further hypothesizes that some behaviors seen in clinical disorders are misinterpretations of neuroception cues.[10] For instance, auditory and visual stimulation can affect neuroception. Therefore, people with auditory sensitivities may have overstimulation of the vagal nerve, causing physiological symptoms to appear. And the stronger the stress, the more regression to behaviors governed by the "older" unmyelinated nervous system. For example, a significant role is played by social engagement and attachment, so that a child growing up in a dangerous environment, such as students in high poverty areas, may be more attuned to the sounds of physical threat or predation and less toward soft, high frequency harmonics, such as phonetic segments.[11] This type of middle ear attunement, may affect a student's ability to master a language. According to Porges, behavior is an adaptive function and that one's inability or ability to read social cues is a function of one's physiological state. Instead, Pouges suggests using co-regulation, face to face play and the use of prosodic voice to reach and treat students who exhibit stress symptoms. Co-regulation is the ability to reciprocally interact and regulate each other; social interaction is necessary for mammalian survival. Indeed, given some of the behaviors seen in students of high-poverty, neuroscientist Matthew Lieberman's revision[12] of Maslow's hierarchy of needs which places the need for love and belonging at the foundation could be correct. Could social communication and play be a way to re-set interpretations of visceral sensations? How could this be included in library lessons?

Unit Goals

The goal of this curriculum unit is to apply some of the content learned in the How to Build a Human seminar which explores the social and cultural definitions of what it means to be human through the lens developmental biology. I will refer to topics in terms of the organizing questions of Developmental Biology: Reproduction, Differentiation, Growth, Evolution, Regeneration, Morphogenesis and Environmental Integration. Some lessons will be directly related to K-4 science content, while the lessons for Grade 5 focuses on applying some of the techniques and protocols developed as a result of Stephen Porges' research on the vagus nerve.

Media lessons in Grades K-2 tend to be based on literature, primarily folktales and picture books, with a few whole-group research lessons and lessons on Nonfiction conventions. However, Media lessons in Grades 3-5 are primarily information based. Students learn to take notes first on paper with pencils and pens, then digitally. All projects in both Media & Technology classes are based on classroom content, providing additional time for students to be immersed in the subjects of Science and Social Studies. Like their research projects, students' technology projects are expected to increase in both depth and complexity as they move up to the next grade. But because of the school's fixed schedule, I often find myself in the awkward position of introducing subjects that will be taught in the homeroom. The task will be to provide lessons with active or hands-on, multi-sensory activities to engage the brain and emotional co-regulating activities so students learn how to productively deal with stressors.

Not only do sensory activities paired with information increase the retention of the information by making lessons enjoyable rather than frustrating, this practice may circumvent the explosions of emotions that indicate Zaretta Hammond calls an "amygdala hijack"[13]. These lessons will include 15-20 minute[14] activities that will stimulate the midbrain, academic conversation and may include independent seatwork for students during the checkout period of each class. Neurobiologically informed lesson design include: "chunking" information, sensory activities to help students pair new information to old information, use of graphic-organizers to assist students comprehension, movement to refresh the brain, active listening and reflection activities that help students to synthesize content or to self-regulate. According to Porges, the hypervigilant state of sustained focused attention required to read and learn new content is not conducive to social-emotional health.[15] So using cognitive routines combined with metacognitive strategies, allow students to monitor their own comprehension[16], placing the responsibility of education back into their hands. Cognitive routines require students to process information internally, physically and socially. The first part includes making sense of the information by noting similarities and differences (Alike/Different), how the new information fits in with existing knowledge (Whole to Part), Connections to other concepts (Relationships) and point of view or bias (Perspective). Students need to connect with the information, so reflection or summarizing might be good activities, as would song or mnemonics. Finally, students need to demonstrate their understanding of the content in some form of academic conversation. A good resource list of these appears in EL: Education Classroom Protocols.[17] Science specific protocols can be found at Institute for Science + Math Education website.[18] This curriculum unit will reference national standards: ISTE, NextGen Science and/or AASL at the

beginning of each section in the form of student objectives and again at the end of the curriculum unit as required. Each of the following sections will begin with Science or Humanities background information, followed by the lesson plan, activities and assessment. An annotated resource list will be found at the end of this curriculum unit.

