



All Traces Left Behind

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This curriculum unit is recommended for 6th Grade Integrated Science

Keywords: ecosystem, biome, biotic, abiotic, epigenetic, pesticide, fertilizer, endocrine, transgenerational

Teaching Standards: See [Appendix 1](#) for teaching standards addressed in this unit.

Synopsis: *How can contaminated water affect a natural and human ecosystem over multiple generations?*

Students will analyze how the presence of toxic chemicals/heavy metals in water supplies can change an ecosystem over multiple generations with a focus on pollutants from fertilizers. This instruction will then be connected to an exploratory activity that asks students to analyze an urban water crisis and make conclusions about how that will affect humans ingesting the water. Students should be able to conclude that toxins presented to an environment have lasting negative impacts on the flora and fauna of the area over multiple generations. Toxins and chemical pollutants are negative abiotic stimuli plants and animals encounter at disproportionate rates dependent on location. Humans, however, experience disproportionate exposures to harmful chemicals due to socioeconomic and racial inequity, which are correlated in an American context.

I plan to teach this unit during the coming year to 140 students in 6th Grade Integrated Science.

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How can contaminated water affect a natural and human ecosystem over multiple generations?

Introduction

In this unit, the teacher will draw a connection between how harmful chemicals can affect ecosystems through forced epigenetic change, and how an urban ecosystems experience similar attacks (i.e. Flint, MI water crisis). Students will analyze how the presence of toxic chemicals can change an ecosystem over multiple generations. Through this exploration, students will be able to identify the fragility and malleability of ecosystems, and how the introduction of a new helpful or harmful stimulus can affect the ecosystem for generations. Students should be able to conclude that toxins presented to an environment have lasting negative impacts on the flora and fauna of the area over multiple generations.

Students will be able to articulate differences between epigenetic change in environments and urban societies. Through restorative justice practices and with a strong focus on social-emotional wellbeing, students at Martin Luther King Jr. Middle School will recognize the disproportionality of epigenetic change in human populations. Toxins and chemical pollutants are negative abiotic stimuli plants and animals encounter at disproportionate rates dependent on location. Humans, however, experience disproportionate exposures to harmful chemicals due to socioeconomic and racial inequity, which are correlated in an American context. This will be uncovered through a study of farmworkers and pesticide exposure.

To close and assess the unit, students will disseminate the information they have learned to a party they decide needs to be aware of this information. They will craft and send a letter summing the work they had done to uncover how pesticides have negative effects on the ecosystems and humans they come in contact with.

School Information and Student Background

The students engaging with this curriculum will be 6th grade general science students at Martin Luther King Jr. Middle School. MLK Middle is located in Hidden Valley neighborhood of Charlotte, and has a student body that is 54% Black/African American, 44% Latinx, 2% other (white, Asian/Pacific Islander, etc.). The student population is transient, with many students leaving and arriving throughout the year from various CMS schools, states, and countries.

MLK Middle is home to a diverse population of learners; nearly 20% of students are receiving services or monitored as English Language Learners (ELL) and 9% of students are classified as Exceptional Children (EC) and receive individualized education plans. The school has seen a significant increase in both of these categories, and have adjusted staffing as much as possible to compensate—the 6th grade team expanded from 12 teachers last year to 16 teachers this year, and co-teaching is more common in ELL and EC heavy core classes.

Martin Luther King Jr. Middle is a Title I school, and received this designation because over 75% of students are considered economically disadvantaged. MLK is over 90% families at or below the poverty line. Title I affords the school funding for supplies and programs to be used to support these students materially, academically, and emotionally. Every student at the school

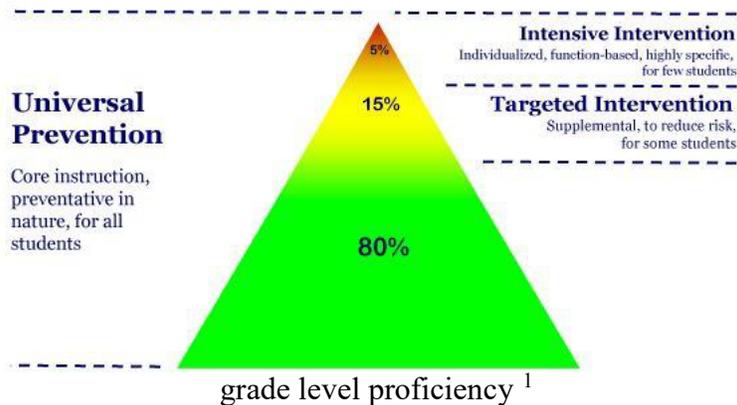
receives free breakfast and lunch, as well as access to needed school supplies, food pantries, health needs, and more.

The 6th grade runs on a block schedule, with students going to each core class once a day for an hour and five minutes. Students test quarterly with Beacon Assessments, which attempt to monitor student success and growth in urban schools in each core subject. Students also prepare for the North Carolina Final Exam (NCFE) at the end of the year. They receive a score 1 through 5, with 1 and 2 indicating that students are not on track to be career and college ready, a 3 indicating grade level proficiency, and a 4 and 5 showing above grade level proficiency. Students in the 2017/2018 school year showed ~32% grade level proficiency on the science NCFE.

All blocks are inclusion classes, indicating that general education, EC, and ELL children receive the same content in the same class setting. While core classes are inclusion, MLK enforces academic and behavior supports with fidelity to support the majority of students with learning and social-emotional deficits (especially reading and math). MLK Middle integrates a Multi-Tiered System of Support (MTSS) for all students at Pride Time (enrichment) block each day. The student will use designated programs and curriculum to build success in areas that they struggle in, such as reading, math, or behavior management. A school meeting typical grade level proficiency would see 80% of students needing no MTSS, and 20% needing moderate or severe support (Figure 1). MLK Middle has an inverted MTSS structure, with 20% of students needing no MTSS, and 80% requiring moderate or severe support.

FIGURE 1

School-Wide Support Systems for Student Success: An MTSS pyramid for schools with typical



Rationale

The rationale for this paper has three main components: academic excellence, social-emotional

¹ "Overview- What Is RI MTSS?" Rhode Island Multi-Tiered Systems of Support. Accessed November 2, 2018. <http://www.ric.edu/sherlockcenter/rimtss/overview.html>

exploration, and developing a civic identity. With an emotionally charged and academically challenging topic like epigenetics, it is important to remember that the whole child is being educated and molded rather than purely their scientific brain.

Academic Excellence

This unit will incorporate North Carolina Essential Standards for 6th grade science into a compelling real-world example of science in action². Standards from all core subjects will be present during this epigenetics exploration (Appendix 1).

