**Genetic Inheritance of Generic Disorders and The Interdependence of Body Systems**

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McClintock Middle School

This curriculum unit is recommended for 7th Grade Integrated Science

**Keywords:** body systems, hierarchical organization, tissue, biology, development, genetics, Punnett square, pedigree, inheritance, endocrine system, cardiovascular system, digestive system, integumentary system, nervous system, reproductive system, skeletal system, muscular system, sexual reproduction, genetic variation, offspring

**Teaching Standards:** See Appendix 1 for unpacked teaching standards for this unit.

**Synopsis:** In this 5E unit students will engage with genetics and human biology in the depth and breadth of standards 7.L.1 and 7.L.2. Students will work in collaboration to construction a comprehension understanding of the human body within the context of genetic inheritance. Student will receive direct instruction to prompt basic understanding and then be prompted in the extend and evaluate phase of 5E to demonstrate high level understanding of their learning. The use of scenarios challenges students to think critically about their learning. Ultimately, students will be challenged to demonstrate their understanding through collective research and the creation of labs and assessments for their peers. This unit also contains a science as social justice piece as students are asked to create a functional and content accurate resource page for people effected but the genetic disorders mentioned. This unit is in full alignment to depth and breadth of standard(s) tagged. This unit clear learning objectives that are achievable through completion of this resource. Has clear assessment strategies that will accurately measure student understanding of genetics and pedigrees and alternative student led summative assessment of human body systems.

*I plan to teach this unit during the coming spring to 160 seventh grade integrated science students.*

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**and The Interdependence of Body Systems**

*By: Kim Mayes*

## Introduction

Rationale

The standards that frame this unit are the North Carolina Essential Science Standards. Unlike 19 states and the District of Columbia who have adopted the Next Generation Science Standards, North Carolina Department of Curriculum and instruction develops their own criteria for curriculum and learning for K-12 Science education. The most recent iteration of these standards was developed in 2010 and has not been updated since. The following standards listed below are the standards that this curriculum unit seeks to address and unify. (See Appendix 1 for a complete list of the standards)

- 7.L.1.3 Summarize the hierarchical organization of multi-cellular organisms from cells to tissues to organs to systems to organisms.
- 7.L.1.4 Summarize the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, and excretion) and ways that these systems interact with each other to sustain life.
- 7.L.2.1 Explain why offspring that result from sexual reproduction (fertilization and meiosis) have greater variation than offspring that result from asexual reproduction (budding and mitosis).
- 7.L.2.2 Infer patterns of heredity using information from Punnett squares and pedigree analysis.
- 7.L.2.3 Explain the impact of the environment and lifestyle choices on biological inheritance (to include common genetic diseases) and survival.

The primary objective of writing this unit is to integrate the North Carolina seventh grade learning standards into a comprehensive curriculum. The life science standards used in North Carolina focus primarily on the ability of students to understand. Pedagogically, the North Carolina Standards fall low on the Bloom's Taxonomical pyramid. The original Bloom's Taxonomy in 1956 ordered learning into six categories knowledge, comprehension, application, analysis, synthesis, and evaluation. Revised in 2001 the new taxonomy: remember, understand, apply, analyze and create, was further classified in to areas of factual knowledge, conceptual knowledge, procedural knowledge and metacognitive knowledge (See Appendix 2). Examining the standards as written by the North Carolina Department of Public Instruction the curriculum does not exceed the second tier of Blooms Taxonomical scale.

Demographics

McClintock Middle School is a partial STEM magnet located in East Charlotte NC. The school originally opened as McClintock Junior High School was established in 1956. The original school building demolished in 2013 and the school was moved to a new building next door. The STEAM magnet opened in the 2014-2015 school year with 100 6th grade students coming from outside the McClintock boundaries ("Program Evaluation: McClintock" 2015: 10). The demographics of the school has shifted substantially over the past 63 years.

East Charlotte was primarily a white neighborhood in the nineteenth century. According to Graves and Smith in *Charlotte, NC : the Global Evolution of a New South City*, East Charlotte "gained a little prosperity in the city's textile mills and other factories moved outward into modest new suburban housing" (Graves and Smith 2010:248). Now East Charlotte is known as the Latino and Immigrant corridor. Eventually, "these white families were joined by African Americans as civil rights movement victories took hold in the 1970s, a process that resulted in some all-black areas, but more mixed-race neighborhoods. History produced an array of affordable housing opportunities by the 1990s" (Graves and Smith 2010:248). Although an area of housing and business opportunity, the state of education in East Charlotte suffered in the post-Swann Era, "between 2003 and 2007 black and liberal white activists made periodic efforts to mobilize their presumed constituents for meetings, rallies, and attendance at school board meetings. Similarly, parent groups at several mid-ring schools mounted efforts to maintain diversity and obtain resources for these schools. But few, if any, of these efforts resulted in the impassioned mass participation that characterized the efforts to deconsolidate CMS" (Graves and Smith 2010:209).

