

Part 1

Basic Medical Microbiology

1-Microbial Taxonomy: Taxonomy is the area of biologic science comprising three distinct, but highly interrelated, disciplines that include **classification**, **nomenclature**, and **identification**.

In diagnostic microbiology, classification, nomenclature, and identification of microorganisms **play a central role in providing accurate and timely diagnosis of infectious diseases**. Because of taxonomy's important contribution to diagnostic microbiology, some detailed discussion of the three areas that make up taxonomy follows.

CLASSIFICATION: Classification is the organization of microorganisms that share similar morphologic, physiologic, and genetic traits into specific groups, or taxa.

NOMENCLATURE: Nomenclature, the naming of microorganisms according to established rules and guidelines, provides the accepted labels by which organisms are universally recognized. In other words, every organism has a scientific "label" consisting of two parts: the **genus** designation, which is always capitalized, and the **species** designation, which is never capitalized.

IDENTIFICATION: Microbial **identification** is the process by which a microorganism's key features are delineated. Once those features are established, the profile is compared with those of other previously characterized microorganisms so that the organism in question can be classified within the most

appropriate taxa (classification) and can be assigned an appropriate genus and species name (nomenclature); both are essential aspects of the role taxonomy plays in diagnostic microbiology and infectious diseases (Box 1-1).

Table 1-1 Identification Criteria and Characteristics for Microbial Classification (identification methods)

1-Phenotypic Criteria Examples	Principles
Macroscopic morphology	Characteristics of microbial growth patterns on artificial media as observed when inspected with the unaided eye. Examples of such characteristics include the size, texture, and pigmentation of bacterial colonies
Microscopic morphology	Size, shape, intracellular inclusions, cellular appendages, and arrangement of cells when observed with the aid of microscopic magnification
Staining characteristics	Ability of organism to reproducibly stain a particular color with the application of specific dyes and reagents. Staining is usually used in conjunction with microscopic morphology as part of the process of bacterial identification. For example, the Gram stain for bacteria is a critical criterion for identification
Environmental requirements	Ability of organism to grow at various temperatures, in the presence of oxygen and other gases, at various pH levels, or in the presence of other ions and salts such as NaCl
Nutritional requirements	Ability of organism to utilize various carbon and nitrogen sources as nutritional substrates when grown under specific environmental conditions
Resistance profiles	Exhibition of a characteristic inherent resistance to specific antibiotics, heavy metals, or toxins by certain microorganisms
Antigenic properties	Establishment of profiles of microorganisms by various serologic and immunologic methods that are useful for determining the relatedness among various microbial groups
Subcellular properties	Establishment of the molecular constituents of the cell that are typical of a particular taxon, or organism group, by various analytic methods. Some examples include cell wall components, components of the cell membrane, and enzymatic content of the microbial cell
1-Genotypic Criteria Examples	Principles
DNA base composition ratio	DNA comprises four bases (guanine, cytosine, adenine, and thymine). The extent to which the DNA from two organisms is made up of cytosine and guanine (i.e., G + C content) relative to their total base content can be used as indicator of relatedness, or lack thereof. For example, an organism with G + C content of 50% will not be closely related to an organism whose G + C content is 25%
Nucleic acid (DNA and RNA) base sequence analysis	The order of bases along a strand of DNA or RNA is known as the base sequence, and the extent to which sequences are similar (homologous) between two microorganisms can be determined directly or indirectly by various molecular methods. The degree of similarity in the sequences may be a measure of the degree of organism relatedness

BACTERIAL GENETICS:

Genetics, the process of heredity and variation, is the starting point from which all other cellular pathways, functions, and structures originate. The ability of a microorganism to maintain viability, adapt, multiply, and cause disease is founded in genetics.

NUCLEIC ACID STRUCTURE AND ORGANIZATION

For all living entities, hereditary information resides or is encoded in **nucleic acids**. The two major classes include **deoxyribonucleic acid (DNA)**, which is the most common macromolecule that encodes genetic information, and **ribonucleic acid (RNA)**. In some forms, RNA encodes genetic information for various viruses; in other forms, RNA plays an essential role in several of the genetic processes to be discussed.

Nucleotide Structure and Sequence

DNA consists of deoxyribose sugars connected by phosphodiester bonds (Figure 2-2, A). The **bases** that are covalently linked to each deoxyribose sugar are the key to the genetic code within the DNA molecule. The four bases include two purines, adenine (A) and guanine (G), and the two pyrimidines, cytosine (C) and thymine (T) (Figure 2-3). In RNA, uracil replaces thymine. Taken together, the sugar, the phosphate, and a base form a single unit referred to as a **nucleotide**. DNA and RNA are nucleotide polymers (i.e., chains or strands), and the order of bases along a DNA or RNA strand is known as the **base sequence**. This sequence provides the information that specifies the proteins that will be synthesized by microbial cells (i.e., the sequence is the **genetic code**).

