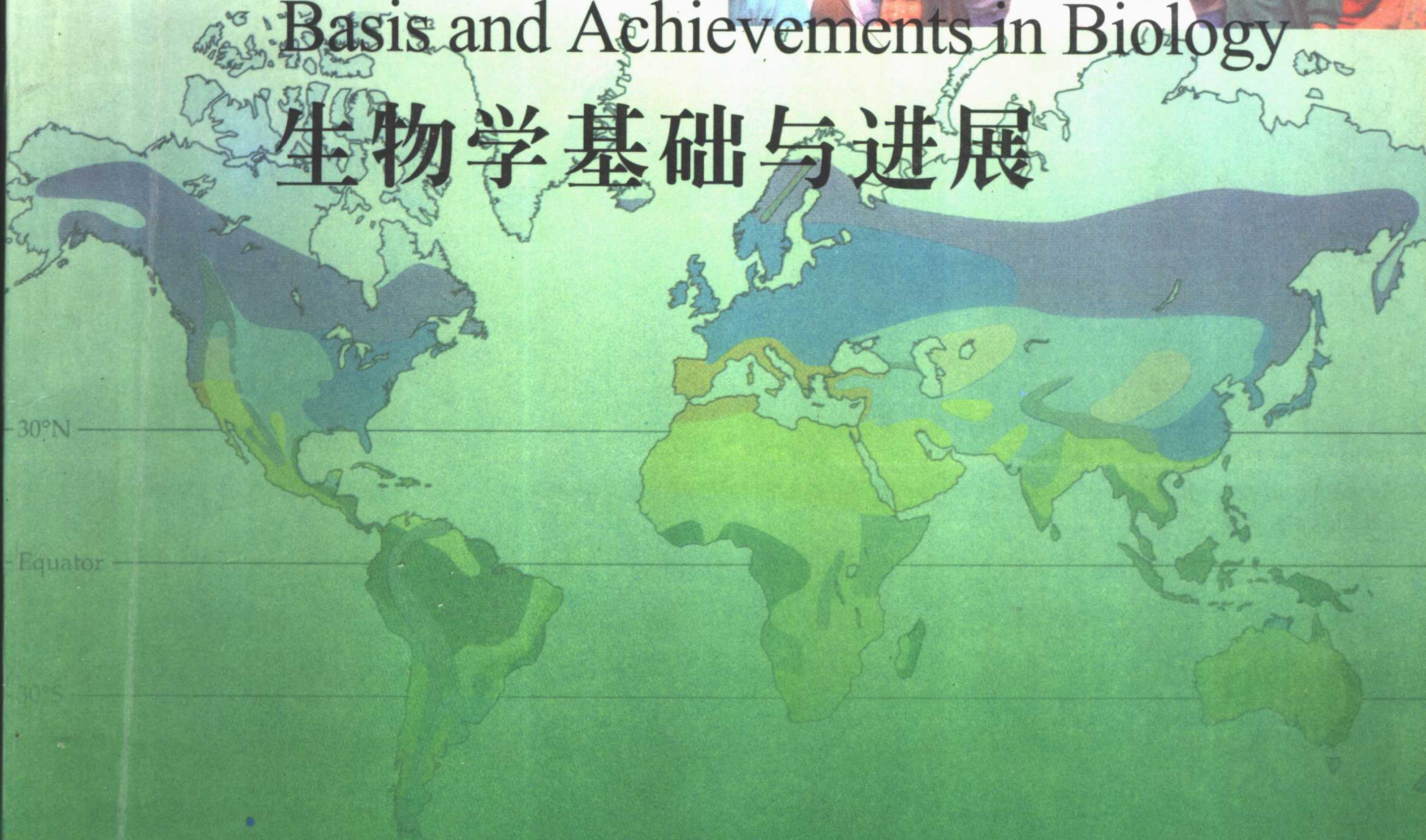
Special English

专业英语

Basis and Achievements in Biology

生物学基础与进展



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内 容 简 介

本书含九个学习单元，约40万字，内容涉及生命科学的广泛领域，词汇量大，系统性强。对书中出现的专业英语词汇加注了国际音标和中、英文注释，有助于提高读者的听、说、读能力。

本书收录了十四条附录，其中1~9条为生命科学教学、研究中常用的理化参数，具有实用性；10~14条为近十年生物学研究的部分新成果，具有指导性。本书可作为从事生命科学教学、科研人员、研究生和高年级本专科生的专业英语教材、辅导读物和参考资料。

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专业英语

Basis and Achievements in Biology

生物学基础与进展

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序

当今世界已进入“全球经济一体化”的时代。“全球科学一体化”的概念是否有人提出尚不知晓，但以我个人的观点，不管是否有这种提法，各国经济、文化和科学，尤其是IT(information technology)的快速发展已迫使每个国家不得不迅猛地发展本国的科学事业，并使之汇合到全球科学发展的大潮中去。

在众多的自然科学中，生命科学是21世纪的主导学科，BT(biological technology)的发展几乎与IT的发展并驾齐驱，甚至有超越的势头，因此，无论是哪个国家和哪个民族，只要在IT和BT方面落后，将不可避免地“挨打”。