Despite being a Title I school, the socioeconomic barriers are addressed at McClintock Middle School. McClintock Partners in Education via Christ Lutheran Church, or McPie, partnered with McClintock Middle School in 2007 after a faith summit challenged churches to support community schools ("Program Evaluation: McClintock" 2015: 9). The partnership, which began with a handful of volunteers, took off following a threat of closure in 2010-2011. The motto of McPie is "Creating Future Stories, Building Community, Supporting Families, Inspiring Volunteers So that all McClintock Students Succeed". McPie provides meals to students once a week via family night and also offers clubs like woman support groups and English classes for caring adults, student interest clubs for students and a nursery for small children. The organization also offers free supplies and support to classroom teachers through Donors Choose donations.

The school teaches 1,191 students which is almost as big as most high schools. The school is 45.3% African American, 14% White, 34.1% Hispanic and 4.7% Asian. As a Title I school, it is quite diverse. In terms of learning needs, McClintock Middle School services 15.5% English Learners (EL) students, 10.2% Students with disabilities (SWD), and 7.8% Academically and Intellectually Gifted (AIG). The academic trajectory of McClintock Middle School has improved over the past 4 years. In the 2015-2016 school year the school performance grade (SPG) was a D and the Education Value-Added Assessment System (EVASS) determined that the school did not make growth. The 2016-2017 school year the school SPG and EVASS determination were the same. In 2017-2018 the school performed at a low C and met growth under EVASS. In the 2018-

2019 school year the SPG was a high C and EVASS growth was met (Navigator Portal). According to the McClintock Middle School School Improvement Plan, the school is on track and has set the goal to make a B SPG and exceed growth (McClintock Middle School School Improvement Plan 2019).

As an educator of four years in middle grades science, there is a deficit in the connectivity of science education to real and tangible science as well as socially and environmentally relevant pedagogy. In the 2019-2020 school year, there are 160 seventh grade students under my care. Approximately 14% of my students are English language learners, 14% are exited English language learners, 13% of students are EC students or students with disabilities and chronically absent students are approximately 18%. My average classroom size this 2019-2020 school year is 26 students. There are also another 300 students under my umbrella as Professional Learning Community Lead.

**Unit Goals**

The classification of the NC Essential Science Standards units are “Human Body Systems” and “Evolution and Genetics”. In the Next Generation Science Standards the same concepts are described under the unit heading “Growth, Development, and Reproduction of Organisms”. Compared to the Next Generation Science Standards (See Appendix 3) the primary focus of teaching students can be classified not. Students need to understand that the body is not a passive detached object, but is instead an active agent that works together and is constantly process signals, signs, external and internal stimuli. The driving question for this curriculum unit, inspired by the name of the CTI seminar How to Build a Human, is “How do you build a human body?”. This driving question reflects the body as an active process and inspires students to consider how they can engage in the process.

The intent is to spiral in learning of genetics into their knowledge of human body systems and not to teach them as individual pieces. According to DevBio developmental biology has rules for body construction. The first rule states that body construction uses a ‘small tool box’ or small group of genes that control the development of the animal kingdom. The second rule states gene expression can be changed in one organ without affecting another, also known as modularity. The third rule states that gene duplication can allow genes to express new patterns and new expression ("Gastrulation" 2014). Using these rules, students will begin to understand that bodies are not static, as well as begin to get students to acknowledge difference in human bodies not as unnatural or strange but as a different mode of development. This prepares them for eighth grade standards and high school biology.

Using case studies about human body development, students will research human body systems and not only seek to understand them, but also analyze the case studies to develop predictions about how other body systems may be affected, as well as evaluate the potential implications of the development and create a plan of action for the case study they are assigned. Students will also be asked how the case study could impact future generations though Punnett squares and pedigrees and to consider the potential social and environmental factors or impact of their case study.

## Background

Pedagogical Research

According to “Characterising the development of the understanding of human body systems in high school biology students – a longitudinal study”, “several studies have shown that understanding the structural and behavioral aspects of complex systems is challenging for science students, since understanding complex systems does not only require looking at their parts in the context of the whole system, but also at their interactions with other complex systems that surround them” (Snapir et al 2017:2093). This is due to the fact that the complex relationships between body systems is not readily apparent and it’s capitalized by the fact that learners are taught the body systems separately. This presentation of curriculum makes the relationships harder to discern especially seeing as they are already not “intuitively obvious” (Snapir et al 2017:2093). However, Snapir and his colleagues say, “It is possible that some of these challenges could be addressed by teaching systems from a broader point of view, one which includes references to the variety of scientific and social aspects that a complex system can incorporate” (Snapir et al 2017:2094).