Grade 1 Content Research: Animal Classification

The "great work" of first grade is classification. Much of the year is spent in learning to discern patterns, similarities, and differences, to sort and to group. In the library, lessons include learning to recognize familiar folktale plots and characters and characteristics of nonfiction, as well as how a media center is organized. It makes a great deal of sense to begin with concrete examples, such as genus and species of animals and move towards more abstract concepts such as library classification. Typically, Grade 1 students have an animal research project they must complete in order to meet a science standard. This project will eventually provide a connection to library classification, but will begin with an introduction to the classification of animals.

How we classify the other inhabitants of our world is constantly changing as technology allows us to increase our understanding of other organisms. One of the earliest taxonomies devised by Aristotle divided living things into two kingdoms, animals and plants, based on analogous traits, that is, the visible physical features that function similarly. Using Aristotle's system, fishes and whales might be grouped together. In 1758, Aristotle's system was expanded upon and standardized by Carolus Linnaeus, who began to consistently use binomial nomenclature to identify specific species.[19] Species are organisms, that within a natural ecological niche, breed within their own group. There are exceptions to this, of course, as classification is a human construct.

Over the years many taxonomists have contributed to our understanding of the living world. Biologic systematics looks at when one species branches into two, considering the form of the organism. This is the basis to the earlier forms of taxonomy. Then taxonomy revisions were made based on fossil records[20] and with the evidence of adaptation and genetic evolution.[21] This method of classification, called Cladistics uses the theory of evolution, grouping organisms by common ancestors and branching when new traits arise. Innovations such as grouping animals with similar internal structures, known as homologous structures, involves examining organisms at various life stages, including embryonic growth, as some structures are evident very early. Homologous structures are anatomical features that are found in animals that are descended from a common ancestor[22], such as a dolphin flipper or a human arm. Crucial, too, is an understanding of analogous structures, that is functional features that developed in organisms that perform a similar function, but do not share a common ancestor, such as birds and bats.

The invention of various types of microscopes allowed scientists to better classify unicellular organisms, such as Protista. The kingdom of Archaea was not created until the 1970s, the phylum and reflects our changing understanding of the world's inhabitants.[23] The most recent changes in classification use molecular evolutionary taxonomy, specifically studying when key genetic differences arise.[24] Genetic inheritance through tracked by RNA is the current tool for taxonomists. Key to this method is the knowledge that messenger RNA, mRNA, transcribes DNA and carries the transcription to ribosomes in the cell to synthesize proteins. Each molecule of mRNA generally codes for only one protein Another form, tRNA decodes the DNA

transcription in the Ribosome. Ribosomal RNA (rRNA) catalyzes proteins by causing peptide bonds between amino acids. Not only are RNA a type of storage for genetic codes, and a protein catalyst, RNA is self-replicating![25] So, homologous genes code for homologous traits in all descendent organisms.[26] And since ribosomes are homologous in all organisms, ribosomes are the oldest homologous trait.

This idea lead to a reconfiguration of classification in 1990, that shifted The 5 Kingdoms, a rather quaint term for the billions of living creatures on this planet, under three domains: Bacteria, Archaea and Eukarya.

- Archaea are prokaryotes, cells with no nucleus, that survive in inhospitable environments such as your intestines, hydrothermal vents, hypersalinic or anaerobic environments. Archea have rRNA that is different in some sections from organisms in the other two domains.
- Bacteria do not have an organized nucleus, making them prokaryotes. They also have rRNA that have different molecular sections than Archaea and Eukaryotes. They are susceptible to antibiotics.[27]
- Eukarya have a nucleus containing the DNA, have rRNA sections that are distinctly different from the rRNA of Archaea and Bacteria. Eukaryotes are divided in to the following four kingdoms[28]:
    - Protista are mostly unicellular with a nucleus. Protista share animal, plant, fungus characteristics.
    - Plantae are multicellular eukaryotes that can photosynthesize, converting light energy into fuel. Plants can be transported, but do not move on their own.
    - Animalia are multicellular eukaryotes who require an external food source. Animals must break down their food internally. Animals exhibit movement.
    - Fungi (most) are multicellular. Fungi do not have a system of digestion, but must absorb an external food source

Grade 1 Instructional Implementation

Teaching strategies:

At this stage of brain development, sorting and grouping[29] provides time for face to face play as well as age appropriate learning. Face to face play allows students to practice their social communication skills in a safe environment. Strategies will include cooperative small group work, graphic organizers, use of visual media. Assessment will be informal.

