# Big Idea 3 Learning Objectives: Genetics

**LO 3.1** The student is able to construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, that RNA are the primary sources of heritable information. [**SP 6.5**]
**LO 3.2** The student is able to justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information. [See **SP 4.1**]
**LO 3.3** The student is able to describe representations and models that illustrate how genetic information is copied for transmission between generations.[See **SP 1.2**]
**LO 3.4** The student is able to describe representations and models illustrating how genetic information is translated into polypeptides. [See **SP 1.2**]
**LO 3.5** The student can justify the claim that humans can manipulate heritable information by identifying *at least two* commonly used technologies. [See **SP 6.4**]
**LO 3.6** The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression. [See **SP 6.4**]

*Can you describe the how genetic information is stored in and passed to subsequent generations through DNA?(6)
*Can you compare the differences between linear DNA found in eukaryotes to circular DNA in prokaryotes?
*Can you describe and explain the uses of plasmids?
*Can you describe experiments and results of the historical scientists that contributed to our understanding of DNA?

- Watson, Crick, Wilkins and Franklin
- Avery-MacLeod-McCarty experiment
- Hershey-Chase experiment

*Can you describe the process of DNA replication?

- semiconservative
- template strand/complement strand
- DNA polymerase/ligase, RNA polymerase, helicase and topoisomerase
- leading/lagging

*Can you explain how retrovirus alter the flow of information from RNA to DNA using reverse transcriptase?
*Can you compare DNA to RNA?

- sugar, phosphate, nitrogenous base
- 3' to 5'
- Uracil/Thymine
- Double/Single
- DNA antiparallel
- purines/pyrimidines (conserved)

*Can you describe the difference structural components and functions of mRNA to tRNA to rRNA to RNAi?
*Can you describe the process of transcription and translation? (protein synthesis)

- RNA polymerase -->mRNA
- mRNA processing, poly A tail, GTP cap, excision of introns
- location of each
- initiation, elongation and termination of translation
- codons, anticodons, stop and start
- protein

*Can you explain how phenotypes are determined through protein activities?

- enzymatic reactions
- transport proteins
- synthesis
- degradation

*Can you explain how genetic technologies manipulate genetic material and for what purpose?

- electrophoresis
- plasmid-based transformation
- restriction enzyme analysis of DNA
- Polymerase Chain Reaction (PCR)

*Can you provide example of products of genetic engineering?

- Genetically modified food
- transgenic animals
- cloned animals
- pharmaceuticals such as human insulin or factor X

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**LO 3.7** The student can make predictions about natural phenomena occurring during the cell cycle. [See **SP 6.4**]
**LO 3.8** The student can describe the events that occur in the cell cycle. [See **SP 1.2**]
**LO 3.9** The student is able to construct an explanation, using visual representations or narratives, as to how DNA in chromosomes is transmitted to the next generation via mitosis, or meiosis followed by fertilization. [See **SP 6.2**]
**LO 3.10** Represent the connection between meiosis and increased genetic diversity necessary for evolution. [ **SP 7.1**]
**LO 3.11** The student is able to evaluate evidence provided by data sets to support the claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization. [See **SP 5.3**]

*Can you describe the steps of the cell cycle including regulated checkpoints that the determine the fate of the cell?
- Interphase (growth, synthesis and growth)
- internal and external controls (MPF, platelet-derived growth factor,
- Cancer
- cyclins and cyclin dependent kinases
- mitosis
- non dividing stage

*Can you explain the role of mitosis in a cell?
- DNA replication passes identical copy of genome
- two genetically identical cells
- growth, repair and asexual reproduction
- order of phases

*Can you explain purpose and process of meiosis?
- haploid
- law of segregation
- law of independent assortment
- crossing over/linked genes
- genetic variation
- fertilization

**LO 3.12** The student is able to construct a representation that connects the process of meiosis to the passage of traits from parent to offspring. [See **SP 1.1, 7.2**]
**LO 3.13** Pose questions about ethical, social or medical issues surrounding human genetic disorders. [See **SP 3.1**]
**LO 3.14** Apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets. [ **SP 2.2**]

*Can you use probability to predict offspring in various patterns of inheritance? (4)
- Mendelian genetics, complete dominance (monohybrid and dihybrid)
- sex-linked
- incomplete and codominance

*Can you explain the cause of genetic disorders by specific gene mutations and nondisjunction?
- sickle cell anemia
- tay-sachs
- Huntington's
- x-linked color blindness
- trisomy 21/Down syndrome
- Klinefelter's syndrome

*Can you discuss ethical, social, and medical issues surrounding human genetic disorders?
- reproductive issues
- ownership of genetic information, privacy, etc.

