

EVOLUTION ALGEBRA

Hartl-Clark and Ayala-Kiger

Freshman Seminar
University of California, Irvine

Bernard Russo

University of California, Irvine

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Hartl and Clark

The science of **population genetics** deals with Mendel's laws and other genetic principles as they affect entire populations (natural, agricultural, experimental) of organisms (human beings, animals, plants, microbes) in various environments (city, farm, field, forest) and habitats (soil, water, air).

Population genetics also includes the study of the various forces that result in evolutionary changes in species through time. Many oddities in biology become comprehensible in the light of evolution, resulting from shared ancestry among organisms, and attesting to the unity of life on earth.

Practical applications of population genetics are extensive. Many applications, particularly those relevant to human beings, also have important implications in ethics and social policy.

Gene is a general term meaning, loosely, the physical entity transmitted from parent to offspring in reproduction that influences heredity traits, such as hair color, eye color, skin color, height, weight, and various aspects of behavior, which are also influenced by environment.

Genes also determine the makeup of proteins, such as hemoglobin, insulin, and can exist in different forms or states, called **alleles**.

A gene corresponds to a region along a molecule of DNA (deoxyribonucleic acid), which is the genetic material. A molecule of DNA consists of two strands would around each other in the form of a right-handed helix (the celebrated “double helix”).

DNA molecules can be very long: *E. coli* bacterium has 4.7 million “base pairs” of nucleotides, the fruit fly 65 million and humans 230 million in their largest chromosomes.

Physical manipulation of such large molecules is impractical; in order to be studied they must first be broken into smaller pieces.

Gene expression is the process by which information from a gene is used in the synthesis of a functional gene product, often proteins.

The process of gene expression is used by all known life—**eukaryotes** (higher organisms, including multicellular organisms), **prokaryotes** (bacteria and other organisms lacking a nucleus), and utilized by viruses—to generate the macromolecular machinery for life.

In genetics, gene expression is the most fundamental level at which the **genotype** gives rise to the **phenotype**.

The genetic code stored in DNA is “interpreted” by gene expression, and the properties of the expression give rise to the organism’s phenotype.

The **genetic code** is the list of all **codons** (separate coding groups) showing which amino acid each codon specifies.

Within a living cell, genes are arranged in linear order among microscopic threadlike bodies called **chromosomes**, which typically contains several thousand genes. The position of a gene along a chromosome is called the **locus** of the gene.

In most higher organisms, each cell contains two copies of each type of chromosome. These are called **diploid** organisms.

In each pair of such chromosomes, one member is inherited from the mother through the egg and the other is inherited from the father through the sperm. At every locus, therefore, diploid organisms contain two alleles, one each at corresponding positions in the maternal and paternal chromosomes.

If the two alleles at a locus are identical, the organism is said to be **homozygous** at the locus under consideration, otherwise **heterozygous** at the locus.

The term *gene* is a general term usually used in the sense of *locus*.

Geneticists make a fundamental distinction between the genetic constitution, **genotype** of an organism and the physical attributes, **phenotype** of the organism.

Genotype refers to the particular alleles present in an organism at all loci, that affect the trait in question. EXAMPLE: if a trait is influenced by two genes, each with two alleles, A,a and B,b, then there are nine possible genotypes

AA;BB	AA;Bb	AA;bb
Aa;BB	Aa;Bb	Aa;bb
aa;BB	aa;Bb	aa;bb

Ayala and Kiger

“Nothing in biology makes sense except in the light of evolution.” (*Theodosius Dobzhansky*). It is even more certain that nothing in biology is understandable except in the light of genetics.

Genetics is the core biological science; it provides the framework within which the diversity of life and its processes can be comprehended as an intellectual whole.

The foundations of genetics were discovered by Gregor Mendel in 1866, but remained unknown until 1900. During the first half of the twentieth century it was gradually established that genes play major roles in the function and evolution of higher organisms.

The fundamental significance of these roles, however, became apparent only with the recognition that nucleic acids are the hereditary materials of all organisms.

The discovery of the chemical nature of DNA laid open the principles of heredity and led to an understanding of how the genes—in the form of DNA molecules—are transmitted from generation to generation and expressed within each generation.

The hereditary information is contained within the nucleotide sequence of the DNA; it is expressed through that sequence as it specifies the amino acid sequences of proteins.

The code relating nucleotide sequences to amino acid sequences is the same in all organisms: in bacteria, in plants, in animals, in human beings.

The genetic material, DNA, has three major features: organization, expression, evolution.

The simplest cellular organisms are the **prokaryotes** (“pre-nuclear”), which includes bacteria. Their hereditary material is contained in a single chromosome, which is not separated from the rest of the cell.

The **eukaryotes** (“having a true nucleus”) include all cellular organisms except the bacteria and blue-green algae. They have a nucleus and contain two or more chromosomes.

The DNA of eukaryotes is complex and eukaryotic cells contain other structures that are lacking in prokaryotes, such as mitochondria and chloroplasts. Eukaryotes may be either unicellular or multicellular.

Reproduction in eukaryotes may be **asexual** (a single parent divides into two or more parts), or **sexual** (the union of two sex cells, or **gametes**, forming a single cell, a **zygote**), each of which grows into a new individual.

The number of chromosomes characteristic of an organism is maintained constant from generation to generation because there are two kinds of cell division, one for the formation of **somatic** (“body”) cells, the other for the formation of gametes.

Somatic cells divide by a process called **mitosis**, in which the chromosomes are exactly duplicated before the onset of cell division, and equally distributed between into the two daughter cells.

Gametes are formed by the process of **meiosis**, during which each cell divides twice while the chromosomes are duplicated only once. The resulting gametes therefore have only half the number of chromosomes as the somatic cells.

Two gametes (one male sex cell and one female sex cell) join in the process called fertilization. The resulting zygote thus has the number of chromosomes characteristic of the somatic cells of the organism.

Mitosis is the process of nuclear division by which one cell results in two daughter cells, each with a set of chromosomes identical to the parental cell.