Objectives: Students will look for patterns and order when making observations about the world.
Students will recall prior and background knowledge as context for new meaning.

Key questions:

(Alike/Different) How are these animals alike or different?
(Whole to Part) How do we recognize a bird?
(Relationships) Are these animals related?
(Perspective) Tell me how your partner categorized his/her cards.

Lesson 1 Alike & Different | Procedures:

This lesson will begin by asking students to work in a small group to cooperatively sort blocks. Teacher will review the five senses and how scientists use observable traits to describe matter and patterns in nature. Each group will then describe how they sorted the blocks, usually by shape, color or other characteristic. Teacher will ask students to brainstorm what they know about birds and will write responses on the board or chart paper. Teacher will read *A Bird is a Bird* by Lizzy Rockwell. Students will be asked how the animals in the book are alike or different.

Lesson 2 Animal Classification | Procedures:
Teacher will begin lesson with a short video on an invertebrate, *Neon Killers*.[30] Students will be asked to work cooperatively in small groups to sort Biome Trading Cards[31], which feature colorful photographs of animals. Each group will be asked to explain how they agreed to sort the cards by describing how animals were alike or different. Teacher will summarize what they learned and use the interactive white board to teach a lesson on animal classification. Students will be informally assessed during a ball-toss game.

Lesson 3 Library Classification| Procedures:

Students will begin the lesson by sorting animal books at their tables. Teacher will ask what characteristics students used to sort the books. Teacher will "think-aloud" book classification. Teacher will point out DDC information on the spine and explain that like animal classification, books are classified by subject or genre. Students will take a tour of the Non-fiction section of the library and be allowed to select a book.

Grade 2 & 3 Content Research: Reproduction of Flowering Plants & Pollinators

On a cool afternoon in late February of 1990, with my two preschoolers playing at me feet, I laid out the lines of what would later expand to become a large family garden. I have always been fascinated by herbs, both culinary and medicinal, but an increasing awareness of the importance of flowering plants to the human species prompted me to share my love of vegetable gardening with my children. It has been an increasing concern of mine in the last decade as the effects of pollution began to cause cascading climate changes on our planet, changes that will, without a doubt, affect our food sources. Understanding the types of plant reproduction is crucial to our survival as species go in and out of extinction. Geologic evidence ties the rise of mammals is due to the proliferation of flowering plants[32]; they are indeed the primary source for the food in the human diet. Fossil evidence of the plants of the Cretaceous period, indicate that while mosses, conifers and ferns existed early in the period[33], there is no evidence of angiosperms until the middle of the Cretaceous[34], when angiosperms appeared in great numbers and varieties.[35] What seemed to be an planet-wide explosion of angiosperms in the mid- Cretaceous has been traced by scientists to, possibly, a case of genetic doubling.[36]

During cell mitosis the DNA strands are duplicated, then distributed, in a four stage process: Prophase, Metaphase, Anaphase and Telophase. Just before prophase starts, the DNA unwinds and is replicated. The chromatin (DNA) condenses itself into a more compact

arrangement called a chromosome; it is that paired, "X" shaped arrangement of chromosomes attached in the middle with a structure called a centromere that is most recognizable in media images of chromatids. Structures called centrosomes move to opposite ends of the cell, stretching microtubules between them. The nuclear membrane dissolves and the chromosomes are pulled along the center of these microtubules during metaphase. Anaphase begins when the chromatids are separated and are pulled by the microtubules towards the centrosomes. Telophase occurs as the nuclear membrane is created around each set of chromosomes and ends when the cytoplasm splits and a new cell plate is created in plant cells. Occasionally, during the DNA replication, genes are doubled on one strand of the DNA and is missing from the second, which results in one non-viable cell and one cell with an excess of genes. In the case of genetic doubling, also known as polyploidy, these extra genes are not discarded and their existence in the surviving cell increases the chances that the gene will be physically expressed in the organism. What might be disastrous in animal cells is a bonus in plant cells. This can cause instantaneous speciation, but more importantly increases variety through diversity.[37]