In “A Unit Plan for Teaching Human Body Systems to Gifted & Talented Students,” Rebecca Bell removes the ownership of learning from the teacher to the student. With moderate preparation, “the ultimate objective was to produce a working model, one that illustrated the basic principle of their chosen system and each group was also required to do a demonstration or to present a lab to the class” (Bell 1989: 504). Although developed for gifted high school students, the premise of the unit can be applied to all students and learning. Bell operates under the assumption that the student has a basic middle school knowledge of the body systems and their functions. In the North Carolinian context, students are supposed to have learned about the human body systems in third grade. The structure of student-led inquiry in the reconstitution of their knowledge and student-led demonstrations requires students to effectively lead their classroom into their learning. In the evaluation of her unit, they report “The students received positive feedback for their efforts from their peers. The talents of quiet students were revealed, much to the delight of all of us. My greatest fears-that the material would not be covered and that tests would be superficial-were un-founded. The students left with a feeling of accomplishment and pride in their group's work” (Bell 1989:506).

Bell’s strategy to develop content experts and then have students share the information through productive and actional conversations is a step forward in the right direction for science education in the “Characterising the development of the understanding of human body systems in high school biology students – a longitudinal study”, the authors developed a CMP framework to cause highly effective learning in the education of human body systems

> The first phenomena category, P1, refers to an overall behaviour or property of a system that is the result of an interaction within that system. Students presenting this level demonstrate some recognition of the patterns characterising a system's behaviour (e.g. Related/unrelated to maintaining homeostasis by providing oxygen by the respiratory system 'The respiratory system needs to work, supply oxygen to the body to maintain homeostasis in the human body').
>
> Higher systems understanding requires the ability to recognise that phenomena are not achieved by a single interaction within the system, but due to a network of interactions leading to the system's overall behaviour. The P2 category represents this level of systems understanding (Related/unrelated to homeostasis maintaining a stable internal environment).
>
> The P3 category refers to the ability to integrate the different processes that bring about the phenomena in the system, including the sequence of events and the materials/molecules participating in the various processes. For example: Related/unrelated to maintaining homeostasis and transportation of materials in the cardiovascular system. (Snapir et al 2017:2105-2106)

In addition to highlighting how to effectively teach body systems, it is also important to highlight how students talk about bodies. In "Teaching Practices Epistemologically Differentiated about Human Body Learning," Aragao questions how we present bodies, especially different bodies. As they say in their introduction, bodies of study are typically presented as "anatomized and misfigurated supposed human bodies' which didn't even look like actual human bodies, because they could never seem to have sheltered life inside themselves" (Arago et al 2011:62). They also say "Tendo presente questões como essas, nos nossos modelos de ensino já são abordados não só alguns aspectos ligados às áreas biomédicas ou à ecologia, mas também aspectos sociais, culturais e emocionais/afetivos ligados ao Corpo Humano, para que seja possível a compreensão da interação deste com o ambiente, de forma tal que se possa vir a estabelecer funções e desenvolver ações que ajudem cada indivíduo a se situar nesta nossa sociedade em um novo século" (Aragao et al 2011:72). Essentially arguing that when teaching bodies, situating them in the sociocultural emotion context allows the possibility to understand the interaction of this subject with the environment, so that we can establish functions and develop actions that help each individual to be situated in our society. Most educators are familiar with the gross approach, captivating student attention by framing things as gross and weird and different. As students are learning about human body systems educators have a responsibility to add students with a "constructive perspective" that drives students want to know more in order to be responsible and caring to human bodies (Aragao et al 2011:62)..

Genetics tends to be a more challenging subject in middle grades science due to the misconceptions that have already formed in middle grades students. Students will be investigating three different genetic diseases, Huntington's disease, Cystic Fibrosis, and Sickle Cell Disease.

Academic Research

Huntington's disease (HD) is an autosomal dominant neurological illness which causes involuntary movements, severe emotional and psychological disturbance, and cognitive decline (Housman 2003: 3498). Huntington's disease is found in 1 in 10,000 people in the Americas, Europe and Sub-Saharan Africa. There are four types of HD based on the location of the mutation.