**LO 3.15** The student is able to explain deviations from Mendel's model of the inheritance of traits. [See **SP 6.5**]
**LO 3.16** Explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics. [ **SP 6.3**]
**LO 3.17** The student is able to describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel's model of the inheritance of traits. [See **SP 1.2**]

*Can you explain and use probability to examine and predict outcomes of sex-linked traits?
- found on X chromosomes, Y chromosome small and few genes, females XX males XY
- milk production in females, male pattern baldness

*Can you discuss traits that are from nonnuclear inheritance?
- chloroplast DNA and mitochondrial DNA
- mitochrondrial DNA comes from egg inherited maternally

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**LO 3.18** The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms.[See **SP 7.1**]
**LO 3.19** The student is able to describe the connection between the regulation of gene expression and observed differences between individuals in a population. [See **SP 7.1**]
**LO 3.20** The student is able to explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function. [See **SP 6.2**]
**LO 3.21** Use representations to describe how gene regulation influences cell products and function. [See **SP 1.4**]

*Can you explain how DNA is regulated? (4)
- Promoters, Terminators or Enhancers
- Inducer in bacteria
- Repressor in bacteria
- Ribosomal genes always turned on
- Transcription factors/regulatory proteins

**LO 3.22** Able to explain how signal pathways mediate gene expression, including how process can affect protein production. [See **SP 6.2**]
**LO 3.23** The student can use representations to describe mechanisms of the regulation of gene expression. [See **SP 1.4**]

*Can you provide **an example** of how signals are transmitted within and between cells to mediate gene expression? (2)
- cytokines in cell replication and division
- mating pheromones in yeast
- cAMP regulate metabolic gene expression in bacteria
- SRY gene
- ethylene levels to ripen fruit
- gibberellins for seed germination

*Can you provide **an example** of how signals are transmitted within and between cells to cell function?
- morphogens
- p53
- HOX genes

**LO 3.24** The student is able to predict how a change in genotype, when expressed as a phenotype, provides a variation that can be subject to natural selection. [See **SP 6.4, 7.2**]
**LO 3.25** The student can **create a visual representation** to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced. [See **SP 1.1**]
**LO 3.26** The student is able to explain the connection between genetic variations in organisms and phenotypic variations in populations. [See **SP 7.2**]

*Can you explain how errors in DNA replication or DNA repair and external factors can cause mutations? (4)
- can be detrimental, beneficial or neutral depending on environment
- primary source of genetic variation

*Can you explain how errors in mitosis or meiosis can result in changes in phenotype?
- triploidy/polyploidy
- Trisomy 21 (Down syndrome), Turner syndrome
- nondisjuction

*Can you explain how changes in genotype may affect phenotype which are subject to natural selection?
- antibiotic resistance mutations
- pesticide resistance mutations
- sickle cell and heterozygous advantage

**LO 3.27** The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains.[See **SP 7.2**]
**LO 3.28** Able to construct an explanation of the multiple processes that increase variation within a population. [**SP 6.2**]

*Can you describe how genetic variation is produced and maintained? (2)
- imperfect replication and repair
- transduction (use of virus), transformation and conjugation in bacteria
- translocation
- crossing over, law of independent assortment, law of segregation

# Big Idea 3 Learning Objectives: Genetics

**LO 3.29** Able to construct an explanation of how viruses introduce genetic variation in host organisms. **SP 6.2**
**LO 3.30** The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population. [See **SP 1.4**]

*Can you explain the process of how virus reproduce? (2)
- lytic cycle
- lysogenic cycle
- can cause mutation
- RNA virus compared to DNA virus (HIV)
- Transduction in bacteria
- Transposons

**LO 3.31** Describe basic chemical processes for cell communication shared across evolutionary lines of descent. **SP 7.2**
**LO 3.32** Generate scientific questions involving cell communication as it relates to the process of evolution. [ **SP 3.1**]
**LO 3.33** Use representation(s) and appropriate models to describe features of a cell signaling pathway. [See **SP 1.4**]

