I'm not a bot

Biologists in the 1940s had difficulty in accepting DNA as the genetic material because of the apparent simplicity of its chemistry. DNA was known to be a long polymer composed of only four types of subunits, which resemble one another chemically. Early in the 1950s, DNA was first examined by x-ray diffraction analysis, a technique for determining the three-dimensional atomic structure of a molecule (discussed in Chapter 8). The early x-ray diffraction results indicated that DNA was composed of two strands of the polymer wound into a helix. The observation that DNA was double-stranded was of crucial significance and provided one of the major clues that led to the Watson-Crick structure of DNA. Only when this model was proposed did DNA's potential for replication and information encoding become apparent. In this section we examine the structure of the DNA molecule and explain in general terms how it is able to store hereditary information.A DNA molecule consists of two long polynucleotide chains composed of four types of nucleotide subunits. Each of these chains is known as a DNA chain, or a DNA strand. Hydrogen bonds between the base portions of the nucleotides hold the two chains together (Figure 4-3). As we saw in Chapter 2 (Panel 2-6, pp. 120-121), nucleotides are composed of a five-carbon sugar to which are attached one or more phosphate groups and a nitrogen-containing base. In the case of the nucleotides in DNA, the sugar is deoxyribose attached to a single phosphate group (hence the name deoxyribonucleic acid), and the base may be either adenine (A), cytosine (C), guanine (G), or thymine (T). The nucleotides are covalently linked together in a chain through the sugars and phosphates, which thus form a "backbone" of alternating sugar-phosphate-sugar-phosphate (see Figure 4-3). Because only the base differs in each of the four types of subunits, each polynucleotide chain in DNA is analogous to a necklace (the backbone) strung with four types of beads (the four bases A, C, G, and T). These same symbols (A, C, G, and T) are also commonly used to denote the four different nucleotides—that is, the bases with their attached sugar and phosphate groups. The way in which the nucleotide subunits are lined together gives a DNA strand a chemical polarity. If we think of each sugar as a block with a protruding knob (the 5′ phosphate) on one side and a hole (the 3′ hydroxyl) on the other (see Figure 4-3), each completed chain, formed by interlocking knobs with holes, will have all of its subunits lined up in the same orientation. Moreover, the two ends of the chain will be easily distinguishable, as one has a hole (the 3′ hydroxyl) and the other a knob (the 5′ phosphate) at its terminus. This polarity in a DNA chain is indicated by referring to one end as the 3′ end and the other as the 5′ end.The three-dimensional structure of DNA—the double helix—arises from the chemical and structural features of its two polynucleotide chains. Because these two chains are held together by hydrogen bonding between the bases on the different strands, all the bases are on the inside of the double helix, and the sugar-phosphate backbones are on the outside (see Figure 4-3). In each case, a bulkier two-ring base (a purine; see Panel 2-6, pp. 120–121) is paired with a single-ring base (a pyrimidine); A always pairs with T, and G with C (Figure 4-4). This complementary base-pairing enables the base pairs to be packed in the energetically most favorable arrangement in the interior of the double helix. In this arrangement, each base pair is of similar width, thus holding the sugar-phosphate backbones an equal distance apart along the DNA molecule. To maximize the efficiency of base-pair packing, the two sugar-phosphate backbones wind around each other to form a double helix, with one complete turn every ten base pairs (Figure 4-5). The members of each base pair can fit together within the double helix only if the two strands of the helix are antiparallel—that is, only if the polarity of one strand is oriented opposite to that of the other strand (see Figures 4-3 and 4-4). A consequence of these base-pairing requirements is that each strand of a DNA molecule contains a sequence of nucleotides that is exactly complementary to the nucleotide sequence of its partner strand.Genes carry biological information that must be copied accurately for transmission to the next generation each time a cell divides to form two daughter cells. Two central biological questions arise from these requirements: how can the information for specifying an organism be carried in chemical form, and how is it accurately copied? The discovery of the structure of the DNA double helix was a landmark in twentieth-century biology because it immediately suggested answers to both questions, thereby resolving at the molecular level