There is ample opportunity for cross-curricular ties in this unit:

1. Social Studies-- Influence of human interaction on soil and water, development of urban and rural centers and spaces, workers migration
2. Math-- Ratios (part to whole and part to part), analyzing graphs and tables, basic statistics and probability
3. ELA-- Reading and analyzing scientific texts, evaluating/crafting opinions on complex topics, crafting a personal and civic identity

Students are expected to showing higher-than-normal academic success during this unit due to the relevance of the topic presented, the novelty of the topic, use of multiple teaching strategies throughout the curriculum, and the diversity of assessment method. Above all, his unit offers an opportunity to discuss difficult societal and scientific topics in culturally responsive methods and with social-emotional supports.

The use of culturally relevant teaching methods have been proven consistently to support increased academic success, retention of information, critical thinking and problem solving skills, and a love of knowledge and learning³. In a middle school devised of over 98% Black/African America and Latinx students, an awareness and study of epigenetics can help students develop a healthy criticism of society, their own societal and personal code of values, and healing through a topic that is more likely to affect them on an everyday basis compared to white and affluent students.

This unit also offers extensive opportunities for differentiation based on English language acquisition and learning differences. Scientific texts employed should be adjusted to different Lexile levels, and project-based learning should have amended rubrics based on IEP-documented annual goals and English Learner documentation. Important areas to incorporate from this curriculum unit will be priming for vocabulary, offering writing and speaking sentence stems, and building a robust background knowledge⁴. Students should also be strategically paired during group work in order to support EC (Exceptional Children) and challenge “high fliers” to teach rather than just absorb information.

² Essential Standards: 6th Grade Science Unpacked Content. PDF. Raleigh: North Carolina Department of Public Instruction, March 28, 2011.

³ Ladson-Billings, Gloria. "Toward a Theory of Culturally Relevant Pedagogy." *American Educational Research Journal* 32, no. 3 (1995): 465-91. Accessed November 4, 2018. doi:10.2307/1163320.

⁴ Helping English Language Learners Understand Content Area Texts. PDF. Indiana Department of Education Office of English Language Learning and Migrant Education.

Social-Emotional Development

Students at MLK Middle are typically low income, and experience a plethora of negative external stimuli that affect them academically, socially, and emotionally. MLK has identified that an intentional stance should be taken to combat the effect these situations could have on hope, self-worth, and future success. Now, each student participates in mandated social-emotional learning (SEL) every day to build relationships, self-worth, hope for the future.

Students start every school day with a restorative circle during their Pride Time, and end each day with a restorative circle in their last block class. Students also participate in set SEL lessons every Wednesday during Pride Time, and use Friday Pride Time to reflect on behavior, academics, attendance, and goal setting from the past week.

MLK's new commitment to SEL has set a firm foundation for discussing topics in class that may be distressing or difficult for our students. As negative epigenetic markers are more likely to affect people of color and low income communities in the United States, this foundation is vital as the topic directly impacts the children participating in the CU. Without this base layer of SEL, the CU would be ineffective and lacking in substance for the students of MLK Middle. Partnerships with the grade level counselor and SEL committee at the school have been developed to create a supportive social-emotional setting for students to share, listen, and learn.

The Framework for Systemic Social and Emotional Learning from Casel (Figure 2) outlines the multi-tiered layers of social-emotional support students should receive during their education. This framework cites that a strong SEL Curriculum and Instruction in the classroom is vital for students to begin implementing their learning into a classroom environment. This CU aims to address each of the internal tiers at different levels of commitment: relationship skills, social awareness, responsible decision-making, self-awareness, and self-management.

FIGURE 2
Framework for Systemic Social and Emotional Learning⁵



Developing a Civic Identity

The stewardship standard which is a core target of this curriculum unit leads students to discuss the ethical implications of using pesticides in agriculture, and who is most affected by their negative side effects. This topic will expose students to questions of environmental, business, legal, and societal ethics. Through an understanding and discussion of civic topics such as these, students will begin to understand their own civic dispositions and build their civic identity. Identity building is supported by practicing political and ethical discourse, agreeing and disagreeing with peers respectfully, and building arguments with reputable primary and secondary sources.

At the end of the curriculum unit, students should arrive at the conclusion Latinx populations are most likely exposed to harmful pesticides due to their overwhelming contribution to the U.S. agricultural workforce. Students should personally arrive at this conclusion by analyzing informational texts, engaging in class discussions/debates, evaluating tables and graphs, and discussing with peers.

Epigenetics Background

Epigenetics is a quickly emerging sub-branch of biology that takes the Nature vs. Nurture debate from a “this-or-that” to a more symbiotic relationship where both nature and nurture influence an organism's development not only together, but also because of each other. According to David S. Moore, author of “The Developing Genome”, “... discoveries about epigenetics have helped undermine the nature vs. nurture debate; because epigenetic events happen at the interface between DNA and its environment, they can help us see how our features always arise from *both* nature and nurture...”⁶. Epigenetics is the theory that an organisms DNA can be altered by the

⁵ "What Is SEL?" Casel. Accessed October 28, 2018. <https://www.casel.org/what-is-SEL/>.

⁶ Moore, David Scott. *The Developing Genome: An Introduction to Behavioral Epigenetics*. New York: Oxford

environment in which it develops and exists before birth, during gestation, and after birth throughout its lifetime.

A main facet of this theory is the assertion that changes in an organism's genome are also passed down through subsequent generations. For example, studies conducted recently have found that roundworms have demonstrated transgenerational epigenetic inheritance over 20 generations. Other organisms such as plants, fruit flies, and rodents have shown similar findings. The influence of methylation patterns through the introduction of new, typically negative stimuli (such as BPA, phthalates, or nicotine) have caused phenotypic anomalies in as many as 4 subsequent generations in rats⁷.

Transgenerational inheritance includes phenotypic and behavioral traits influenced by both environmental exposures and experience⁸. For example, exposure to positive or negative stimuli such as folic acid in utero or lead, respectively, can affect offspring and successive generations. Experiences can also influence offspring health and wellness, such as exposure to trauma. Two such examples are as follows:

- Pesticide Exposure and Endocrine Disruption⁶

Pesticides are chemicals that protect plants from unwanted insects, weeds, fungi, or other undesirable organisms that might harm the plant. Pesticides are used throughout homes, parks, farms, schools, or anywhere insects or pests might live. Therefore, exposure to these chemicals are high for humans, and even higher if you frequent areas that use more-than-normal levels of pesticides like large-scale agricultural operations. Vinclozolin is a pesticide used on farms, which has been proven to be an endocrine disruptor. In studies of rats and mice, pregnant mothers were exposed to this dangerous chemical and third (F3) and fourth (F4) generations were assessed for anomalies. These animals had higher rates of abnormalities in testes, kidneys, and prostate. Other studies found significant increase in the development of prostate disease, kidney disease, immune system abnormalities, sperm motility, and more in the F3 and F4 generations.