> HDL1 is caused by an octapeptide repeat expansion in the PRNP gene at 20p12.1. HDL2 is caused by a CAG/CTG trinucleotide repeat expansion in the Junctophilin 3 locus (JPH3) gene on 16q24.3.2. HDL3 has only been reported in a Saudi Arabian family with an autosomal recessive pattern; the locus was mapped to 4p15.3;3 and HDL4 is a spinocerebellar ataxia (SCA17) caused by mutations at the TATA box-binding protein gene TBP (6q27).4. (Pardisi et al. 2013: 3)

The type of mutation which causes HD is correlated the location of origin of the individual. HDL1 is found in the Caucasoid community, HDL2 in less than 3% of those of the Caucasoid community and not in the Japanese. Because my students are predominately of Hispanic and African descent the case study for students will be the HDL2 mutation (Pardisi et al. 2013: 3).

The HD mutation is an unstable triplet repeat (CAG) expansion, acting with a dominant gene action. Penetrance of the disease is determined by the number of alleles, alleles with 34 CAG repeats or fewer do not produce symptoms, alleles containing 35–39 repeats produce incomplete penetrance, while a repeat of 40 CAGs is considered fully penetrant (Housman 2003: 3499). Symptoms and age of onset of HD is variable, even within families even among people sharing the identical CAG expansion length in their HD gene (Housman 2003: 3502). The greatest prevalence of HD can be found in Venezuelan communities due the stigma of the disease already in communities of poverty concentrating the disease and interrelationships produces homozygotes which are destined to develop the disease (Housman 2003: 3502).

Sickle cell disease describes the condition where hemoglobin S mutation is present on both beta chains (Shah et al. 2017:109). Persons with sickle cell have mutated, sticky and abnormally shaped red blood cells restricting flow through the blood vessels (Ciribassi 2016:131). Sickle cell affects different body systems. According to Shah, "If the mutation affects only one β globin chain and the other is normal, the patient is said to have the sickle cell trait, which is a relatively benign carrier state and does not have the classic phenotypic features of sickle cell disease (SCD). When both β chains carry HbS mutation, the patient exhibits phenotypic features of SCD which may include recurrent painful crisis, anemia, infections, stroke, organ failure and premature death due to various complications and end organ damage". In the digestive tract, "manifestations range from benign hyperbilirubinemia to overt liver failure, with the spectrum of acute clinical presentations often referred to as "sickle cell hepatopathy" (Shah et al. 2017:102). Therefore, this disease is autosomal recessive. According to the US National Library of medicine Sickle cell is the most common inherited blood disorder in the United States, affecting 70,000 to 80,000 Americans and the disease is estimated to occur in 1 in 500 African Americans and 1 in 1,000 to 1,400 Hispanic Americans ("Sickle Cell Disease - Genetics Home Reference - NIH.").

Cystic fibrosis is an autosomal recessive genetic disorder, Cystic Fibrosis is common in Europe, North America, and Australia. The disease is caused by "mutation of a gene that encodes a chloride-conducting transmembrane channel called the cystic fibrosis transmembrane conductance regulator (CFTR)" (Elborn 2016:2519). The mutation of the gene interferes with anion transport and mucociliary clearance in the airways causing mucus retention and chronic infection (Elborn 2016:2519).

> CFTR dysfunction mainly affects epithelial cells, although there is evidence of a role in immune cells. Cystic fibrosis affects several body systems, and morbidity and mortality is mostly caused by bronchiectasis, small airways obstruction, and progressive respiratory impairment. Important comorbidities caused by epithelial cell dysfunction occur in the pancreas (malabsorption), liver (biliary cirrhosis), sweat glands (heat shock), and vas deferens (infertility). (Elborn 2016:2519)

Newborn screening of the disease is common and Cystic Fibrosis is usually identified in the first few years of life. The most common disease associated with Cystic fibrosis is lung disease as the lungs are unable to clear microorganisms from the environment (Elborn 2016:2523). With respect to reproduction Cystic Fibrosis interferes particularly in women; "CFTR is found in large quantities on the cervix and, although anatomically normal, histologically the columnar epithelium is distorted by mucus filled balloon or cygnet ring cells" ( Edenborough 2001:649). The relationship between CF and pregnancy outcomes is as follows; "There was a spontaneous abortion rate of 4.6%(range 0–21.4%) across the studies; 13.8% were terminated and 81.6% of pregnancies progressed beyond 20 weeks. Of these, 24.3% delivered prematurely, 11.6% due to maternal complications of CF and 88.4% due to spontaneous natural labour " (Edenborough 2001:651)

**Teaching Strategies**

Student Led Inquiry

This is a student-led lesson plan. There is no direct teaching in this lesson. The role of the teacher is as a facilitator and resource. Students are encouraged to engage in a productive struggle. Students should be encouraged to ask and research questions through the duration of the lesson in order to evolve their products. Creativity, critical thinking, innovation, problem solving and initiative are 21st-century skills develops students that are ready for the next step in education.

