Standards used for *"Nanogenetics: The Battle Against Genetic Disorders"*

- Indiana Standards: Indiana Department of Education, Science Standards adopted in 2010
- Next Generation Science Standards -These are not used in the applied schools and will not be included in the project.
- 21st Century Skills: Framework for 21st Century Learners
- Nanoscience Learning Objectives: Standards provided by Research Goes To School

Indiana Biology Core Standard 5: Molecular Basis of Heredity

Describe the basic structure of DNA and how this structure enables DNA to function as the hereditary molecule that directs the production of RNA and proteins.
Understand that proteins largely determine the traits of an organism.

Indiana Biology Content Standard	**Bloom's Taxonomy**	**Objective**	**Application to PBL Unit**
B.5.1 Describe the relationship between chromosomes and DNA along with their basic structure and function.	compare/discuss	-be able to recognize the structure of chromosomes and DNA.	What is the size of a DNA strand? What is the hierarchal organization of DNA into a chromosome? How small are nanoparticles in comparison to DNA?
B.5.2 Describe how hereditary information passed from parents to offspring is encoded in the regions of DNA molecules called genes.	compare/solve/ examine/judge	- be able to understand the processes of transcription and translation. - be able to use the codon chart to see how the mutation may change the gene.	What do sections of DNA represent? Where does the genetic disorder originate on a person's genome?
B.5.3 Describe the process by which DNA directs the production of protein within a cell.	compare/solve/ examine/judge	- be able to understand the processes of transcription and translation. - be able to use the codon chart to see how the mutation may change the gene.	What proteins are correctly or incorrectly coded for in your genetic disorder? What effect does the coding issue induce?
B.5.4 Explain how the unique shape and activity of each protein is determined by the sequence of its amino acids.	plan/investigate	- be able to decode segments of DNA to determine the protein that will be produced.	How is the function of the incorrectly coded protein controlled by its chemical structure?
B.5.5 Understand that proteins are responsible for the observable traits of an	investigate/ conclude	- be able to understand the processes of transcription and translation.	Which proteins are responsible for symptoms of the genetic disorder?

organism and for most of the functions within an organism.			How could nanosized particles affect the coded proteins?
B.5.6 Recognize that traits can be structural, physiological or behavioral and can include readily observable characteristics at the organismal level or less recognizable features at the molecular and cellular level.	investigate/ conclude/analyze	-be able to describe how all traits visible and invisible are controlled by genes.	What symptoms does a person with a specific genetic disorder have? Where are the symptoms stemming from? What is the difference between curing a disorder and treating symptoms?

Indiana Biology Core Standard 7: Genetics

Explain how the genetic information from parents determines the unique characteristics of their offspring

Indiana Biology Content Standard	**Bloom's Taxonomy and Higher Order Thinking Skills**	**Objective "The student will…"**	**Application to PBL Unit**
B.7.1 Distinguish between dominant and recessive alleles and determine the phenotype that would result from the different possible combinations of alleles in an offspring.	compare/determine	-be able to compare dominant and recessive alleles. -sse a punnett square to determine the phenotypic ratio.	How do some people have the genetic information for a disease but not express it? What is the probability your offspring could receive a genetic disorder?
B.7.2 Describe dominant, recessive, codominant, sex-linked, incompletely dominant, multiply allelic and polygenic traits and illustrate their inheritance patterns over multiple generations.	compare/explain/ solve	- be able to relate heritable diseases to the proper mode of inheritance.	How will treatment of a genetic disorder differ based on how the disorder originates? Why are genetic disorders passed on in certain populations?