the problem of heredity. We discuss briefly the answers to these questions in this section, and we shall examine them in more detail in subsequent chapters.DNA encodes information through the order, or sequence, of the nucleotides along each strand. Each base—A, C, T, or G—can be considered as a letter in a four-letter alphabet that spells out biological messages in the chemical structure of the DNA. As we saw in Chapter 1, organisms differ from one another because their respective DNA molecules have different nucleotide sequences and, consequently, carry different biological messages. But how is the nucleotide alphabet used to make messages, and what do they spell out?As discussed above, it was known well before the structure of DNA was determined that genes contain the instructions for producing proteins. The DNA messages must therefore somehow encode proteins (Figure 4-6). This relationship immediately makes the problem easier to understand, because of the chemical character of proteins. As discussed in Chapter 3, the properties of a protein, which are responsible for its biological function, are determined by its three-dimensional structure, and its structure is determined in turn by the linear sequence of the amino acids of which it is composed. The linear sequence of nucleotides in a gene must therefore somehow spell out the linear sequence of amino acids in a protein. The exact correspondence between the four-letter nucleotide alphabet of DNA and the twenty-letter amino acid alphabet of proteins—the genetic code—is not obvious from the DNA structure, and it took over a decade after the discovery of the double helix before it was worked out. In Chapter 6 we describe this code in detail in the course of elaborating the process, known as gene expression, through which a cell translates the nucleotide sequence of a gene into the amino acid sequence of a protein. The complete set of information in an organism's DNA is called its genome, and it carries the information for all the proteins the organism will ever synthesize. (The term genome is also used to describe the DNA that carries this information.) The amount of information contained in genomes is staggering: for example, a typical human cell contains 2 meters of DNA. Written out in the four-letter nucleotide alphabet, the nucleotide sequence of a very small human gene occupies a quarter of a page of text (Figure 4-7), while the complete sequence of nucleotides in the human genome would fill more than a thousand books the size of this one. In addition to other critical information, it carries the instructions for about 30,000 distinct proteins. At each cell division, the cell must copy its genome to pass it to both daughter cells. The discovery of the structure of DNA also revealed the principle that makes this copying possible: because each strand of DNA contains a sequence of nucleotides that is exactly complementary to the nucleotide sequence of its partner strand, each strand can act as a template, or mold, for the synthesis of a new complementary strand. In other words, if we designate the two DNA strands as S and S′, strand S can serve as a template for making a new strand S′, while strand S′ can serve as a template for making a new strand S (Figure 4-8). Thus, the genetic information in DNA can be accurately copied by the beautifully simple process in which strand S separates from strand S′, and each separated strand then serves as a template for the production of a new complementary partner strand that is identical to its former partner. The ability of each strand of a DNA molecule to act as a template for producing a complementary strand enables a cell to copy, or replicate, its genes before passing them on to its descendants. In the next chapter we describe the elegant machinery the cell uses to perform this enormous task.Nearly all the DNA in a eucaryotic cell is sequestered in a nucleus, which occupies about 10% of the total cell volume. This compartment is delimited by a nuclear envelope formed by two concentric lipid bilayer membranes that are punctured at intervals by large nuclear pores, which transport molecules between the nucleus and the cytosol. The nuclear envelope is directly connected to the extensive membranes of the endoplasmic reticulum. It is mechanically supported by two networks of intermediate filaments: one, called the nuclear lamina, forms a thin sheetlike meshwork inside the nucleus, just beneath the inner nuclear membrane; the other surrounds the outer nuclear membrane and is less regularly organized (Figure 4-9). The nuclear envelope allows the many proteins that act on DNA to be concentrated where they are needed in the cell, and, as we see in subsequent chapters, it also keeps nuclear and cytosolic enzymes separate, a feature that is crucial for the proper functioning of eucaryotic