DNA Molecular Structure:

The intact DNA molecule usually is composed of two nucleotide polymers. Each strand has a 5' and a 3' hydroxyl terminus (see Figure 2-2, *B*). The two strands run antiparallel, with the 5' terminus of one strand opposed to the 3' terminal of the other. The strands are also complementary as the adenine base of one strand always binds, via two hydrogen bonds, to the thymine base of the other strand, or vice versa. Likewise, the guanine base of one strand always binds by three hydrogen bonds to the cytosine base of the other strand, or vice versa. The molecular restrictions of these base pairings, along with the conformation of the sugar-phosphate backbones oriented in antiparallel fashion, result in DNA having the unique structural conformation often referred to as a “twisted ladder” (see Figure 2-2, *B*). Additionally, the dedicated base pairs provide the format essential for consistent replication and expression of the genetic code. In contrast to DNA, RNA rarely exists as a double-stranded molecule and, whereas DNA carries the genetic code, the three major types of RNA (**messenger RNA [mRNA]**, **transfer RNA [tRNA]**, and **ribosomal RNA [rRNA]**) play other key roles in gene expression. A DNA sequence that encodes for a specific product (RNA or protein) is defined as a **gene**. Thousands of genes within an organism encode messages or blueprints for production, by gene expression, of specific protein and RNA products that play essential metabolic roles in the cell. All genes taken together within an organism comprise that organism's **genome**. The size of a gene and an entire genome is usually expressed in the number of base pairs (bp) present (e.g., kilobases [10^3 bases], megabases [10^6 bases]). These similarities and differences in gene content and sequences are the basis for the development of molecular tests used to detect, identify, and characterize clinically relevant microorganisms.