Reading to Learn

Students will be complete readings in order to introduce and engage them with the content. It is important to use classroom literacy strategies. Exposure to grade level text in alignment to the standards supports learning and increases student outcomes. Although students may struggle, proving vocabulary list, multiple exposures to the words, and scaffolded comprehension questions can aid in student retention of the concept. Digital text can also be annotated for increased classroom engagement (See Appendix 6).

Collaborative Learning

Collaborative Learning is the process of utilizing each other as resources for the content.

**Lesson Plan**

Engage (60-90 min)

Students will receive a reading about the Kentucky blue people and pedigree. Students will answer reading comprehension questions. Students will examine the pedigree and begin to construct basic definitions of key concepts such as what is a pedigree and how to read it, the difference between homozygous and heterozygous, carriers, and the importance of genetic variation.

Students should work independently originally and be encouraged to engage in a productive struggle. Gradually release students to work in groups especially as they get closer to the end of the activity and start to consider genetic variation. At the end of the activity, reassemble the group for discussion and correction.

Explore (45- 60 min)

Transitioning into the next activity, discuss with students how different disorders can affect different and multiple parts of the body. In this section, students should begin to understand that body systems are interdependent.

Students will be introduced to body systems utilizing a virtual reality scavenger hunt. Around the room, set up 10 virtual reality stations. Students investigate the circulatory system, digestive system, nervous system, immune system, endocrine system, excretory system, respiratory system, muscular system, integumentary and skeletal system. Although the reproductive system is not included here it can be added or alternatively teach it separately when students learn about sexual and asexual reproduction and mitosis and meiosis after they have learned about the general overview of genetic inheritance later in the unit. Students traditionally have more questions about the reproductive system so it has been omitted in this unit so that it can be addressed more in depth later.

Teachers will need to arrive early and obtain ten virtual reality headsets and have access to Wi-fi with Google Expeditions pre-loaded onto cellular devices in order to set up ten virtual reality stations. If the teacher does not have access to virtual reality headsets, alternatively, the teacher can print out poster of the human body systems and place in ten places around the room. Teachers will distribute the Human Body Scavenger Hunt (Appendix 4). Students will be given a list of organs with missing details and functions.

As an exit, have students think back to the Kentucky blue people and apply their learning to what body systems were affected.

Explain

Students will complete a guided investigation on the various disorders. (See Appendix 4)

Extend

Students will prove knowledge by the application of knowledge and skills though student led inquiry students will be provided with the following objectives.

Students must prove body systems work together in maintaining a constant internal environment. When the balance is disrupted, the body systems may not function properly and human health can suffer.

Students must explain the impact of the environment and lifestyle choices on biological inheritance

*Required Activities*

1. Relate the objectives for your genetic disorder to applicable body systems
2. Perform one demonstration or experiment for your class.
3. Research and review one current article from a popular science journal.
4. Produce a test or quiz to be given to your classmates about body systems, your presentation and genetic inheritance. Can be multiple choice or short answer. Create on Google Forms.
5. Produce an informational website including the following information
    a. About the disease
    b. Inheritance
    c. Body Systems Effected
    d. Living with the Disease
    e. In the News
    f. Resources
6. Meet the stated deadlines for project completion.

**Final Unit Assessment**

Evaluate:

Students will take the assessment as written by their peers.

**Appendix 1**

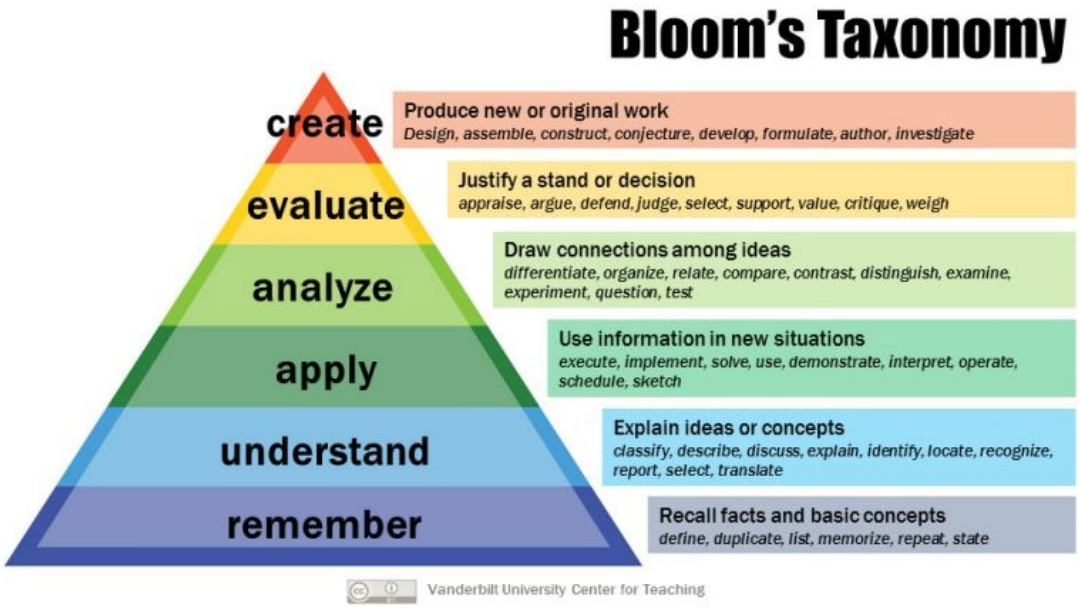
7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.