cells. Compartmentalization, of which the nucleus is an example, is an important principle of biology; it serves to establish an environment in which biochemical reactions are facilitated by the high concentration of both substrates and the enzymes that act on them.Genetic information is carried in the linear sequence of nucleotides in DNA. Each molecule of DNA is a double helix formed from two complementary strands of nucleotides held together by hydrogen bonds between G-C and A-T base pairs. Duplication of the genetic information occurs by the use of one DNA strand as a template for formation of a complementary strand. The genetic information stored in an organism's DNA contains the instructions for all the proteins the organism will ever synthesize. In eucaryotes, DNA is contained in the cell nucleus. (redirected from Double-stranded)Also found in: Dictionary, Thesaurus, Legal, Encyclopedia. complementary DNA (cDNA) (copy DNA (cDNA)) synthetic DNA transcribed from a specific RNA through the reaction of the enzyme reverse transcriptase.Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health, Seventh Edition. © 2003 by Saunders, an imprint of Elsevier, Inc. All rights reserved.Abbreviation for deoxyribonucleic acid. For terms bearing this abbreviation, see subentries under deoxyribonucleic acid.Farlex Partner Medical Dictionary © Farlex 2012 (dē′ĕn-ā′)n. A nucleic acid that carries the genetic information in cells and some viruses, consisting of two long chains of nucleotides twisted into a double helix and joined by hydrogen bonds between the complementary bases adenine and thymine or cytosine and guanine. DNA sequences are replicated by the cell prior to cell division and may include genes, intergenic spacers, and regions that bind to regulatory proteins.The American Heritage® Medical Dictionary Copyright © 2007, 2004 by Houghton Mifflin Company. Published by Houghton Mifflin Company. All rights reserved. Abbreviation for:deoxyribonucleic aciddid not arrivedid not attend, see thereSegen's Medical Dictionary. © 2012 Farlex, Inc. All rights reserved. Deoxyribonucleic acid Molecular biology A double-stranded linear macromolecule which encodes an organism's genetic informationMcGraw-Hill Concise Dictionary of Modern Medicine. © 2002 by The McGraw-Hill Companies, Inc.Abbreviation for deoxyribonucleic acid. Medical Dictionary for the Health Professions and Nursing © Farlex 2012 Abbrev. for deoxyribonucleic acid. The very long molecule that winds up to form a CHROMOSOME and that contains the complete code for the automatic construction of the body. The molecule has a double helix skeleton of alternating sugars (deoxyribose) and phosphates. Between the two helices, lying like rungs in a ladder, are a succession of linked pairs of the four bases adenine, thymine, guanine and cytosine. The molecules of adenine and guanine are larger than thymine and cytosine and so, to keep the rungs of equal length, adenine links only with thymine and guanine only with cytosine. This arrangement allows automatic replication of the molecule. The sequence of bases along the molecule, taken in groups of three (codons), is the genetic code. Each CODON specifies a particular amino acid to be selected, and the sequence of these, in the polypeptides formed, determines the nature of the protein (usually an ENZYME) synthesized. Polypeptide formation occurs indirectly by way of MESSENGER RNA and TRANSFER RNA. Periodicity of DNA is defined as the number of base pairs per turn of the double helix.Collins Dictionary of Medicine © Robert M. Youngson 2004, 2005Fig. 137 DNA. Replication.Fig. 136 DNA. The 'double helix' shape produced by coiling.Fig. 135 DNA. Complementary base pairing. a complex NUCLEIC ACID molecule found in the chromosomes of almost all organisms, which acts as the primary genetical material, controlling the structure of proteins and hence influencing all enzyme-driven reactions. structure. DNA is a polymer of deoxyribonucleotides. The model proposed by WATSON and CRICK in 1953 has now become universally accepted for double-stranded DNA. The DNA is considered to consist of two POLYNUCLEOTIDE CHAINS joined together by hydrogen bonds between NUCLEOTIDE BASES, with COMPLEMENTARY BASE PAIRING between specific bases ensuring a parallel-sided, stable structure: ADENINE pairing with THYMINE (2H bonds) and CYTOSINE with GUANINE (3H bonds). The two polynucleotide chains each have an opposite polarity due to the way the phosphates are attached to the sugar groups by 3'- 5' PHOSPHODIESTER BONDS. DNA can exist in a number of configurations, of which B-DNA is the predominant form. In this form the molecule is twisted into a right-handed double helix, with a complete turn every tenth base. See also A-DNA, Z-DNA. replication (see SEMICONSERVATIVE REPLICATION MODEL). Replication is initiated at the ORIGIN OF