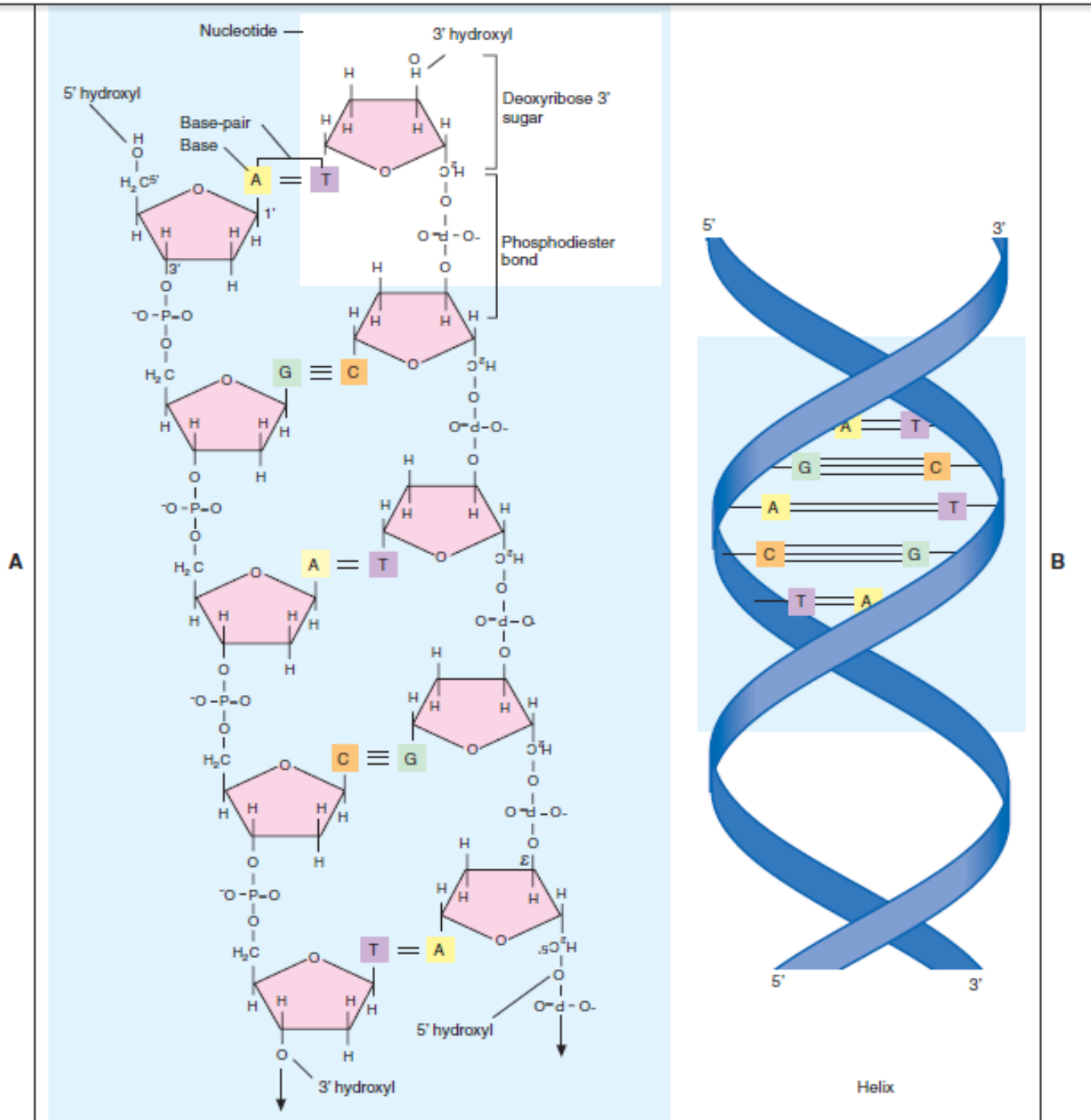


Figure 2-2 **A**, Molecular structure of DNA showing nucleotide structure, phosphodiester bond connecting nucleotides, and complementary pairing of bases (A, adenine; T, thymine; G, guanine; C, cytosine) between antiparallel nucleic acid strands. **B**, 5' and 3' antiparallel polarity and helical ("twisted ladder") configuration of DNA.

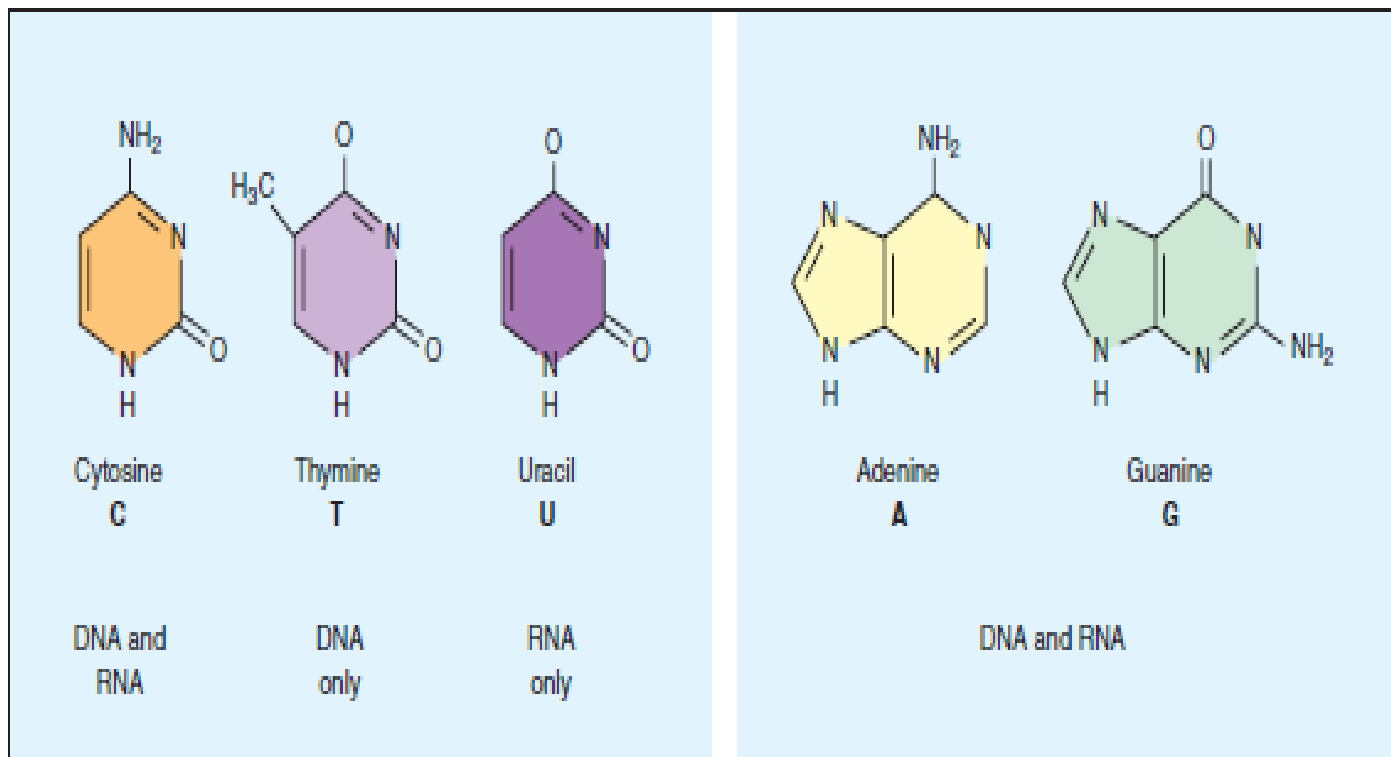


Figure 2-3 Molecular structure of nucleic acid bases. Pyrimidines: cytosine, thymine, and uracil. Purines: adenine and guanine.