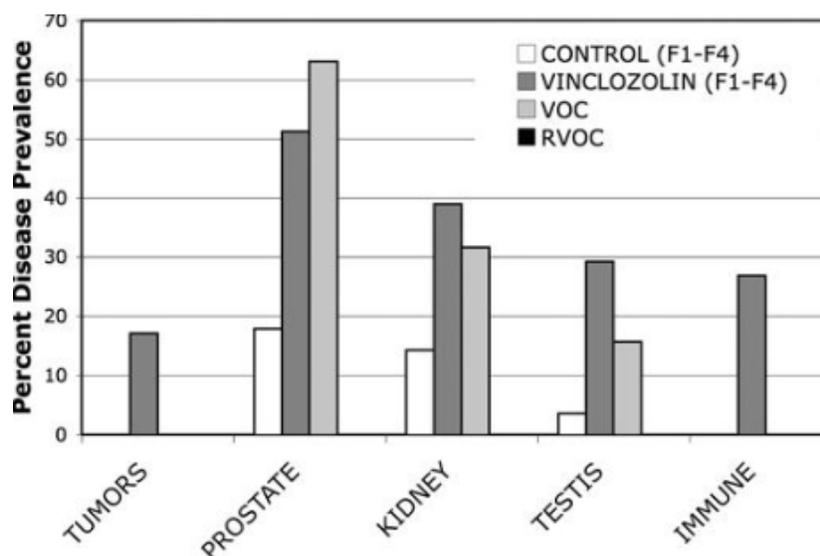
University Press, 2017.

⁷ Rothstein, Mark A., Heather L. Harrell, and Gary E. Marchant. "Transgenerational Epigenetics and Environmental Justice." *Environmental Epigenetics* 3, no. 3 (2017). doi:10.1093/eep/dvx011.

⁸ Youngson, Neil A., and Emma Whitelaw. "Transgenerational Epigenetic Effects." *Annual Review of Genomics and Human Genetics* 9, no. 1 (2008): 233-57. doi:10.1146/annurev.genom.9.081307.164445.

FIGURE 3

Tumor growth in F1-F3 rats exposed to different pesticides, including Vinclozolin.⁹



- Maternal Care and Stress Management¹⁰

Mother rats will lick pups as a tool for social connectedness. This interaction has been studied since the 1950's to identify developmental differences in rat pups into adulthood. Rats that were licked and groomed by their mother grew to be healthy, calm adults with normal reactions to stress. Those who were not licked, or ignored, by their mother were more likely to develop nervous, stressful tendencies. When the mother licked her pups, their inactive glucocorticoid receptor (GR) gene demethylated and became more active. Those who did not receive attention had a GR gene that was never active. Rats that were licked as pups were more likely to lick and groom their own pups, while those who were ignored are more likely to treat their pups the same.

Pesticides

Pesticides have contributed to a considerable jump in United States crop yields over the past 50 years. Herbicides, insecticides, and fungicides applied appropriately has positively impacted crop quality while controlling unwanted pests such as weeds, insects, and plant pathogens. This is a necessity in the United States agriculture industry, which typically operates via large-scale high-yield farms. However, concerns for human health and environmental well-being have been raised and studied since many of these pesticides possess toxic properties¹¹.

⁹ Anway, Matthew D., Charles Leathers, and Michael K. Skinner. "Endocrine Disruptor Vinclozolin Induced Epigenetic Transgenerational Adult-Onset Disease." *Endocrinology* 147, no. 12 (2006): 5515-523. doi:10.1210/en.2006-0640.

¹⁰ Francis, Darlene D., and Michael J. Meaney. "Maternal Care and the Development of Stress Responses." *Current Opinion in Neurobiology* 9, no. 1 (1999): 128-34. doi:10.1016/s0959-4388(99)80016-6.

¹¹ Fernandez-Cornejo, Jorge, Richard Nehring, Craig Osteen, Seth Wechsler, Andrew Martin, and Alex Vialou. *Pesticide Use in U.S. Agriculture: 21 Selected Crops, 1960-2008*, EIB-124, U.S. Department of Agriculture, Economic Research Service, May 2014.

Vinclozolin, previously cited as an endocrine disruptor, is listed by the USDA as a fungicide. In an archived US EPA report, human exposure to Vinclozolin has relatively low immediate side effects past skin irritation. The report states that truly dangerous effects of Vinclozolin's toxicity related to its role in decreasing androgenic activity. According to the report, "androgens are the principle male steroid hormones, such as testosterone, which stimulate the development and maintenance of the male reproductive system and secondary sex characteristics."¹²

Mammals in contact with Vinclozolin have shown a variety of dramatic physical abnormalities dependent on the amount of exposure. In a study, rats receiving a low amount on Vinclozolin daily exhibited notable androgen effects, such as decreased prostate size, weight reduction in sex organs, and decreased nipple/areole development. At higher doses, however, effects became more drastic, such as delayed puberty, kidney stones, sex organ malformations, and more¹¹.

While the effects on the human androgen systems have not been studied, it is assumed that the effects on humans would be similar. Human's would be exposed to Vinclozolin via their diets, post-application exposure from sod, and playing on treated golf courses at low levels.

Occupational exposure to Vinclozolin carries a higher risk, and thus presents more concerns for human health effects. Reviews of the long term effects of pesticides show inconclusive results for the carcinogenic effects of many pesticides, but reproductive effects are the subject of great concern. For example, recent findings suggest female greenhouse workers exhibit lowered fertility rates. It is assumed that exposure to pesticides may be part of their causal chain¹³.

Main Instructional Tools

In order to build learning objectives through a series of learning levels, the Depth of Knowledge wheel has been used as a guide (Appendix 2). Through the completion of this curriculum unit, students should see the following learning markers:

Students will be able to:

- Describe the concept of an ecosystem, and how diverse relationships between living and nonliving things support different environments (Level 3 DOK)
- Identify human environments as ecosystems with complex relationships involving living and nonliving things, as well as ideas and sociological ideologies. (Level 1 DOK)
- Connect how introducing harmful substances affects human environments disproportionately based on race and class in the United States (Level 4 DOK).

The tools employed to achieve these outcomes are as follows:

1. North Carolina Essential Standards—Updated 2015 for 6th grade science
2. Two weeks of classroom instruction time on an everyday schedule with 1 hour classes
3. Access to Chromebooks or other students devices that access the internet (preferable, but not completely necessary)
4. Social/emotional support and guidance for students.

¹² EPA R.E.D. Facts: Vinclozolin. PDF. Washington, D.C.: Environmental Protection Agency, October 2000.

¹³ Bolognesi, Claudia. "Genotoxicity of Pesticides: A Review of Human Biomonitoring Studies." *Mutation Research/Reviews in Mutation Research* 543, no. 3 (2003): 251-72. doi:10.1016/s1383-5742(03)00015-2.

Teaching Strategies

Through this curriculum unit, the teacher will use an engage/explore/explain/elaborate/evaluate model to teach epigenetics through the lens of standards 6.L.2.3 and 6.E.2.4. Students should have the prior knowledge of 6.P.1.1-6.L.2.2 in order to fully understand how things are moved, shared, and changed in an ecosystem. Special attention should be put on 6.L.2.1 and 6.L.2.2 as these are standards which introduce the idea of energy moving throughout an ecosystem, cycles of oxygen, nitrogen, oxygen, and water in an environment, and how organisms react to positive and negative external stimuli. Finally, this curriculum unit assumes that the teacher has already taught limiting factors (one half of the 6.L.2.3 standard).