REPLICATION. DNA HELICASE enzymes unwind the double-stranded DNA and each parental strand acts as a TEMPLATE for new DNA synthesis. The anti-parallel nature of the double-stranded DNA molecule affects the replication process. The DNA POLYMERASES involved in replication can only add NUCLEOTIDES to the 3'- OH group of a polynucleotide chain, that is, a DNA strand can only be synthesized in the 5'- 3' direction requiring a template running 3'-" 5'. Thus the two newly synthesized strands must grow in different directions. One daughter strand (the leading strand) is synthesized continuously in the 5'- 3' direction. The other daughter strand (the lagging strand) is synthesized discontinuously in fragments (called Okazaki fragments) that have been synthesized in the normal 5'- 3' direction, but the strand grows overall in the 3'-" 5' direction. These fragments are afterwards joined to make a continuous strand. The region in which replication occurs is called the replication fork. In E. coli, replication occurs as follows: the DNA unwinds, SSB protein is laid down on the single strands to stabilize them and to prevent rewinding. An RNA PRIMER initiates DNA synthesis on the leading strand. RNA primers initiate synthesis of each fragment on the lagging strand. These primers are later removed and the gaps left are filled in by the activity of a DNA polymerase. DNA LIGASE then joins the fragments together to form a complete strand. In eukaryotes, DNA replication occurs in the 'S' phase of the CELL CYCLE prior to nuclear division. location. DNA is found in all chromosomes except those of certain viruses (such as tobacco mosaic virus, TMV), where the heritable material is RNA. In PROKARYOTES, DNA is generally in the form of a single coiled molecule in a continuous loop (see NUCLEOID and may also occur as extrachromosomal material in the cytoplasm. In EUKARYOTES the DNA is also highly coiled but is complexed with basic and acidic proteins. There is probably only one very long DNA molecule per chromosome. DNA is also found in CHLOROPLASTS and MITOCHONDRIA of eukaryote cytoplasm (see CYTOPLASMIC INHERITANCE). DNA as a genetic material. There are several pieces of evidence to suggest the role of DNA in inheritance: (i) TRANSFORMATION experiments with Streptococcus (Diplococcus) pneumoniae in 1928, by F. GRIFFITH; (ii) the identification of the 'transforming principle' as DNA by AVERY MacLeod and McCarty in 1944; (iii) the fact that the wavelength of ultraviolet light which causes most mutations in various prokaryotes and eukaryotes matches the ABSORPTION SPECTRUM of nucleic acids (260 nm); (iv) HERSHEY and Chase's experiment with labelled BACTERIOPHAGE. DNA has several features which make it an ideal genetic material: great stability (see structure above); accurate replication so that all cells contain an identical copy of information; four nucleotide bases to provide storage of coded information (see GENETIC CODE); it is capable of mutation by altering the base sequence; it may be broken and rejoined to form new genetic combinations (see RECOMBINATION); stored information can be accurately 'read' by other cell molecules (see TRANSCRIPTION). Collins Dictionary of Biology, 3rd ed. © W. G. Hale, V. A. Saunders, J. P. Margham 2005The abbreviation for "deoxyribonucleic acid," the primary carrier of genetic information found in the chromosomes of almost all organisms. The entwined double structure allows the chromosomes to be copied exactly during cell division.Gale Encyclopedia of Medicine. Copyright 2008 The Gale Group, Inc. All rights reserved.A type of nucleic acid that constitutes the molecular basis of heredity. It is found principally in the nucleus of all cells where it forms part of the chromosome, or in the cytoplasm of cells lacking a nucleus, such as bacteria. It acts as the carrier of genetic information containing the instructions (code) to make proteins. It consists of two single chains of nucleotides, which are twisted round each other to form a double helix or spiral. The nucleotides contain sugar (deoxyribose), phosphate and the bases (adenine, cytosine, guanine and thymine). The two strands of DNA are held together by hydrogen bonds located between specific pairs of bases (adenine to thymine and cytosine to guanine). The sequence of bases and consequently gene sequence is sometimes altered, causing mutation. Assessment of DNA has found many applications, including forensic science to help identify a perpetrator (a process called genetic fingerprinting), to establish family relationships or the history of a particular population (phylogenetics). See chromosome; gene; inheritance; mutation.Millodot: Dictionary of Optometry and Visual Science, 7th edition. © 2009 Butterworth-HeinemannAbbreviation for deoxyribonucleic acid. Medical Dictionary for the Dental Professions © Farlex 2012 