# Genetics Content Guidelines

## Science and Engineering Practices

Gen.1 Using the content in the Genetic Content Guidelines, students will demonstrate an understanding of scientific and engineering practices by

1. asking questions and defining problems
   * ask questions that arise from careful observation of phenomena and/or organisms, from examining models and theories, and/or to seek additional information
   * determine which questions can be investigated within the scope of the school laboratory to determine relationships between independent and dependent variables
   * generate hypotheses based on research and scientific principles
   * make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated
2. planning and carrying out investigations
   * individually and collaboratively plan and conduct observational and experimental investigations

* plan and conduct investigations or test design solutions in a safe and ethical manner including considerations of social, and personal effects
* determine appropriate sample size and techniques
* select and use appropriate tools and technology to collect, record, analyze, and evaluate data

1. interpreting, analyzing, and evaluating data

* construct and interpret data tables showing independent and dependent variables, repeated trials, and means
* construct, analyze, and interpret graphical displays of data
* use data in building and revising models, supporting an explanation for phenomena, or testing solutions to problems
* analyze data using tools, technologies, and/or models to make valid and reliable scientific claims or determine an optimal design solution

1. constructing and critiquing conclusions and explanations
   * construct and revise explanations based on valid and reliable evidence obtained from a variety of sources including students’ own investigations, models, theories, simulations, and peer review
   * apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and design solutions
   * construct arguments concerning bioethical dilemmas in the medical field based on evidence and discuss these issues from multiple viewpoints;
   * compare and evaluate competing arguments or design solutions in light of currently accepted explanations and new scientific evidence
   * construct arguments or counterarguments based on data and evidence
2. developing and using models
   * + evaluate the merits and limitations of models
     + develop, revise, and/or use models based on evidence to illustrate or predict relationships
     + develop and/or use models to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems
3. obtaining, evaluating, and communicating information

* compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem
* gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source
* communicate scientific and/or technical information about phenomena in multiple formats

## Molecular Genetics

Gen.2 The student will investigate and understand that the structure of DNA enables the processes of both protein synthesis and inheritance. Key concepts include

* the structure and function of DNA is directly related to its function;
* DNA is a helical macromolecule consisting of nucleotide monomers; and
* DNA replication ensures continuity of hereditary information.

Gen.3 The student will investigate and understand that genes located on chromosomes encode instructions for proteins that result in the characteristics of organisms. Key concepts include

* gene expression is regulated during DNA transcription and RNA translation which leads to the formation of proteins;
* most proteins act as enzymes to carry on cellular processes;
* proteins are folded into a particular confirmation to be active and functional by genetically coded structures; and
* changes in gene expression occur over time at the molecular level, tissue level and organ/gland level.

## Chromosomal Genetics

Gen.4 The student will investigate and understand that meiosis results in the transmission of alleles from one generation to the next. Key concepts include

* meiosis results in the formation of haploid gametes;
* events such as crossing over, independent assortment, and segregation of alleles promote genetic variability; and
* errors in the process of meiosis will lead to genetic disorders.

Gen.5 The student will investigate and understand that Mendelian genetics account for the predictability and variability of genetic patterns in all diploid organisms. Key concepts include

* Punnett squares are models that are used to determine the probability of genotypes in offspring; and
* pedigrees show the inheritance patterns of a phenotype over several generations and can be used to predict the chance that an offspring will have a trait.

Gen.6 The student will investigate and understand that there are exceptions to Mendelian genetics. Key concepts include

* multiple alleles, incomplete dominance, codominance, gene linkage, sex linked traits, and epistasis results in phenotypes that do not align to those predicted in Mendelian genetics;
* penetrance and expressivity indicate the extent of expression of a phenotype; and
* mitochondrial DNA allows genes to be passed from the mother to both male and female offspring,

Gen.7 The student will investigate and understand that sex-linked inheritance leads to changes in the probability that a phenotype will be expressed based on gender. Key concepts include

* sexual identity includes sex chromosome makeup, gonadal specialization, expression of phenotypic structures, and gender identity;
* the SRY gene controls the sexual development of the fetus; and
* traits can be inherited on sex chromosomes.

Gen.8 The student will investigate and understand that multifactorial traits are attributable to both the environment and genes. Key concepts include

* heritability estimates the proportion of variation in a multifactorial trait that is attributable to genetics; and
* studies have shown that some behavioral traits are multifactorial.

## Genetics and Human Health

Gen.9 The student will investigate and understand that mutation is a change in a gene’s nucleotide base sequence that results in errors in protein function. Key concepts include

* inserting, deleting or substituting nucleotides or DNA segments can alter the genetic code and the resulting proteins;
* mutation in a sex cell is the underlying cause for genetic disorders that can be passed from parent to child; and
* spontaneous mutation arises to due chemical phenomena or due to an error in DNA replication.

Gen.10 The students will investigate and understand that deletions and/or duplications of chromosomes are considered mutations can lead to genetic disorders in humans. Key concepts include

* changes in portions of a chromosome may occur during meiosis including deletions and substitutions;
* translocation and inversions of portions of a chromosome occur during meiosis; and
* karyotypes are charts that display the chromosome pairs by size type.

Gen.11 The student will investigate and understand that genetic disorders are caused by mutations that may occur during the process of meiosis or are passed from parent to offspring. Key concepts include

* autosomal dominant disorders need one copy of the allele to express the trait and genders are equally affected;
* autosomal recessive disorders require two recessive alleles to be expressed and genders are equally affected; and
* sex-linked disorders are carried primarily on the X chromosome and is not expressed equally between genders.

## Synthetic Biology

Gen.12 Students will investigate and understand that synthetic biology been applied in numerous fields including agriculture, medicine, and industry Key concepts include

* genetics engineering is possible because all organisms share a universal genetic code;
* technological advances have made it possible to treat certain genetic disorders and help infertile couples reproduce;
* medical advances in biotechnology include the diagnosis and treatment of genetic disorders and infertility;
* CRISPR technology is a powerful tool for editing genomes;
* new discoveries and innovations in DNA technology are continuously developing; and
* the study of genetics creates a variety of ethical dilemmas.

Gen.13 The students will investigate and understand that the completion of the Human Genome Project that has led to advances in the area of genomics. Key concepts include

* genetic engineering techniques are used to analyze and/or manipulate DNA;
* the fields of genomics and pharmacogenetics lead to the development of many scientific advances; and
* bioinformatics is an emerging field that integrates both the fields of science and computer science.

## Population Genetics

Gen.14 The students will investigate and understand that random occurrences effect the genetic makeup of a population. Key concepts include

* genetic drift, mutation, and selection lead to changes in the genetic makeup of a population;
* changes in the genetic makeup of a population occur over time (evolution); and
* allele frequencies in a population can be calculated from genotype frequencies.