- 7.L.1.1 Compare the structures and life functions of single-celled organisms that carry out all of the basic functions of life including: Euglena, Amoeba, Paramecium, Volvox.
- 7.L.1.2 Compare the structures and functions of plant and animal cells, including major organelles (cell membrane, cell wall, nucleus, chloroplasts, mitochondria, and vacuoles).
- 7.L.1.3 Summarize the hierarchical organization of multi-cellular organisms from cells to tissues to organs to systems to organisms.
- 7.L.1.4 Summarize the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, and excretion) and ways that these systems interact with each other to sustain life.

7.L.2 Understand the relationship of the mechanisms of cellular reproduction, patterns of inheritance and external factors to potential variation and survival among offspring.

- 7.L.2.1 Explain why offspring that result from sexual reproduction (fertilization and meiosis) have greater variation than offspring that result from asexual reproduction (budding and mitosis).
- 7.L.2.2 Infer patterns of heredity using information from Punnett squares and pedigree analysis.
- 7.L.2.3 Explain the impact of the environment and lifestyle choices on biological inheritance (to include common genetic diseases) and survival.

**Appendix 2**



**Appendix 3**

**MS-LS1-4.** **Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.** [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]

**MS-LS1-5.** **Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.** [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [*Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.*]

**MS-LS3-1.** **Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.** [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [*Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.*]

**MS-LS3-2.** **Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.** [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

**MS-LS4-5.** **Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.** [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection

(such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]

**Appendix 4: Worksheets**

Scenario 1: Sickle Cell

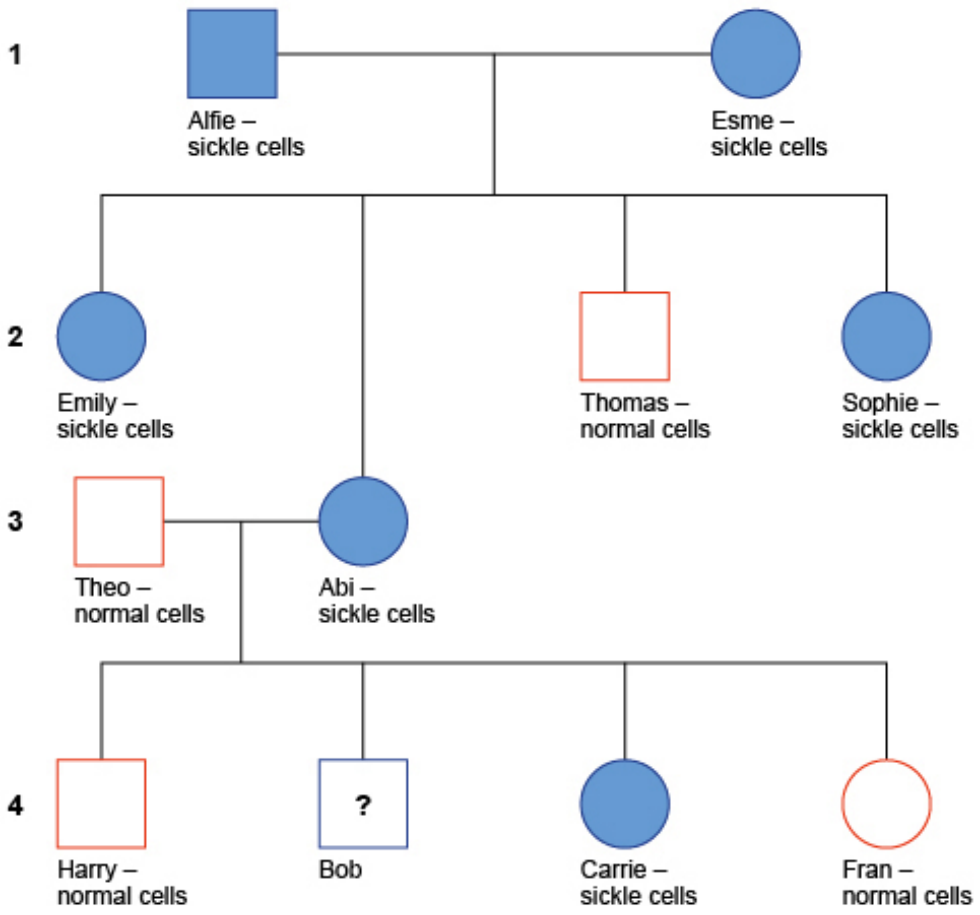
The Morgan's have a history of Sickle Cell in their families. Alfie and Esme had four children. Three of their children inherited the trait or the sickle cell disease. Sophie the youngest died early from the disease and Emily their first daughter never married. Thomas the third child and only boy never married but he did not carry the sickle cell trait. There second daughter Abi their second daughter married a man Theo who did not have the sickle cell trait. Harry the first boy does not have sickle cell disease. Neither does Fran their last daughter. Carrie the middle child does not have the disease but does carry the trait and has symptoms when they go to the mountains. The status of the second son Bob is unknown. Below is a basic pedigree it does not show who is a carrier for the trait and who has sickle cell. Modify and redraw the pedigree to accurately reflect who is homozygous or heterozygous for the disease.

