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The Master Molecule

The genome in the nucleus of every human cell (except red blood cells) consists of 6 billion deoxyribonucleic acid (DNA) nucleotides packaged in 48 chromosomes. The life of every human being begins with DNA, a polymer of a long series of nucleotides, with a backbone of five-carbon sugars. Ribonucleic acid (RNA) contains ribose in the place of deoxyribose. Human DNA contains 22,000 genes, containing 750 MB of data (the Bible contains 5 MB).

Humans and chimps evolved separately from a common ancestor about 6 million years ago. Nearly 99% of the gene sequences in chimps are identical to those of humans. Macaque monkeys branched off the family tree of a common ancestor about 25 million years ago. Even in 93% of macaque DNA is the same as that of human beings. Ninety-nine percent of each person‘s DNA is identical to that of all other human beings.

Today, the evolution of genes, programmed cell death (apoptosis), and the action of messenger RNA (mRNA) are three major targets of research. mRNA contains the blueprint for every protein in the body. It is transcribed from a DNA template, and carries information to ribosomes, the sites of protein synthesis. The sequences of nucleic acid polymers are translated by transfer RNA (tRNA) into amino acid polymers. tRNA recognizes the three-nucleotide sequences that encode each amino acid. Ribosomal RNA directs the ribosome's production of proteins. Codons carry the messages that terminate protein synthesis.

The DNA of genes is made of four nucleotide bases: two purines, adenine (A) and guanine (G); and two pyrimidines, thymine (T) and cytosine (C). The genetic code is based on these four letters, AGCT, that encode the amino acids making up the body‘s peptides and proteins. The genetic code is the same in all living creatures.

Nobel Prize winner Sydney Brenner showed that a sequence of three nucleotide bases in a row encode each specific amino acid. RNA strands complementary to a DNA strand are responsible for the process called transcription, which is brought about by the action of the enzyme, RNA polymerase.

DNA not only passes information from one generation to the next, but throughout a person‘s entire life it is involved in the continual reproduction of the molecules in all the cells of the body. From the moment of conception until the time of death, it is the continual transfer and selective expression of genetic information that makes life possible.

The total complement of genes in a living organism is called the genome. Three billion nucleotides that make up human DNA carry instructions that control the structure and function of all cells of the body (except red blood cells, which have no nuclei). Three percent of human DNA encodes information. The remaining 97% is called junk DNA, the function of which is not yet known.

Specific genes, called exons, are activated by promoter genes located along the sequence of the DNA molecule. Noncoding sequences are called introns, and do not lead to the production of products. Exons encode specific peptides and proteins: structural molecules, neurotransmitters, and enzymes regulating chemical processes.

The evolution of different species is the result of genetic mutations, which occur in organisms as primitive as bacteria. Bacteria can exchange genes. When grown in a culture medium, they reproduce every 20 or 30 min. Mutations enhance their survival in the face of a harmful environment, such as an environment containing antibiotics. Mutations result in the reproduction of bacteria resistant to the effects of antibiotics. The antibiotic-resistant bacteria survive and reproduce, creating a new strain of bacteria.

The nervous system lies between genes and behavior. In his Nobel Prize lecture in 2002, geneticist Sydney Brenner said, "Behavior is the result of a complex, ill-understood set of computations performed by nervous systems. It seems essential to decompose the question into two: one concerned with the question of the genetic specification of (different) nervous systems and the other with the way nervous systems work to produce behavior … We are drowning in a sea of data and starving for knowledge.

"The biological sciences have exploded, largely through our unprecedented power to accumulate descriptive facts. How to understand genomes and how to use them is going to be a central task of our research for the future. We need to turn data into knowledge. Biology has become so focused on genetics that we have forgotten that the real units of function and structure in an organism are cells and not genes …

After the basic principles of information transfer from genes to proteins had been established with the identification of messenger RNA, the discovery of the mechanism of protein synthesis and the structure of genetic code, it was natural for some of us to ask whether the lessons learnt in molecular biology could be applied to the genetics of more complex phenotypes."

Brenner advises students to study the relationship of genes to biological processes: "All you have to do is to find a gene and have it sequenced and then make some protein using the gene and get someone to determine its amino acid sequence."

One can use molecular imaging with radioactive tracers to determine the role of proteins and other molecules in the process of living. More recently, optical imaging, based on luminescence or fluorescence, also makes this possible.

Tracers emit radiant energy as radioactive particles or photons, which can penetrate the body to be detected by imaging devices that show where the source of radiation lies within the body.

Molecular imaging makes it possible to detect abnormalities of one or more modifiable molecular manifestations associated with abnormal perceptions, thinking, and behavior. Measuring these manifestations of disease provides the foundation of molecular medicine.

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