All plants produce haploid cells that contain half of the genetic material needed for sexual reproduction as well as the diploid cells that contain the full complement of DNA needed to grow specialized tissues. The diploid cells reproduce through mitosis, during which the DNA strand is unwound and duplicated. The cell then divides into two separate, but identical cells, each containing the same set of DNA. The sex cells, also known as haploid cells, are created by a process called meiosis, during which the cell duplicates its DNA but then divides into *four* cells, each containing only half of the DNA. These are the gametes. The difference between primitive plants and the more complex ones are methods of fertilization and gamete dispersal and whether they have vascular tissues. Primitive plants, such as mosses and ferns, require water as a medium for fertilization and disperse spores, not seeds. Gymnosperms neither flower, nor fruit. Gymnosperms produce male and female structures in the form of cones; the ovum are unenclosed, meaning that the unfertilized seeds are exposed and do not necessarily require water to pollinate. Note that every plant discussed above produces gametes, or haploid cells and has fertilization structures in which the gametes are created and housed before fertilization. Plants can either self-pollinate or cross-pollinate.

So, what makes angiosperms so special? Unlike the more primitive plants, which may have male and female plants or male and female parts on different branches, angiosperms are considered perfect or "complete" when they contain within both male and female reproductive structures on the same stalk, being true hermaphrodites.[38] The male parts are known collectively as the stamen and are made up of filaments topped by anthers which contain pollen. Pollen grains contain the smaller gametes. The female parts are known collectively as the carpel and consist of the stigma, style, ovary and large gametes or ovules. Animals, water or wind transfer the pollen from the anthers of the stamen to the stigma of the pistil. The pollen travels down the style to the ovary. The mature ovary becomes the fruit; the mature ovule is the seed. Petals form the corolla, protected by the calyx, the sepals of the calyx make up the outermost part of the base of the flower. A complete flower will have all four components attached at the receptacle: sepal, corolla, carpel and stamen.

Plant reproduction can be sexual or asexual. Asexual reproduction is simply when a plant replicates without an exchange of gametes with another plant, in essence, creating a clone. If you

have ever pinched off a cutting and rooted it, that is asexual reproduction. The strawberry plants in my garden are all clones, because the mother plants sent out runners, which when rooted, created daughter plant clones. More than likely, the giant spears of asparagus purchased at the grocery store or farmer's markets are clones of male plants, grown from divided root crowns. The real magic of gardening lies in being able to see and manipulate the range of color, size, and shape of plants through sexual reproduction. The combination of polyploidy and sexual reproduction yields incredible variety and decreases the risk of extinction. Animal pollinators play a key role in the sexual reproduction of plants, indeed there are indications that plants have adapted reproductive structures that attract the most beneficial type of pollinator, while protecting the seed-bearing ovum.[39]

Grades 2 & 3 Instructional Implementation

Teaching strategies:

The second-grade lesson assessment will be creating a model, an age-appropriate activity because it allows practice with scissors and strengthens fine motor skills. Other brain-based strategies for this lesson include differentiated reading and the use of video to spark discussion. The main project of this grade 3 lesson will be diagrams. Teaching students about interpreting and creating visual literacy is a key component of Media & Information skills. Using diagrams to teach science concepts links tier-3, low frequency content specific, vocabulary to an image, providing a sensory anchor to an abstract concept, an appropriate task for this age when students are beginning to read in order to learn.[40] There are many types of diagrams used to teach: analytic and synthetic (linear, cyclical or webbed). For third grade, we will begin with the simple analytic diagram that will assist students in organizing information. In addition to the required title, labels, lines or arrow, students will be asked to include a sense of scale through the use of magnifying circles. Students would also have demonstrate an understanding of root structure in the form of a cut-away in their diagram

Objectives: Students will develop a simple model based on evidence to represent a proposed object.
Students will develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.
Students will generate products that illustrate learning

Key questions:

(Grade 2 Alike/Different) How are bees different from other insects?
(Grade 2 Whole to Part) How do we recognize a queen, drone, worker?
(Grade 2 Relationships) Why do flowers need bees?
(Grade 2 Perspective) Why do we need bees?
(Grade 3 Alike/Different) What did you see?
(Grade 3 Whole to Part) Would your flower be able to make seeds?
(Grade 3 Relationships) What is the purpose of petals?
(Grade 3 Perspective) Based on your flower, what do you predict other flowers would be like?

Grade 2 Lesson 1 Animal Life Cycles | Procedures:

Teacher will assess knowledge with a quick Q&A ball game. Teacher will show *Animal Life Cycles*. Since the video covers insects, amphibians and mammals, students will discuss what they learned after each segment of the video, using the Back-to-Back and Face-to-Face protocol. Students will work on a color, cut and paste life cycle worksheet to reinforce lesson.