Background Questions:

1. What is the difference between being heterozygous and homozygous for a trait?
2. Are you homozygous or heterozygous if you are a carrier?
3. On a pedigree which shape is male and which shape is female.

Critical Thinking Questions.

1. Did Alfie and Esme have Sickle Cell Disease or the sickle cell trait? Explain why?
2. Is Bob a more like homozygous or heterozygous for sickle cell? Explain why.




**Source:**

"Genetics: Pedigree Analysis." Genetics: Pedigree Analysis, February 7, 2015. http://laaaaast.blogspot.com/2015/02/last-january-27-new-topic-was-tackled.html.

Scenario 2: Cystic Fibrosis

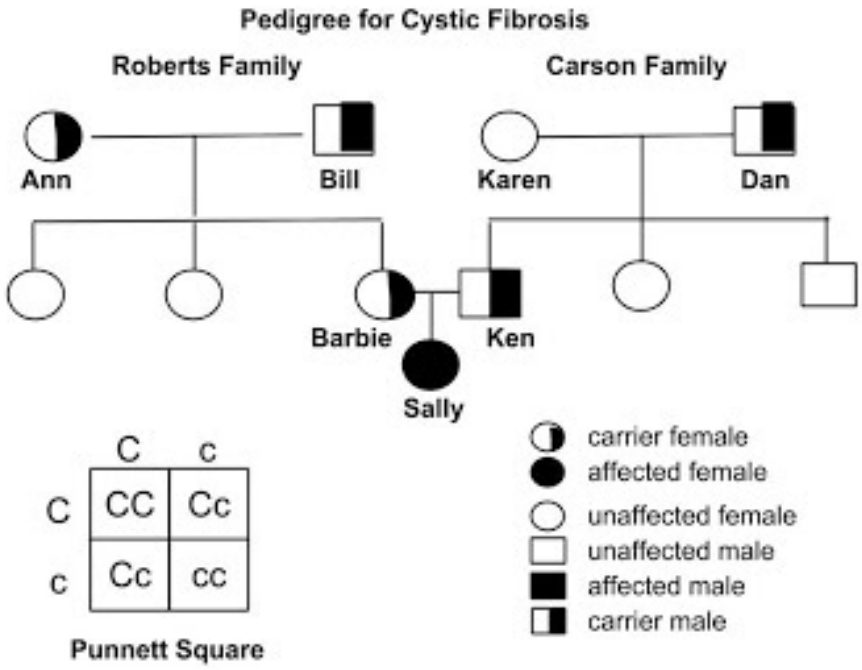
The Roberts family and the Carson family are joined together about a year ago and eight and a half months later had a baby girl Sally. During newborn screen it is revealed that Sally has Cystic Fibrosis. Ken and Barbie are surprised seeing as no one in their immediate family has Cystic Fibrosis. Barbie and Ken decide to do some research and ask their parents about their parents.

Background Questions:

1. What is the difference between being heterozygous and homozygous for a trait?
2. Are you homozygous or heterozygous if you are a carrier?
3. On a pedigree which shape is male and which shape is female.

Critical Thinking Questions.