Engage

The main part of standard 6.L.2.3 is identifying the biotic and abiotic parts of an ecosystem, and how they work together to support life, growth, and survival. The engagement piece of the unit will be one day long, but each day will process from a short engagement activity to spark student curiosity and interest.

Day 1

In the beginning stages of this unit exploration, students will think about different environments around the globe. Students should choose one type of ecosystem they are interested in from a designated list, and create an anticipation guide (list provided by teacher, or teacher can choose for students). Through this anticipation guide, students will make predictions about what they will find if they visit a certain ecosystem. Students should have a variety of things listed, both biotic and abiotic. It is suggested that students create their anticipation guide as an introduction to the unit's part in their notebook, interactive journal, or the like. (Figure 5)

FIGURE 5
Example of interactive notebook anticipation guide

	DATE: ___ / ___ / ___
	<u>Ecosystems Anticipation Guide</u>
○	My Chosen Ecosystem: <i>(List chosen ecosystem)</i>
	What I would find in the <i>(list chosen ecosystem)</i>
	Rocks
	Trees
	...

Upon the completion of the anticipation guide, students will divide into different areas of the room according to their chosen ecosystem. As a group, they will discuss what might be found in the selected ecosystem. Students should be able to see that many of their ideas were the same as their classmates, and will be directed to write all of the different ideas in their group on individual index cards, discussing each as they write it. At the end of this group time, the group should have written each idea on an index card and discussed whether they agreed or disagreed if it belonged in the ecosystem.

The teacher will then pass out index cards with different categories of things found in a certain ecosystem: Living Animals, Living Plants, Living Microorganisms, Non-Living Objects, Sources of Energy, Manmade Things, and Other. Students will sort their index cards into the 7 respective categories and discuss what they notice about their groups. The group should focus on which categories they felt comfortable with (filled with ideas) and which they did not understand (did not sort any index cards into).

The engagement lesson will conclude with a brief set of guided notes that define an ecosystem and a biome (Appendix 3). The teacher will tell the students that they had already predicted some of the things that are found in ecosystems, and will learn how their predictions fit into a complex, ever-changing environment. The lesson will conclude with the students completing a brief exit ticket assessing their acquisition of the notes given for the day and their understanding of an ecosystem (Appendix 4).

Explore

Day 2

Teacher will administer a Do Now to start class on Day 2 based on Day 1 exit ticket data. Briefly review whole-class misconceptions before moving on to the activator. For the activator, the teacher should post multiple pictures of different biomes around the class in color. The students should complete a gallery walk and make predictions around which biomes is shown in each picture. There should be multiple pictures for each biome shown. When the gallery walk is complete, students and teacher will correct the hypotheses and engage in a discussion about how students categorized these photos. This will engage their students prior knowledge before moving on to independent work. Possible probing questions could include:

1. What caught your eye in each picture?
2. Did you notice similarities between these biomes?
3. What was something surprising to you? What was something that showed up which you did not expect in that biome? Were any of your ideas challenged?
4. What were some giveaways? What were obvious parts of certain biomes? Why were they so obvious?

After the Day 2 gallery walk, students will briefly research different biomes. They will receive a research guide (Appendix 5) and be instructed to choose 3 ecosystems that interest them. They should use informational texts provided by the teacher or any other research methods the teacher deems necessary (internet sources, informational graphs and charts, videos, etc.) to finish their

research guide. Through this activity, students will briefly see the characteristics of each ecosystem, and be exposed to the rich diversity of the natural world. For the day 2 exit ticket, students will choose which ecosystem interests them most and submit this to the teacher with a rationale about why they found that ecosystem intriguing.

Research articles can be administered via Chromebooks/iPads, or printed to accommodate based on technology access.

- Types of Ecosystems Overview (could be used as part of the activator, or used to spark students interest): <https://sciencing.com/types-environmental-ecosystems-8640.html>¹⁴
- Deep Dive into Each Ecosystem: https://www.ducksters.com/science/ecosystems/world_biomes.php¹⁵

Days 3 to 4

Through the Day 2 exit ticket, students chose one biome that interested them most. Students will complete a poster describing various parts of their chosen ecosystems. Past concepts such as predators, decomposers, consumers, energy transfer, etc. will also be re-assessed on this project. Students will receive a project summary and rubric to ensure equity in grading (Appendix 6). At teacher's discretion, students could have 2 total days to complete their project. Students should be directed to either do their project digitally through PowerPoint or on a physical poster board. Teacher should choose concepts from past standards that need re-looping to use as Do Now's and mini-lessons during day 3 and/or 4 at his/her discretion.

Day 5

When projects are complete and the teacher has checked the projects for accuracy, the projects will be posted around the room and grouped by ecosystem for Day 5. The class will be able to have a "museum day" exploring each of the ecosystems that they did not personally research. Students will complete a graphic organizer on a clipboard as they move throughout the room to collect information about the 7 ecosystems (Appendix 7). As an exit ticket, students will see similar pictures to the ones posted during the day 2 activator. For each picture, students will identify which biome it is, and answer various questions using their gallery walk guide to assist. The teacher should craft this assessment to mirror the most important information the students should have found in their "museum day".

Explain

During this portion of the unit, teacher-led instruction is the heaviest. The teacher will lead activities based around the multitude of symbiotic relationships that exist in an ecosystem. Previously learned vocabulary will be enforced heavily throughout this beginning section of the unit, as students are encouraged to use "science speak" in the classroom. Vocabulary should

¹⁴ Harris, Amy. "Types of Environmental Ecosystems." Sciencing.com. March 13, 2018. Accessed November 18, 2018. <https://sciencing.com/types-environmental-ecosystems-8640.html>.

¹⁵ "Biomes." Ducksters Educational Site. Accessed November 18, 2018. https://www.ducksters.com/science/ecosystems/desert_biome.php.

include, but is not limited to the following: ecosystem, ecology, community, population, biotic, abiotic, consumer, producer, decomposer, limiting factors, tolerance, etc. The start of “explain” on Day 6 is an appropriate day to assess types of ecosystems and ecosystem vocabulary with a quiz (teacher discretion).

Day 6

On day 6, after the foundation of ecology is set, students will be asked to think about how humans might affect a certain ecosystem. Students should consider that humans can affect the environment in both positive and negative ways. In order to organize thoughts, students will create a T-Chart in their notebooks. The title should be “How Humans Affect Ecosystems” with “Positive” and “Negative” at the top of each section (Figure 6).

FIGURE 6
How Humans Affect Ecosystems T-Chart Example

How Humans Affect Ecosystems	
Positive	Negative

After this activator, students should begin sharing their ideas in a small group or as a full group (teacher discretion). If small group, consider assigning a limit of 1-2 minutes for one person at a time to talk. During that time, the speaker cannot be interrupted for any reason. If they finish before time is up, the group can sit in silence. As the discussion develops, students should be asked to think more about the negative ways that humans interact with ecosystems.