Grade 2 Lesson 2 Pollinators| Procedures:

This lesson features differentiated reading passages in the form of non-fiction articles on the importance of pollinators through ReadWorks articles. Students will read 2 self-selected articles from beginning to end and will write a summary of each. The lesson will end with a video short such as *Sid the Science Kid Shorts: Pollination* or *Fixies: How Do Bees Make Honey*?, videos that summarize the lesson.

Grade 2 Lesson 3 Making Models| Procedures:

The anticipatory set of this lesson is a small group activity of sequencing a set of bee life cycle cards. Students will review what they learned in a quick discussion before storytime. The teacher will read a non-fiction book such as Laura Marsh's *National Geographic Reader: Bees*. Students will return to their tables to assemble a paper plate or sentence strip model of the life cycle of the honey bee, there are a number of models available online.

Grade 3 Lesson 1 Plant Life Cycles | Procedures:

Teacher will assess background knowledge with a human bar graph activity. Teacher will show a plant life cycle video. Since the video covers conifers and flowering plants, students will discuss what they learned after each segment of the video, comparing similarities and differences with their tablemates. Students will work on a color, cut and paste life cycle worksheet to reinforce lesson.

Grade 3 Lesson 2 Flower diagram | Procedures:

Students will then do a close viewing of a diagram, with magnification bubbles and cutaways. Students will compare details of how the images are alike. Teacher will explain how diagrams are used to help them remember information. Students will create a diagram, which links content literacy with a visual, a bridge activity for many students who struggle with language. Vocabulary should be posted on the board. Magnifying glasses, paper, pencils and erasers should be on the table. Wipes and masks should be available for students who need them. Teacher will sketch a flower on the board, explain the purpose of cutaway diagrams. With another color, lines are drawn to connect science vocabulary to image. Teacher will distribute flowers. Teacher will explain that students will be required to identify the parts of the flowering plant, including whether their flower is perfect or imperfect, complete or incomplete as well as creating a cutaway diagram. This lesson is anticipated to take an entire 45-minute period.

Grades 3 & 4 Content Research: Adaptation & Evolution

Changes in an organism's form, movement, state or activity rate are considered phenotypic plasticity. This type of change can be either the result of genotype expression or a reaction to the environment. Reaction norms occur when a genome produces a continuous range of expressions, known as morphs, and the environment determines the most adaptive or successful of those adaptations. The other type of phenotypic plasticity is discontinuous phenotypes. Think of these as either/or switches and are entirely dependent on environmental factors such as temperature or in the case of bees, diet.[41]

Developmental plasticity is the term used to describe when the environment causes a phenotypic change in the embryonic or larval state of animal. An example of this kind of change is predator-induced polyphenism, which occurs in species of tadpoles that react to predators by growth control in terms of size or color.[42] Indeed, it appears that amphibians are particularly susceptible to compound environmental stressors, such as the presence of predators and toxins together, making frogs both a "sentinel" or indicator species as well as a keystone species.

Adaptation is a physical or behavioral change that occurs in order to meet a basic need. In grade-4, reproduction added to the list of basic needs that the students study. One of the more interesting behavioral adaptations is the interbreeding of species, such as the coyote which can breed with both the gray and red wolves. This interbreeding of coyotes and wolves surprisingly produces viable offspring, who carry the genes for another generation. Since wolves are a keystone species this is good news for evolution, problematic for humans simply because coyotes can easily adapt to urban environments.

Teaching strategies:

Students will be able to explain how animals meet their needs by using behaviors in response to information received from the environment by summarizing from the graphic organizers created by academic conversation and research. [Insert Sousa info on information organizing being key skill]

Objectives: Students will use evidence to support the explanation that traits can be influenced by the environment.
Students will construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
Students will problem solving through cycles of design, implementation, and reflection.

Key questions:

(Grade 3 Alike/Different) How are amphibians alike or different?
(Grade 3 Whole to Part) How do we recognize a frog?
(Grade 3 Relationships) What is a frog's job?
(Grade 3 Perspective) What is causing frogs to disappear? Is the disappearance of frogs important?