1. What were the odds that Barbie and Ken would have a baby with Cystic Fibrosis.
2. If Ann tells Barbie that all of her siblings were heterozygous for Cystic Fibrosis what was the Cystic Fibrosis status of her parents.
3. Explain why no one Karen and Dan's kids have Cystic Fibrosis.
4. Is it possible the one of Barbie's siblings could have gotten Cystic Fibrosis?




**Source:**
"2. Pedigree 1 - Genetics Challenge." Genetics Challenge. Accessed November 15, 2019. https://sites.google.com/a/wyckoffschools.org/genetics-challenge/2-pedigree-analysis.

Scenario 3: Huntington's Disease

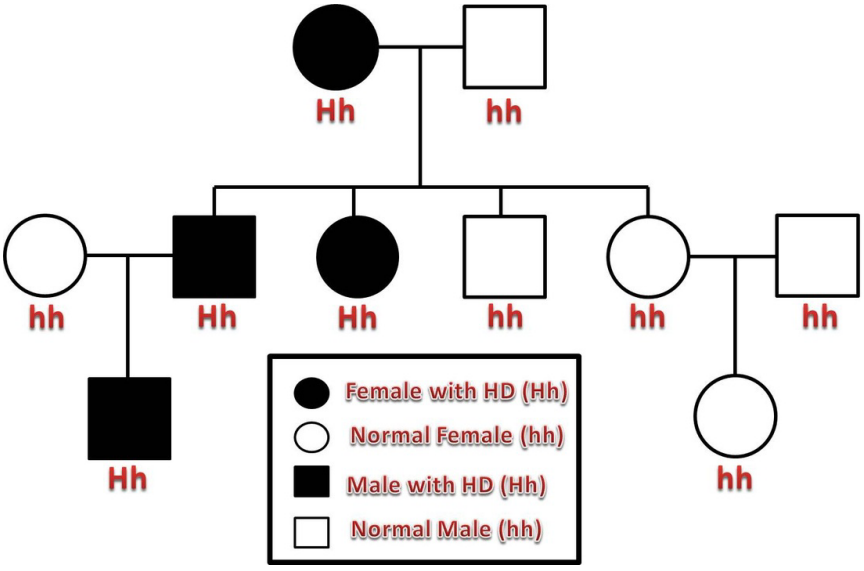
Huntington's disease (HD) is autosomal dominant disease. It was discovered that in Venezuela there is a high concentration of Huntington's disease and symptoms can go for years without knowing if they have the disease.

Background Questions:

1. What is the difference between being heterozygous and homozygous for a trait?
2. Are you homozygous or heterozygous if you are a carrier?
3. On a pedigree which shape is male and which shape is female.

Critical Thinking Questions:

1. How many males and females are in this family?
2. How many generations are in this family
3. Based off the image why is Hh shaded completely?
4. What combination of alleles is "safe" from Huntington's and why?
5. Julio is the youngest male in his family and has decided to map his family tree because he wants to have a child with his partner and doesn't know if he may pass on the gene. His dad is young and has shown no signs of the disease. He knows his dad is a child of four and his aunt has HD, and his other aunts and uncles definitely do not. He concludes his dad more than like has HD. How does he come to this conclusion?




**Source:**
"Huntington's Disease." 2019. *Huntington's Disease*. Accessed November 16. https://vanhornhuntingtonsdisease.weebly.com/.

**Appendix 5: Annotated Student Resources**

https://www.cdc.gov/ncbddd/sicklecell/healthyliving.html

This website aids students in understanding the components of a useful website and is extra research on the disease. It may be useful to ask students questions about the design of the website.

https://ghr.nlm.nih.gov/

This website is useful for student research into the various genetic disorders.

**Appendix 6: Annotated Teacher Resources**

https://teach.genetics.utah.edu/

This website is a tool to help teacher understand how to teach genetics. This website also includes other lesson plans that are student led, that can further aid in the facilitation of learning.

https://sites.google.com/site/pedigreeanalysis/home/inbreeding-kentucky-blue-mountain-people

This is a website where the pedigrees have been pulled and contains an age appropriate reading about the Kentucky Blue People.

https://applieddigitalskills.withgoogle.com/c/middle-and-high-school/en/annotate-text-in-google-docs/overview.html#annotate-text-in-google-docs

This is a lesson by google that teaches students how to effectively use google docs to annotate text. If teacher uses google classroom or Canvas- Google Drive this can help students engage with the text in a meaningful way.

Scenario Worksheets (Appendix 4)

The scenario worksheet are scaffolded for ability. Sickle Cell should be given to high students, Huntington's to intermediate, and Cystic Fibrosis to low students.

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