Teacher will use a mini case study to examine what might happen if humans introduce a harmful substance to an ecosystem—in this case, the example is fertilizer. This case concerns the effects of pollution on a water source as this represents a fragile ecosystem with which students are already familiar. Students will see how pollution in a freshwater environment can disrupt the oxygen cycle, survival of species, and promote the disruptive growth of harmful plants like algae. Students will have a series of resources to use in order to explore what happens when fertilizer is introduced to a water source:

- 1) An encyclopedia-like online article discussing algae blooms and oxygen depletion:
<https://www.ck12.org/book/CK-12-Life-Science-Concepts-For-Middle-School/section/12.28/>
- 2) A newspaper article about an aggressive algae bloom on Lake Okeechobee:
<https://www.wtsp.com/article/news/red-tide/scientists-say-florida-can-avoid-future-red-tide-disasters-but-special-interests-might-be-in-the-way/67-609206540>
- 3) EPA webpage with algae bloom information:
<https://www.epa.gov/nutrientpollution/harmful-algal-blooms>
- 4) An EPA infographic about nutrient pollution:
<https://www.epa.gov/sites/production/files/2013-08/infographic-nutrient-pollution-explained.png>

- 5) A video from Science Safeguards explain hazards to drinking water from harmful algal blooms: <https://www.youtube.com/watch?v=18wFyybikIY&feature=youtu.be>

Students should work in teams on Day 6 to complete a case brief synthesizing the information found in these 5 resources (Appendix 8). At the end of the case brief, students will be directed to identify different reasons the fertilizer might have been introduced to the environment, regardless of the negative effects it has on water supplies.

To summarize, students should discuss the ethical implications of the decision to pollute, and why humans are compelled to disrupt the environment in this way. The class should bring up ideas such as entitlement, expansion, money, regulations, laws, and the like without diving into one specific topic too deeply. As an exit ticket, students will develop their own timeline of fertilizer pollution event to synthesize the causes and effects of the problem. This should be used as a CFU, and illustrate that the student can follow the timeline from the introduction of the pollutant to the environmental effects. Students can be directed to think of a large scale fertilizer event, like Lake Okeechobee, or a smaller scale one, like deciding to fertilize a personal garden.

Elaborate

Students should already know that pollution in an ecosystem has detrimental effects on the present community. To elaborate, students will now expand their thoughts to consider how the harmful effects of pollution can affect future generations of the community's species through the lens of a human ecosystem.

Day 7

To start the day, the teacher will arrange students in a circle without anything obstructing them from their classmates. In this way, students are completely open to discussion with classmates, and on a level playing ground with their peers. Teacher will pose questions during this circle based on the following hypothetical problem. The teacher will toss a "talking piece" from student to student to signify whose turn it is to speak. This restorative circle-style discussion forum will be an effective way for children to be heard as they are sharing their views and predictions, which may be ethically or morally based.

Hypothetical Story

s"Pest-No-More, a local pest removal company, has expanded to North Carolina. They are advertising pest killers to farmers and families as a way to protect flowers and crops this spring. Pest-No-More is the most effective pest removal company in the South East, because they use a chemical called Vinclozolin. Vinclozolin removes almost all of a harmful fungus from plants, but is also very dangerous to animals in the area. It can cause growth defects. But crops are doing better than ever, and farmers are making a lot of money!

Discussion Questions

- What is the purpose of Pest-No-More?
- Who would benefit from Pest-No-More? Who would they help in North Carolina?
- Who would be hurt by Pest-No-More?
- The story says that crops are doing better than ever! Should Pest-No-More come to North Carolina?
- The story cites that Vinclozolin, the dangerous chemical in Pest-No-More's pesticides, can cause defects in animals. What about people?

Once the discussion has closed, the teacher will tell the students that Vinclozolin is a real chemical in pesticides, and has been linked to defects in animals when they're exposed to it. Not only that, but the animal's offspring were affected as well. Teacher should ask students if this changes their view of whether Pest-No-More should come to North Carolina. The teacher should also ask students if this presents any possible dangers to humans exposed to the chemical.

The teacher will begin to draw the connection between how toxins move in an environment and how energy moves in an environment. The students will take brief notes on the basics of epigenetics, and how environmental markers introduced to an organism can create lasting changes in their physiology that can be passed down to their offspring (Appendix 9). Students should have a grasp of genetics from their 5th grade curriculum. At this point, students should think again about the parts of the ecosystem this chemical is affecting—Humans? Animals? Plants? The future children of people exposed to the pesticide? The conversation should lead students to consider how humans might be affected by Vinclozolin inadvertently, but a possible misconception would be forgetting the pesticide manufacturers and farm workers that have primary contact with the chemical.

The teacher will tell students that Vinclozolin exposure has been assumed to affect the androgen and endocrine systems of humans, although this has not been specifically studied. This would mean that human hormones, reproductive organs, neural capabilities, and more would be jeopardized with prolonged exposure to this harmful chemical. As a class, students will read excerpts from "Exposed and Ignored", a report by Farmworker Justice (Appendix 10). This should be a whole-class reading exercise, as the excerpts are taken verbatim from the report. The teacher should encourage students to use their annotation skills to assist with the text, and students should read the text more than one time. Possible vocabulary primes are suggested in Appendix 11, and other supports can be used at teacher discretion.

To close the class, students will draw a mind map with Vinclozolin in the center. From there, they should try to identify as many different parts of the ecosystem that the chemical touches. Secondary contacts can be attached to primary contacts to show how the chemical is traveling through the ecosystem. For example, a primary contact could be a bee pollinating the field, but a secondary contact would be if the bee landed on another animal or plant.

Day 8

To open Day 8, the teacher should administer a Do Now, which recalls the notes students took the previous day on epigenetics. After the Do Now, the lesson will be activated with a short story

about Juana, a farmworker in Arizona who was poisoned by pesticides on a lettuce farm (Appendix 11). Students should read the story once on their own, and be instructed to jot down words that come to mind when they read. These can be emotions, important vocabulary words, challenging words, whatever they feel. This is meant to help tie their emotions and thoughts to the story, instead of just reading it and moving on.

When students are finished with reading the story, they will form the circle from Day 7 to discuss what they read. Teacher should present questions for discussion, but ultimately, student conversation should be free flowing and unrestricted (except by the talking piece). It is important to affirm student's thoughts and opinions during this time, and praise courteous and healthy discussion practices between students. Some guided questions include:

- What were some of the words that you wrote down while you read this story?
- How did you see epigenetics present in this story?
- Did any of this story make you feel sad? Angry? Frustrated?
- Is there hope in this story?

Students will be primed that much of what they will discuss on Day 8 is race related. It is important to understand the class and student demographics to set up best practices for discussing race relations healthily and productively in the classroom space. The teacher should consider using the resource "Race Talk"¹⁶ from the Anti-Defamation League to guide their understanding of what a race-based conversation might look like in their classroom.