(Grade 4 Alike/Different) How are members of the Canidae family alike or different?
(Grade 4 Whole to Part) How do we recognize a coyote?
(Grade 4 Relationships) What is the role of the coyote in the food web?
(Grade 4 Perspective) What is the significance of the emergence of the coywolf?

Grade 3 Lesson 1 Mystery of the Disappearing Frogs | Procedures:

This lesson builds off of a second grade life cycle unit, when students explored the life cycle of several types of animals including amphibians. Teacher will review needs of living creatures and amphibian life cycle as part of anticipatory set. Students will fill out a KWL organizer as part of a whole group exercise. After check-out, the teacher will read a non-fiction book such as Frogs by Seymour Simon or Gail Gibbon's book of the same title. Teacher will show *Stunning Close-ups: Meet These Frogs Before They Go Extinct.* Students will finish class KWL.

Grade 3 Lesson 2 Frog Adaptations | Procedures:

Students will read "*Why Are So Many Frogs Vanishing*?" on Readworks.org and/or "*Many Types of Frogs Are Going Extinct; Scientists Are Trying to Learn Why"* on Newslea. Students will also have the option of using the audio support in Readworks, if they prefer auditory learning. Teacher will model how to access a virtual lab, *Featuring Frogs*, in Discovery Education. Students will manipulate characteristics of shape, features and color in Level 1 of the virtual lab to determine which colors, shapes and features might prove to be the most advantageous adaptation. Students will share what they learned towards the end of class. Lesson may end with a short video clip featuring scientific research on frog adaptation, if time allows.

Grade 4 Lessons 1&2 Adaptations to meet basic needs | Procedures:

Students will be introduced to mind mapping, a visual note-taking method. Mind mapping and sketchnotes are two methods that require students to link images to words. Mind mapping is an effective technique for learning about relationships Students will independently view *Animal Adaptations* while taking notes on the first three sections, practicing this new method independently. Then each table will be assigned to view and record physical and behavioral adaptations to meet one basic need: food, water, protection from predators, oxygen, climate, reproduction using mind mapping. Students will share what they learned in a jigsaw activity that requires them to learn from each other to build a complete "game board". This type of activity provides for the social learning needs of students and serves as a formative assessment.

Grade 4 Lesson 3 Adaptation to meet the need of reproduction | Procedures:

Students will read Coyotes on the Move while waiting for check-out to finish. Students will view a 20-minute clip from *Meet the Coywolf*. The Rank-Talk-Write[43] exercise would be a perfect way to assess what students learned about Eastern Coyote adaptations.

Grade 5 Content Research: Plasticity, Neuroception & Brain Growth

While developmental research shows that the developing brain generally is capable of learning new information all the time, there is some information to be aware of when planning lessons for students. Neural pathways that are not activated time and time again, get pruned by the brain, so practice makes information permanent. The brain myelinates, is insulated with lipids by glial cells from back to front, which means that students can learn more complex and abstract ideas as they age. Furthermore, the timing and rate of mylenation controls the speed of learning, but research shows that experiences can physically change brain, this is usually referred to as brain plasticity. Brain plasticity can be functional, meaning that another area of the brain can sometimes take over a function when there is injury. Structural plasticity is change in the neural pathways that is caused by learning. The "Information path" may look something like this-- Input comes from one of the five senses and travels to the thalamus for sorting. Visual data is routed to the occipital lobe, auditory input is sent to the temporal lobe, important factual information goes to the hippocampus, and significant emotional sensations go to the amygdala. Ideally, everything then goes to the neocortex to be assigned pattern and meaning.[44] Except that for children of poverty, frustration is often interpreted by the body as a fight/flight signal. The vagal nerve sensations of unease erupt in an amygdala hijack. What is going on?

Our human brain is considered a triune brain because it composed of three major subdivisions. The brain stem is the first to develop and lies in the posterior region. It connects the spinal cord to the cerebellum and directs instinctive movement, such as functions controlled by the autonomic nervous system and is sometimes called the primal, pre-reptilian or reptilian brain. This is where arousal, feeding, flight and fight and other ritual repetitive movements are hard-wired into our bodies. The limbic or mammalian brain develops next becoming the amygdala and hippocampus, around the brain stem and cerebellum. It is thought to form memories and emotions, often this is where our unconscious behavior is generated.[45] The last part of our brain to develop is the neocortex, the seat of our rational, conscious "thinking" brain.[46] Trauma and stressors, such as poverty compromise ability to recruit the neural circuit. To be very specific, students who are in the midst of a fight/fight reaction are not present for a social interaction. [47] This is an overwhelming involuntary reaction, one quite beyond the control of a child. It is the role of the adult to model calm behavior in voice volume and speed of speech as well as providing adequate facial cues, co-regulation. While Porges suggests using co-regulation, face to face play and the use of prosodic voice to reach and treat students who exhibit stress symptoms, the better solution is to create a better learning environment that does not trigger an amygdala hijack.