B.7.3 Determine the likelihood of the appearance of a specific trait in an offspring given the genetic make-up of the parents.	predict/examine	- based on the mode of inheritance, students will be able to track the transmission of a disease by using a pedigree.	What kind of genetic probability would make someone feel the need to utilize nanotechnology to treat a disorder?
B.7.4 Explain the process by which a cell copies its DNA and identify factors that can damage DNA and cause changes in its nucleotide sequence.	draw/construct	-be able to list factors that can cause mutations in DNA sequences.	How can errors in the replication process affect a person on the physical level? What environmental factors can contribute to errors in DNA replication? How could nanotechnology prevent or treat errors at the nucleotide level?
B.7.5 Explain and demonstrate how inserting, substituting or deleting segments of a DNA molecule can alter a gene, how that gene is then passed to every cell that develops from it and how the results may be beneficial, harmful or have little or no effect on the organism.	solve/investigate/ summarize	-be able to complete a point mutation and frameshift mutation problem. -be able to use the codon chart to see how the mutation may change the gene. -be able to summarize how a single change can have different results on the organism.	How can mutations affect a gene? Do all types of mutations alter the physical execution of a gene? How can or will a mutation in one cell potentially affect future cells? Why have some mutations that seem “bad” stuck around for generations? Will eradicating a disorder have potential ramifications?

Potential Overarching Themes/Content Area

Indiana Biology Content Standard	**Bloom’s Taxonomy**	**Objective**	**Application to PBL Unit**
B1.2 Understand the shape of a molecule determines its role in many different types of cellular processes (eg metabolism, homeostasis, growth and development and heredity) and understand that the majority of these processes involves proteins that act as enzymes	apply/ investigate	-be able to describe how the size/shape of nanoparticles can change their properties and how that affects cell processes.	How do size dependent properties affect the behavior of nanoparticles? How can nanoparticle properties be applied to treating the genetic disorder?

B 3.3 Recognize and describe that metabolism consists of all of the biochemical reactions that occur inside cells, which include the production, modification, transport, and exchange of materials that are required for the maintenance of life	examine/ conclude	-be able to describe how the size/shape of nanoparticles can change their properties and how that effects cell processes.	How are symptoms of the genetic disorder effecting a person's homeostasis?

Nanoscience Learning Objectives

Nanoscience Content Standard	**Bloom's Taxonomy and Higher Order Thinking Skills**	**Objective "The student will…"**	**Application to PBL Unit**
Learners will be able to relate the size of nanosized objects to objects encountered in daily life (macroscale).	investigation/ conclude/compare	- be able to assemble DNA and compare their models to the true scale.	How do the size of enzymes that carry out replication relate to the size of the actual DNA molecule?
Learners will compare surface area to volume ratios of different sized objects and explain that surface area to volume ratios play a role in the unique properties of objects at nanoscale.	categorize/investigate/analyze	- be able to explain how nanotechnology can influence the external environment of a cell and therefore effect how a cell functions.	How do granulated sugar and sugar cubes compare in their solubility? How does the concept of surface area to volume ratio relate to absorption of medicine or materials into cells? How does surface area to volume ratio relate to aggregation of nanoparticles and how can this effect your nanosolution to your genetic disease?
Learners will be able to explain why (intensive) properties can change at the nanoscale.	investigate/analyze	- be able to explain how nanotechnology can influence the external environment of a cell and therefore effect how a cell functions.	What happens to nanomaterials when reduced to a nanoscale? How are size dependent properties different at a nanoscale than at a macroscale? How can you harness the abilities of a size dependent property for your application of nanomedicine in your genetic disease?
Learners will be able to develop a definition of self-assembly reflecting the process and the role it plays in making nanostructures.	create/apply	- be able to model the process of transcription.	What chemical properties of nanoparticles induce self-assembly? What organelle exhibits self-assembly? Will your nanomedicine utilize the self-assembly properties? Why/why not?

21st Century Skills

LEARNING AND INNOVATION SKILLS

Standard	Substandard	Unit Objective to be Assessed
CS1.1: Creativity and Innovation	• Think Creatively • Work Creatively with Others • Implement Innovations	• Create a new idea to treat a genetic disease through research or medicine • Work with teammates effectively and cooperatively through the project • Use outside academic resources to understand the real world limits in their new idea
CS1.2: Critical Thinking and Problem Solving	• Reason Effectively • Make Judgments and Decisions • Solve Problems	• Evaluate the relevance of a source towards implementing it in the project • Make connections between nano-content and bio-content
CS1.3: Communication and Collaboration	• Communicate Clearly • Collaborate with Others	• Explain a self produced experiment and its conclusions to peers • Describe the intentions of a project through a gallery walk • Provide constructive feedback to peers • Develop a script for communication with academic professionals for different modes of contact