

## Lecture #21 April 29, 2010: Genetics

Physics and astrophysics tropes in SF are often about hopeful possibilities  
Biology tropes in SF are often about fearful anxieties, often centered around themes of *identity*.

<u>Trope</u>	<u>Theme</u>
Aliens	Fear of the Other
Cloning	Loss of identity
Genetic manipulation	Loss / change of identity (hopeful improvements)

### Introduction to genetics

Themes from genetics: nature versus nurture, or, biochemistry is (?) destiny

Genetics: the biochemical basis for heredity and natural selection.

Genetic engineering: “unnatural” selection, or by design.

### Genetics, the simple version

A gene: the “atom” of heredity. Your genome: the collection of your genes. Genes are found on *chromosomes* in your cells. Chromosomes are long, coiled strands of DNA (deoxyribonucleic acid).

Genes are recipes for making *proteins*. Proteins are the biochemical workhorses of biology. Proteins that create, modify, or destroy other chemicals are called *enzymes*. Hence, genes orchestrate all your biochemistry by creating enzymes. Proteins (polypeptides) are long strands of amino acids. Amino acids are basic chemical building blocks. There are about twenty of them: phenylalanine, lysine, glycine, leucine, cysteine, tryptophan, asparagine, etc

Genes are long sections of DNA. DNA are long chains of nucleotides ATGC (adenine, thymine\*, guanine, cytosine). \*in RNA thymine replaced by uracil (U).

DNA is a digital code for amino acids.

A triplet of nucleotides (a “codon”) encodes an amino acid: Phenylalanine is coded by TTT or TTC. STOP coded by TAA, TAG, TGA. This is like Morse code or ASCII.

DNA’s digital nature makes copying (via *mitosis*) easy.

A gene is really a location on a chromosome. A gene may come in different types, or *alleles*, which make different enzymes (or may not make an enzyme at all).

You inherit your genes from your parents, but 50% of your alleles come from your father and 50% from your mother. (The process of splitting DNA in two is *meiosis*.) Offspring who inherits advantageous alleles (e.g., more resistant to disease) may have a better chance to reproduce and those alleles get passed on to more offspring.

Mutants: Mutations—due either to outside influences, such as chemicals or radiation, or through simple copying errors—are changes in a gene. Most mutations are harmful, but once in a while one is slightly more beneficial.

“Genetic engineering” (as commonly understood) is direct modification or insertion of genes into a chromosome, in order to produce a protein.

Viruses are genetic engineers. We can use viruses (and human-designed tools) to modify an organism’s genome.

“One gene, one enzyme.” A few traits are governed by a single gene (a single protein) but many traits governed by several genes. Therefore one seldom finds *the* gene for X, but genes that contributes to X.

### Genetics, the more complicated story

You are not just a sum of your enzymes.... Those enzymes must be at the right *place* and at the right *time*. There are extremely complicated mechanisms to turn genes on and off (and the story is not yet fully understood).

Genes are not neat, linear, fixed, contiguous strings of DNA. Your genome is full of “junk DNA” or *introns* that do not express proteins— approximately 97% of your DNA! Introns may be inherited “drafts” of genes that are no longer used.

So while genes are a recipe for proteins, they are messy to read.

Much of the work of the cell is in extracting the correct recipe.

### Genetics and evolution

Selection: natural pressures (or unnatural, from humans) will allow for some alleles to propagate more than others. A change in environment can cause a change in allele frequencies.

One important type of mutation is *gene duplication*. If the entire genome is duplicated, it is called *polyploidy*, common in plants.

Gene duplication answers one critique of evolution: how did organisms with smaller genomes (nematodes: 18,000 genes) evolve into organisms with larger genomes (humans: about 30,000 genes)?

A: Genes can be duplicated, and then evolve separately.

### **Summary of genetics:**

Your genes are a *code* for making proteins & enzymes from amino acids: Proteins and enzymes are the building blocks of life.

*Alleles* are variations on the same gene.

The digital nature of DNA makes it easy to copy. The full code can be duplicated and passed on to cells within your body (mitosis).

Split DNA in two—*meiosis*—to “mix and match” genes in sexual reproduction.

*Mutations* are a change to the code, which in turn change the proteins and enzymes.

Often this change is deleterious or neutral, but sometimes it offers an advantage.

Genes that confer an advantage are more likely to be passed on to offspring.

Sexual reproduction—mixing and matching genes from two parents—makes for more efficient selection of advantageous alleles.

The process is not quite this simple. First, the code contains many *introns*, or

“nonsensical” sections, which must be ignored during transcription from gene to protein.

One important form of mutation is *gene duplication*: allows the genome to get larger.