Sprenger suggests giving students a task that their brains can do. K-2 students need concrete operations, such as hands-on activities that develop gross motor skills. The average length of focus for this age group is between 3-8 minutes[48], while 3-5 students can focus 7-11 minutes and can begin to handle abstract thinking. At this age students can complete basic research. They are also building empathy for others as the begin to look outside their local community for information, yet the still prefer tactile stimulus.[49] Sprenger also suggests that teachers provide repetition of content and instruction, giving specific feedback, adapt learning activities so they are age-appropriate and above all maintaining consistency and intensity of instruction.[50] Hammond adds story, music and movement to her ideal "enriched" classroom,

using culturally responsive tools to assist neurons in firing in sync, creating permanent associations in the brain. Hammond recommends pairing the maximum focus time for each age with 10 minutes of reflection time to consolidate the information.

Grade 5 Instructional Implementation

Teaching strategies:

In this fifth grade unit, I will be applying Hammond's macro level instructional strategies: Ignite, Chunk, Chew, Review[51], by presenting the information in short 10 minute bursts, allowing students to control the flow rate of information in their note-taking by using the technology and method (Cornell, Outline, Mind Map, Sketchnote) of choice and allowing them to "story-fy" or dramatize their response in a video or podcast. Since this expected to be a long project, I will be using Catch & Release[52] to check where the groups are in their project. While the Media objectives will be to practice their note-taking skills and learn to listen closely, the content will come from their Healthy Living curriculum.

Objectives:

Students will be able to model and apply positive stress management strategies.
Students will evaluate the effectiveness of stress management strategies in reflection.
Students will establish connections with other learners to build on their own prior knowledge and create new knowledge by modeling active listening skills

Key questions:

(Alike/Different) How do you behave when you are angry?
(Whole to Part) How does your body react to anger/fear?
(Relationships) How does anger/fear affect others?
(Perspective) What is the best way for you to deal with conflict?

Grade 5 Lesson 1 Procedures:

This set of lessons will begin with a short skit read by volunteers from the audience about siblings fighting over borrowed clothing. Teacher will introduce the unit on dealing with conflict by explaining what will happen over the course of the lesson. Teacher will review all note-taking methods and grading rubric briefly. Students will view selections from a short video about the effects of anger. Students will take notes, then compare at their tables the key points recorded by each. Teacher will cover the grading rubric for the PSA project at the end of this lesson.

Grade 5 Lesson 2 Procedures:

Students will randomly select tokens instructing them to view one of six short videos provided through Discovery Education on anger, anxiety, bullying, cliques, or conflict resolution to view independently and take notes. Students will then locate their study group by token and compare notes. Using those notes, they will collaboratively decide their end-product and begin outlining a creative PSA project that covers the four key questions.

Grade 5 Lesson 3 Procedures:

Students will write their script and record using an iPad or Chromebook, their video or podcast. During the final class, students will grade themselves using the rubric. QR codes will be generated and students will link their code to a copy of their recording. These will be posted on the wall for students to see and hear the final projects from other 29 groups. The best will air on the school's CCTV.

Appendix 1: Teaching Standards

Grade 1

NextGen (1-LS1-2) Scientists look for patterns and order when making observations about the world.

AASL (I.A.2) Recalling prior and background knowledge as context for new meaning

Grade 2

NextGen (2-LS2-2) Develop a simple model based on evidence to represent a proposed object or tool.

AASL (I.B.3) Generating products that illustrate learning

Grade 3

NextGen (3-LS1-1) Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

NextGen (3-LS3-2) Use evidence to support the explanation that traits can be influenced by the environment.

AASL (I.B.3) Generating products that illustrate learning

Grade 4

NextGen (4-LS1-1) Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

AASL (V.B.1) Problem solving through cycles of design, implementation, and reflection

Grade 5

NC (5.MEH.1) Apply positive stress management strategies.