Students will be shown graphs highlighting age and race trends in farm workers across the United States (Appendix 12). The teacher should discuss best practices for analyzing charts and graphs before the students dive in. The students should be instructed to tell a story about the graph—what is the information saying about farmworkers in the United States? Who might be most likely exposed to harmful pesticides? Are they protected if they are exposed to something dangerous? What might be some barriers they will experience if they are exposed to dangerous chemicals like Vinclozolin?

Students may complete this assignment individually or in teams, but it is essential to highlight the important of proper writing techniques during this time. They will bring the story back to the whole group and share on a voluntary basis. Peers should be encouraged to praise parts of the story they agree with, and appropriately challenge parts they do not. During this time, the teacher is a moderator, and should keep the conversation focused and respectful.

Instead of an Exit Ticket, the teacher will thank and praise students for a respectful conversation. The teacher will also remind students that their voice is powerful, and when that voice is backed by a strong education, a student's voice is unstoppable. The class will end with a sequential circle question wherein students will share one emotion they are feeling after the class. The teacher will give the "homework" of pondering the following Martin Luther King, Jr. quotes:

¹⁶ "Race Talk: Engaging Young People in Conversations about Race and Racism." Anti-Defamation League. Accessed November 19, 2018. <https://www.adl.org/education/resources/tools-and-strategies/race-talk-engaging-young-people-in-conversations-about>.

“Our lives begin to end the day we become silent about things that matter.”
“Injustice anywhere is a threat to justice everywhere.”

Evaluate

Day 9

On the final day of the curriculum unit, students will pick one of the previous quotes and describe in a couple sentences how that quote relates to what they have learned in science class. To activate the final day, the teacher will remind students of the work they did on Days 7 and 8 to understand the dangers of pesticide exposure to workers, their families, and the environment. Students will brainstorm all the people they can think of who might need to know about this information. These answers could range from the news, to family members, to friends, to the president—any answer can be justified.

Students will choose one of their answers and construct a letter to them throughout the class period. This letter should contain the following content in order to be used effectively as an assessment:

- 1) The topic of the letter should be pesticides and how they affect the people and ecosystems they come in contact with.
- 2) Facts about how pesticides affect ecosystems, and the lasting damage they can create.
- 3) Facts about how pesticides affect people. Students should include information relevant to human health and the possible transgenerational nature of harmful toxins in pesticides.
- 4) Why they are writing—do they have moral, ethical, personal, etc. responsibility to do so? Students should convey their own rationale for who they chose to write to, and why they chose that person.

At the end of the class period, students will address an envelope to the person they wish to send their letter to. Letters should be vetted and graded by the teacher before sealing the envelope. The teacher will assist students in obtaining addresses if necessary.

Appendix 1

Curriculum Unit Standards

The 6th grade science standards are as follows:

1. 6.E.2.4 Conclude that the good health of humans requires: monitoring the lithosphere, maintaining soil quality and stewardship
2. 6.L.2.3 Summarize how the abiotic factors (such as temperature, water, sunlight, and soil quality) of biomes (freshwater, marine, forest, grasslands, desert, Tundra) affect the ability of organisms to grow, survive and/or create their own food through photosynthesis.

At the end of this curriculum unit, students will be able to:

- Describe the concept of an ecosystem, and how diverse relationships between living and nonliving things support different environments (Level 3 DOK)
- Identify human environments as ecosystems with complex relationships involving living and nonliving things, as well as ideas and sociological ideologies. (Level 1 DOK)
- Connect how the introduction of harmful substances, like lead, affect human environments disproportionately based on race and class in the United States (Level 4 DOK).

Through this curriculum unit, the teacher will use an engage/explore/explain/elaborate/evaluate model to teach epigenetics through the lens of standards 6.L.2.3 and 6.E.2.4. Students should have the prior knowledge of 6.P.1.1-6.L.2.2 in order to fully understand how things are moved, shared, and changed in an ecosystem. Special attention should be put on 6.L.2.1 and 6.L.2.2 as these are standards which introduce the idea of energy moving throughout an ecosystem, cycles of oxygen, nitrogen, oxygen, and water in an environment, and how organisms react to positive and negative external stimuli. Finally, this curriculum unit assumes that the teacher has already taught limiting factors (one half of the 6.L.2.3 standard).

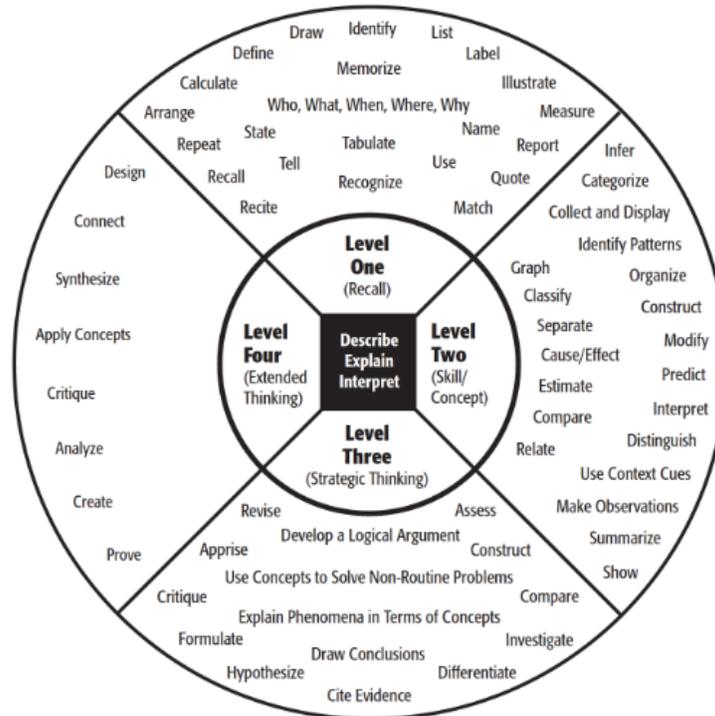
Appendix 2

Depth of Knowledge Wheel¹⁷

Further information about DOK Levels can be found here:

<http://www.niesc.k12.in.us/index.cfm/staff-development/public-consulting-group-co-teaching-session/depthofknowledgechart-pdf/>

Depth of Knowledge (DOK) Levels



¹⁷ *Depth of Knowledge (DOK) Levels*. PDF. <https://www.edulastic.com/blog/wp-content/uploads/2017/04/DoK-Wheel-Webbs.png>

Appendix 3

DAY 1: Guided Notes

Rationale: Guided notes are typically used for students to accommodate individualized learning needs of EL's and Exceptional Children. The underlined words should be omitted for students to fill in. Guided notes are a preferred method of note taking to ensure students have neat, legible notes to refer back to. It is suggested to pass out notes as small slips of paper and have students glue or tape them into their notebook.

NOTE: The differences between these an ecosystem and a biome should be noted as a typical misconception.

What is an Ecosystem?