*Can you explain how a signal transduction pathway occurs between organisms? (3)
- quorum sensing in bacteria
- pheromones (ability to sense is a strong selective pressure)
- external signals by bacteria influence cell movement

*Can you explain how a signal transduction occurs within an organism?
- epinephrine stimulates glycogen breakdown
- temperature determination of sex in some vertebrates
- DNA repair

**LO 3.34** Construct explanations of cell communication through cell-to-cell contact or by chemical signaling. **SP 6.2**
**LO 3.35** The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling. [See **SP 1.1**]

*Can you describe how cells communicated through cell to cell contact or chemical signaling? (2)
- Antigen presenting cells (macrophages) cell to cell
- plasmodesmata cell to cell
- neurotransmitters (local), plant immune response (local) quorum sensing (local) morphogens (local)
- endocrine signals such as insulin, human growth, thyroid, testosterone, estrogen (long distance)

**LO 3.36** The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response.[See **SP 1.5**]

*Can you explain how a receptor protein recognizes a signal molecule, changes shape, initiating a transduction? (1)
- ligand gated ion channels, g-protein receptors or tryrosine kinases
- cyclic AMP calcium ions
- phosphorylation can cause change in shape

**LO 3.37** The student is able to justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response. [See **SP 6.1**]
**LO 3.38** The student is able to describe a model that expresses key elements to show how change in signal transduction can alter cellular response. [See **SP 1.5**]
**LO 3.39** The student is able to construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways. [See **SP 6.2**]

*Can you explain the consequences of a blocked or defected signal transduction pathway? (3)
- diabetes, cancer
- neurotoxins, poisons
- high blood pressure medicine, antihistamines, birth control

**LO 3.40** The student is able to analyze data that indicate how organisms exchange information in response to internal changes and external cues, and which can change behavior. [See **SP 5.1**]
**LO 3.41** The student is able to create a representation that describes how organisms exchange information in response to internal changes and external cues, and which can result in changes in behavior. [See **SP 1.1**]
**LO 3.42** The student is able to describe how organisms exchange information in response to internal changes or environmental cues. [See **SP 7.1**]

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*Can you explain how organisms exchange internal and external cues which change behavior?(3)
- fight or flight response
- predator warning and territorial marking
- plant to plant interactions due to herbivory
- Coloration in flowers

*Can you explain how animals use visual, tactile, electrical & chemical signals to show dominance, find food & territory?
- bee dance
- bird songs
- pack behavior/schooling, flock/predator warning

*Can you provide examples of both innate and learning behavior that can help increase an organism's survival?
- migration
- courtship and mating behavior
- parent/offspring interactions
- avoidance behavior

*Can you give examples of cooperative behavior that leads to survival?
- pack mentality
- schooling
- predator warning, colony formation in insects

**LO 3.43** The student is able to construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses. [ **SP 6.2, 7.1**]
**LO 3.44** The student is able to describe how nervous systems detect external and internal signals. [See **SP 1.2**]
**LO 3.45** The student is able to describe how nervous systems transmit information.[See **SP 1.2**]
**LO 3.46** Student is able to describe how the vertebrate brain integrates information to produce a response. [ **SP 1.2**]
**LO 3.47** The student is able to create a visual representation of complex nervous systems to describe/explain how these systems detect external and internal signals, transmit and integrate information, and produce responses. [**SP 1.1**]
**LO 3.48** Create a visual representation to describe how nervous systems detect external and internal signals. [**SP 1.1**]
**LO 3.49** Create a visual representation to describe how nervous systems transmit information. [See **SP 1.1**]
**LO 3.50** Create a visual representation to describe how the vertebrate brain integrates information to produce a response. [See **SP 1.1**]

*Can you describe and draw the structure of a neuron affects its function? (9)
- axon, dendrite, cell body and myelin sheath
- detection, generation and transmission of information
- Schwann cells

*Can you describe and illustrate how an action potential is propagated along a neuron?
- polarized/depolarized
- Na+/K+ channels, Na+/K+ pump

*Can you explain and illustrate the transmission of information from neuron across synapse to elicit a response?
**(Choose 1)**
- Achetylcholine, Epinephrine, norepinephrine, dopamine, serotonine, GABA

*Can you discuss the different functions of the brain, found in different regions?
- In general, vision, hearing, muscle movement, thought, emotions, cerebrum, brainstem, cerebellum, right and left hemispheres