- NC (5.MEH.1.1) Implement positive stress management strategies.
- NC (5.MEH.1.2) Evaluate the effectiveness of stress management strategies.

AASL (III.B.2.) Establishing connections with other learners to build on their own prior knowledge and create new knowledge

Teacher Resources

Eiseley, Loren. 2010. "'How Flowers Changed the World.'" http://2010yeagleyenglish.pbworks.com/f/How+Flowers+Changed+the+World.pdf.
This is the one that started it all for me as a fifth-grader. Originally published as a chapter in his 1957 classic, The Immense Journey: An Imaginative Naturalist Explores the Mysteries of Man and Nature. After reading this piece, I was smitten with the idea that one fluke could change the world.

"EL Education: Classroom Protocols," accessed November 10, 2019, https://curriculum.eleducation.org/sites/default/files/curriculumtools_classroomprotocols_053017.pdf.
A handy reference of academic conversation protocols that can be used in the classroom.

Tools : StemTeachingTools." Stemteachingtools.org, 2014. http://stemteachingtools.org/tools.
The Institute of Science + Math Education made its entire teaching toolkit available on line via Google Drive. Go grab a copy now!

https://scienceprojectideasforkids.com/author/janice-2. 2017. "History Of Classification." VanCleave's Science Fun. September 16, 2017. https://scienceprojectideasforkids.com/history-of-classification/.
While old, Janice Van Cleave's book series on science are still used in school libraries as the go-to source for information and science project ideas. Her website, geared towards teachers and homeschoolers, is still good.

Jensen, Eric. 2009. *Teaching with Poverty in Mind: What Being Poor Does to Kids' Brains and What Schools Can Do about It. ASCD*. ASCD. Alexandria, VA. https://eric.ed.gov/?q=%22Jensen+Eric%22&id=ED507689.
An excellent introduction to the effects of poverty on students. Should be paired with his other book, Engaging with Poverty in Mind.

"Justice Map - Visualize Race and Income Data for Your Community." 2010. Justicemap.Org. 2010. http://www.justicemap.org/index.php.
This is a very useful source for income data. Seriously, save this site for grant-writing.

"Newsela | Instructional Content Platform," Newsela.com (Newsela, 2019), https://newsela.com/.
Newslea provides leveled current event content sorted by discipline. Pro subscription offers reading comprehension activities and quizzes.

Paquette, Veronique. 2014a. “Life Cycle of a Honey Bee.” BetterLesson. BetterLesson. November 11, 2014. https://betterlesson.com/lesson/629259/life-cycle-of-a-honey-bee. Better lesson is an excellent resource for lesson plan ideas to deepen your students’ understanding.

Porges, Stephen W. 2017. *The Pocket Guide to Polyvagal Theory : The Transformative Power of Feeling Safe*. New York, N.Y.: W.W Norton & Company.
An easy to read explanation of the polyvagal theory.

“ReadWorks.” 2019. Readworks.Org. 2019. https://www.readworks.org/article/Vanishing-Frogs/d8ae9323-b2ff-4b73-bbbb-10b9a3af572d#!articleTab:content/.

Readworks offers leveled fiction and nonfiction reading passages for students, as stand-alone, paired-texts or grouped by subject. Some articles offer highlighting and commenting features. Others provide vocabulary support, differentiated reading levels or audio recordings to support student learning. Upper level history articles supplied by Gilder-Lerhman.

Roughgarden, Joan. 2013. *Evolution’s Rainbow : Diversity, Gender, and Sexuality in Nature and People*. Berkeley, Calif.: University Of California Press.
The first half is a useful secondary text, if gender and sexuality are being studied.

Sprenger, Marilee. 2008. *The Developing Brain : Birth to Age Eight*. Thousand Oaks, Calif.: Corwin Press.
If you only had funds to purchase one professional title this year, this would be it. For the elementary educator, this explains some of the most common behaviors for each developmental age as well as tasks that appeal to each age.

Wayman, Erin. 2012a. “Primate Origins Tied to Rise of Flowering Plants.” Smithsonian. Smithsonian.com. November 28, 2012. https://www.smithsonianmag.com/science-nature/primate-origins-tied-to-rise-of-flowering-plants-145971956/.
Our fates are indeed tied to flowers, this article explains why we should care about pollinators and flowering plants.

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