Ecosystems can be huge, like the Sahara Desert, or tiny like a tide pool. An ecosystem is all the living and non-living things in a given area.

Living things are called biotic and non-living things are called abiotic.

- 3 examples of biotic things: (*student lists 3 examples*)
- 3 examples of abiotic things: (*student lists 3 examples*)

Biomes are ecosystems that have different living and non-living characteristics.

Biome: a way to describe a large group of similar ecosystems.

There are 7 typical biomes on earth:

- 1) Forest
 - a. Temperate
 - b. Tropical
- 2) Grassland
- 3) Prairie
- 4) Desert
- 5) Tundra
- 6) Freshwater
- 7) Marine

Appendix 4

DAY 1: Exit Ticket

An ecosystem is ...

- A. The living organisms in a certain space
- B. Very large, because it has to contain lots of different plants and animals
- C. All the living and nonliving things in a certain area
- D. A certain kind of environment on earth

Circle all the things that are biotic. Underline all the things that are abiotic.

- Rocks
- An elm tree
- An old tire
- Sunlight
- Bacteria
- Animals
- Minerals in the soil
- Insects
- Wind
- Fungus
- Humans
- Weather
- A candy bar wrapper
- Flowers

What is a biome?

- A. A large group of similar ecosystems
- B. An ecosystems with biotic and abiotic things in it
- C. A small ecosystem, like a tide pool
- D. A place with no human interaction

Look at the following descriptions. List is they are an ECOSYSTEM, a BIOME, or both.

- A puddle in a forest (ecosystem)
- All coral reefs in the Caribbean (ecosystem, biome)
- a tidal pool (ecosystem)
- A rotting tree (ecosystem)
- The arctic circle (ecosystem, biome)

Appendix 5

DAY 2: Research Guide

Instructions: Use the articles provided by your teacher to complete this research guide. This should lead you through a quick introduction to 3 biomes that already interest you.

Which biomes interest you the most? CIRCLE 3

Temperate Forest

Tropical Forest

Grassland

Prairie

Desert

Tundra

Freshwater

Marine

Biome One: _____

What is the weather like in this biome? _____

Where could you find this biome on earth? _____

What are three main characteristics of this biome?

- 1) _____
- 2) _____
- 3) _____

Biome Two: _____

What is the weather like in this biome? _____

Where could you find this biome on earth? _____

What are three main characteristics of this biome?

- 1) _____
- 2) _____
- 3) _____

Biome Three: _____

What is the weather like in this biome? _____

Where could you find this biome on earth? _____

What are three main characteristics of this biome?

- 1) _____
- 2) _____
- 3) _____

Appendix 6

DAYS 3 AND 4: Project Summary and Rubric

Through your research, you have identified one biome that interests you. Your job now is to dive deep into that ecosystem, and create a poster of research on an area of the world that contains that biome. Your poster will not only present new information you have found, but also bring up past knowledge from our other standards. Here are your guidelines...

- 1) Introduce and describe your biome
- 2) Describe the weather in your biome
- 3) Describe the food chain in your biome
 - a. Who are the consumers, producers, and decomposers in your biome?
- 4) Describe the fauna (plant life) in your biome
- 5) Discuss if humans are present in your biome, and how they interact with the ecosystem around them

Please refer to the rubric below to understand what is necessary to receive a proficient grade on this poster assignment.

Ecosystems and Biomes Poster **Name:** _____ **Total Points:** ____ / 20

	1 Point	3 Points	5 Points	Extra Credit
Scientific Accuracy	Presenter makes many mistakes on scientific information throughout the paper– little of the information is accurate	Presenter struggles to explain their biome accurately. Presenter makes some mistakes.	Presenter has included accurate information about their biome Presenter has explained their biome in depth in order to teach others	Presenter has expanded on each part of their poster, and presented more information than necessary. Presenter has included in-depth explanations about each part of the biome
All Info is Present	Presenter is missing over half of the information necessary on their poster.	Presenter is missing important information in their poster.	Presenter has included all necessary information on their poster	Presenter has included extra information on their poster, and drawn more connections between new and old content than necessary
Neatness and Creativity	Poster is not attractive to look at. Presenter did not take time to make a neat poster	Poster is messy, but readable. Presenter has an emerging understanding of how to organize a poster.	Poster is neat and orderly. Presenter shows an understanding of how to organize a poster.	Poster is neat and orderly. Poster shows an understanding of how to organize a poster. Presenter exhibits a high level of creativity.
Writing	Presenter had many spelling and grammar mistakes Poster has many incomplete sentences and writing lacks explanation	Presenter has some spelling and grammar mistakes. Sentences and explanations are not structured correctly	Presenter does not have spelling or grammar mistakes. Poster has complete sentences and explanations are clear.	Presenter exhibits no grammar or spelling mistakes, and advanced understandings of how to construct a poster.

Appendix 7

DAY 5: Gallery Walk

Instructions: Use your classmates posters around the class to answer the following questions about the other 6 biomes that you did not research. Use this classroom like a museum—the following gallery walk should fill in all missing information on this sheet.

Biome: _____

1) Describe the weather in this biome _____

2) Describe the food chain in this biome _____

a. Consumers: _____

b. Producers: _____

c. Decomposers: _____

3) Describe the fauna (plant life) in this biome: _____

4) How do humans interact with this biome? _____

NOTE: Students should receive a sheet with 6 of these question sets listed out for the 6 biomes that they did not research.

Appendix 8

DAY 6: Case Brief

Instructions: Use the resources provided to answer the following questions. Consider what might happen when human introduce harmful substances to ecosystems.

Resource 1: Effects of Water Pollution

- 1) What is Eutrophication?
- 2) What is the purpose of fertilizer? How did this purpose end up being negative for the environment?
- 3) What are three negative effects of eutrophication?

Resource 2: Scientists say Florida can avoid future red tide disasters but special interests might be in the way

- 4) What is Red Tide?
- 5) How did humans influence the growth of Red Tide?
- 6) How are sugar farmers involved in the growth of Red Tide?

Resource 3: Harmful Algae Blooms

- 7) What does the word “economy” mean? What does it mean when the article says that algae blooms hurt local economies?
- 8) What causes algae blooms?
- 9) What is one economic harm from algae blooms?

Resource 4: Nutrient Pollution Infographic

- 10) The Mississippi River Basin is extremely big—it spans 31 states! Predict how pollution in part of the Mississippi River Basin might affect other parts of it, and ultimately the Gulf of Mexico.
- 11) What are two sources of nutrient pollution?

Resource 5: Science safeguards drinking water from harmful algal blooms

- 12) How does climate change affect the growth of algae blooms?
- 13) How is the work cleaning tap water now different than when water treatment plants were built?

Appendix 9

DAY 7: Notes on Epigenetics

Epigenetics: How Toxins Stick Around in an Ecosystem

When a substance, positive or negative, is introduced to an ecosystem, it sticks around for a while. Toxins not only affect the organisms in an ecosystem in the present, but also their offspring.

