Biology 325: Genetics

Basic principles of Mendelism, molecular genetics, structure and function of genes and chromosomes, populations and evolution.

BIG IDEA I: DNA and RNA Store & Express Genetic Information

DNA Structure, Replication, and the Molecular Mechanism of Recombination: The Watson-Crick model of DNA structure explains how the information within DNA can be accessed and how its integrity can be maintained through replication and recombination.

Discovery of the Molecular Nature of the Gene through Mutation: Gene mutations enabled scientists to understand what a gene is and also to discover the genetic code.

Gene Structure and Expression: The information in DNA flows to RNA molecules via transcription, and then to proteins via translation.

Eukaryotic Chromosome Structure and Function: The DNA Component of the eukaryotic chromosome interacts with different proteins that compact the chromosome, maintaining chromosomal integrity and genome integrity and are targets of gene expression regulators.

Gene Regulation: In response to their environments, cells turn gene transcription "on" or "off" through the actions of *trans*-acting proteins and *cis*- or *trans*-acting RNAs. Multicelluar eukaryotes turn their genes "on" or "off" mainly to generate different cell types during development. Eukaryotes and prokaryotes use similar regulatory mechanisms, but more components exist in eukaryotes because of their more complex chromosomal architecture and the demands of multicellularity.

BIG IDEA II: Genetic Information Is Transmitted

Mendel's Principles of Heredity: Many organisms, for example humans, are diploid, meaning that they have two copies (alleles) of each of their genes, one from each parent, that interact to control individual traits.

Genes Travel on Chromosomes: Chromosome movements, including those of chromosomes that control sex determination, parallel the behavior of Mendel's genes.

Extensions to Mendel's Laws: Most traits are complex: They are controlled by many genes whose alleles interact in a variety of ways and also sometimes by the environment.

Linkage, Recombination, and Mapping Genes on Chromosomes: Genes close together on the same chromosome tend to travel together.

Organellar Genetics: Mitochondrial and chloroplast genomes are interdependent with the nuclear genome, inherited maternally in most organisms and affect the phenotype of the organism.

Bacterial Genetics: The ability of bacteria to transmit their genes horizontally makes bacteria both human symbionts and pathogens.

BIG IDEA III: Genetic Information Evolves

Molecular Mechanisms of DNA Mutation: The ultimate cause of most DNA mutation is faulty DNA replication due to the inefficiency of DNA repair mechanisms.

Large-Scale Changes in Chromosomes: Mutations of large chromosomal regions can alter chromosome segregation into gametes and can also affect the functions of many genes. Incomplete chromosome sets, as well as the number of complete chromosome sets affect phenotype.

Digital Analysis of Genomes: Technology developed originally for the Human Genome Project advances continually at a rapid pace, allowing DNA sequence analysis of individuals of any species.

Analyzing Genomic Variation: Detection of variants in individuals is useful for diagnosis and identification of disease genes and forensics.

Variation at the Population Level: Allele frequencies in populations change due to natural selection and chance. Analysis of variants in different populations can help to trace human ancestry.

Genetic Analysis of Complex Traits: The genes controlling complex traits can be identified in genomic studies that include many individuals.

BIG IDEA IV: Humans Can Manipulate Genetic Information

Transgenic Organisms: The introduction of genes from a test tube into the genome of an organism has many applications in genetic research, gene therapy, pharmaceuticals, and agriculture.

Genome Editing: Available technology allows scientists to change any base pair of the genome at will, and also to add DNA from any source into a particular location in the genome.

BIG IDEA V: Genetic Analysis Can Be Used to Study Biological Processes

Genetic Dissection of Development: Arguably the greatest triumph of genetics in human understanding of the molecular processes or development.

Understanding Cancer: Cancer, characterized in part by uncontrolled cell division, is many different diseases with a common cause: the accumulation of certain gene mutations in somatic cells. The ability to identify specific cancer-causing gene mutations is allowing the development of drugs that eradicate specific cancers in particular individuals