Epigenetics- when the environment causes an organism's genes to be shown in a different way

Example: fertilizers in lakes cause algae to grow more quickly

Epigenetic changes can be passed from one organism to its children.

Example: The pesticide Vinclozolin can cause defects in animals exposed to it. Even if their children have never been exposed to Vinclozolin, their parents pass the gene down to them, and they have defects too.

Appendix 10

DAY 7: Farmworkers Background Reading¹⁸

A growing number of US consumers have reduced their consumption of produce grown with pesticides to protect their family's health. Despite increased demand for food grown without pesticides, conventional growing practices dominate agriculture production. Little is being done to protect the farmworkers who are routinely exposed to high levels of toxic pesticides in the fields where they work and in the communities where they live. They can be exposed at levels hundreds of times greater than consumers' exposures to pesticides.

In July 2005, a crew of farmworkers was poisoned in an onion field in Caldwell, Idaho. During the night, a crop duster had applied three pesticides to the field but had not notified the farm owner. At 6:30 a.m., a crew of 29 workers began weeding the field that had not been posted with warning signs. They noticed that their clothes became wet as they worked but they believed the liquid was just dew. By noon, several workers were vomiting and suffering from headaches, nausea, and diarrhea.

Farmworkers suffer serious short- and long-term health risks from pesticide exposure. Short-term (acute) effects may include stinging eyes, rashes, blisters, blindness, nausea, dizziness, headaches, coma, and even death. Some long-term health impacts are delayed or not immediately apparent such as, infertility, birth defects, endocrine disruption, neurological disorders, and cancer.

Farmworkers are usually unaware of the pesticides to which they are exposed, the health effects of such exposure, or the laws meant to protect them from exposure. They are ill equipped to take the necessary precautions to guard against associated risks. Even physicians can experience difficulty determining whether flu-like symptoms resulted from acute pesticide exposure. Workers often do not know the nature of their illness and are motivated to keep working to support their families.

Possible Vocabulary Prime: Consumers, Consumption, Exposure, Ill Equipped

¹⁸ *Ignored and Exposed: How Pesticides Are Endangering Our Nations Farmworkers*. PDF. Washington, D.C.: Farmworker Justice.

Appendix 11

DAY 8: Juana's Story

This is a direct excerpt from *Ignored and Exposed*, a report by Farmworker Justice.



Juana's Story // Arizona //

With an intense gaze, Juana describes her childhood experiences of crossing the border into Arizona every morning with her parents. They would dress her in multiple layers of clothing to protect her from the harsh rays of the sun. "We were always so worried about the sun because in Arizona and Mexico it is so very strong."

"What I didn't realize was the real danger was actually the pesticides that were all around us."

During her first pregnancy in her early 20s, she worked in the lettuce harvest. "I was in charge of packing the boxes with heads of lettuce. It wasn't heavy work; I just had to be quick. At that time, I didn't know how important it was to wear gloves and protect myself from those pesticide residues. I would lean right into the boxes, breathing those residues in. I thought it was important to do the work as quickly as possible; I didn't realize it was more important to think about protecting myself and my baby."

Juana lost her baby when she was well into her pregnancy and even now wonders if her miscarriage was due to working so intensely with a crop loaded with pesticides.

About 10 years after her miscarriage she was diagnosed with lymphoma, and shortly thereafter her youngest son was diagnosed with the same disease.

"Our house was (and still is) right along the edges of the lettuce fields. When we started living there I still didn't know about how dangerous pesticides could be. I would hang the clothes outside to dry in the fresh air, and my son would play in the water that collected in the irrigation ditches. We didn't know the risks."

Both she and her son have been cancer-free for a number of years, but she still fears for their health because they are living in the same house, and Juana continues to work in the lettuce harvest.

"I try to be so much more careful now. I understand how important it is to wear clothes that can help protect me when I'm working. We drink bottled water instead of the water from our land because I just don't trust it. And I try to have my son play in places that are truly safe for him and won't cause him any more danger."

"I think it's so important that every single person know about how dangerous pesticides really are. If you are living in our community or any other farming community in this country, you could be at risk because pesticides don't have boundaries. They can freely cross wherever they want and we all need to know this."

Juana's experience demonstrates that with knowledge, farmworkers are able to take precautions to minimize their exposure to pesticides. However, even these precautions are inadequate to prevent all risks, as some exposures are beyond their control.



Appendix 12

DAY 8: Charts and Graphs¹⁹

Figure 1.1: Place of Birth, 2013-2014

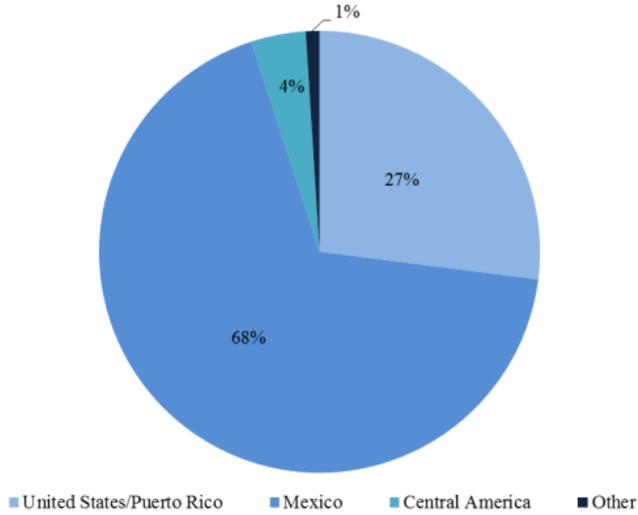
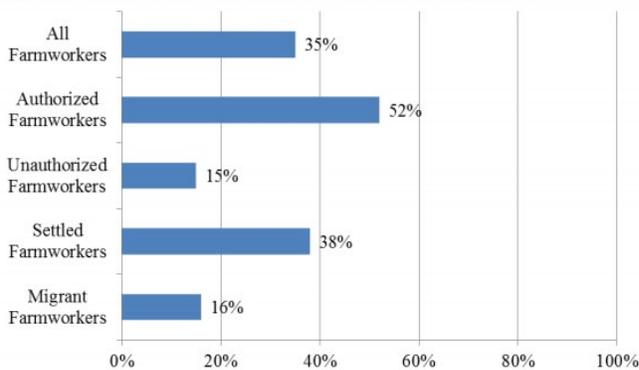


Figure 2.1: Age Distribution of Farmworkers, 2013-2014

Age Group	Percent of Farmworkers
14-17	1%
18-21	9%
22-24	8%
25-34	27%
35-44	24%
45-50	11%
51-54	7%
55-64	14%

Figure 9.1: Percent of Farmworkers With Health Insurance, 2013-2014



¹⁹ Hernandez, Trish, Susan Gabbard, and Daniel Carroll. *Findings from the National Agricultural Workers Survey (NAWS) 2013-2014: A Demographic and Employment Profile of United States Farmworkers*. PDF. Washington, D.C.: U.S. Department of Labor, Employment and Training Administration, Office of Policy Development and Research, December 2016.

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