那么，怎样可以使我国的BT能与国际BT接轨并融汇到其发展的大潮中去呢？这是一个大课题，不是我们几个平凡的教授所能完成的。但是，作为一个有抱负的、有责任心的教师，都会为此而尽自己的天职。我想，正是有鉴于此，河南师范大学徐存拴教授、张为民副教授才编写出了《Special English—Basis and Achievements in Biology》一书。因为作者深深地体会到中华民族的希望寄托在青年一代学者身上，为了能使他们的生命科学研究工作走向世界，帮助他们提高生物学英语听、说、读能力十分必要，不然何以与国际同行交流，何能知已知彼，赶上与超越世界水平呢？本书是他们多年心血的结晶，是他们丰富的生物学教学与英语教学的经验总结，更是他们对中国BT走向世界的希望。

作为一名读者，同时也作为一名医学生物学教师，带着多年既教生物学也教英语的阅历，我审阅了该教程的目录，大部分文章，尤其是其后的附录，深感本书有如下两个显著特点：

1.它既是英语教材，又是最新的生物学教材。因为本教材所选的文章大多是从当前最新的经典原版英文教科书或是世界权威杂志中精选出来的，其内容不但照顾到生物学知识的完整性、系统性，而且反映出当代生命科学的最新进展，广大读者不但可从阅读中提高英语水平，而且还可领略到世界生命科学发展的光辉前景。

2.文章都是从原版书中选出的，避开了某些教材中出现的“中国式英语”弊病。我认为学习英语必当纯正，“洋经滨”的英语要不得！我们绝不能让学生初遇外宾时说出“您吃过饭了吗？”这样的问候语。

一个人能同时掌握精湛的专业知识和具备熟练应用外语的能力是十分幸福的事。因为你可以随心所欲地、十分有效地交流，不需要“第三者插足”，何况第三者往往会搞不清“病毒(virus)”指的是生物学属语还是计算机语言，更不用说能明白DNA、RNA与蛋白质之间的关系了。因此，我衷心祝贺《Special English—Basis and Achievements in Biology》的出版，并预祝读者从中得到英语和专业知识的共同提高。

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PREFACE

There are more new science words in an introductory biology textbook than are in a foreign language textbook. This discovery in the 1980s by some U.S. science educators led them to propose that the technical terminology should be removed from biology books; biology "concepts" should be taught without the burden of adding complex words that supposedly only specialists needed. This educationist fad proved to be a disaster when the next edition of textbooks appeared with biology terminology missing. University educators learned – and classroom biology teachers always knew that the scientific terms of biology are indispensable in learning biology and it is not possible to teach biology concepts separate from the terminology.

Scientists-in-training must learn many new terms because advancement in biology involves recognizing more-and-more detail and distinctions. Advancement in biology can be measured in the more precise and exact language used to describe the ever-more-complex detail discovered each day. The hallmark of an educated person is the person's ability to use more specific terms and to use them with narrow precision. Over half of the biology terms in this book would not appear in a biology book written in 1950. Nearly all of the molecular and cellular biology words were developed after the Watson and Crick description of the structure of DNA. And even terms that pre-date this milestone, such as words dealing with plants and animals, today have more refined definitions reflecting our advanced understanding of evolution and molecular mechanisms. Researchers must use terms correctly to communicate with each other and to stay at the cutting edge of discovery. As this book's title asserts, and with deep meaning, terminology is truly the "Basis for Progress in Biology."

Biology teachers and the literate public must also recognize and use this growing vocabulary correctly in order to reap the benefits of the new understanding gained through research. While Louis Pasteur and Robert Koch rapidly expanded medical knowledge of bacterial infections among doctors, a much wider understanding of germ theory among the public was necessary to reap the benefits of handwashing, safe food preparation, and other hygienic practices. India's prime minister Nehru once said "The future belongs to those who make friends with science." A country that builds a new generation of scientists who are current in the most advanced science terminology, and that has a public that is also science literate, has "made friends with science" and has a future.

Authors Zhang and Xu bring together their experience in both biology teaching and advanced molecular and cellular biology research to present a concise and accurate explication of today's core biology concepts. The brief but compact discussion of each biology subdiscipline is tightly integrated with definitions and glossary, helping the student to keep "thinking biology in English" but allowing a student to confirm the definition or its application in Chinese. And while the number of new terms does indeed equal the number found in a language course, the common rootwords and context make it easier to recognize the shared origins of many terms, just as a Chinese student can parse the meaning and pronunciation of a new Chinese character based on its components. Chinese students are known worldwide for their ability to accomplish hard intellectual work. This book should make that work in biology much easier.

(John Richard Schrock, Ph.D.)
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前　言

在近几年为研究生开设《生物学专业英语》课的教学实践中，感到有必要编写一本能集生命科学知识和专业英语训练于一体的教材。编写本书的指导思想是：(1)加强专业词汇的听、说、读训练，使英语真正成为交流的工具；(2)照顾专业知识的学习和提高，使学生在提高专业英语水平的同时，也能增加生物学知识；(3)使学生在提高专业英语水平的同时，也能提高基础英语水平；(4)语言尽可能规范和贴近英语国家表达习惯。

本书分九个学习单元，约40万字，内容涉及动物学、植物学、微生物学、生态学、遗传学、细胞生物学、生物化学、生理学、发育生物学、分子生物学、生物技术、物种起源和进化、环境和健康等领域的基础知识和研究进展，内容广泛而系统，词汇量大且重复率高，可帮助读者在较短时间内掌握生物学专业英语、具备阅读生命科学英文文献资料能力。同时，在选材上力图体现实用性、可读性和趣味性，以提高读者的学习兴趣。

为了提高对专业英语词汇表达和理解的准确性，在对本书出现的专业英语词汇加注国际音标和中文的基础上，又对其进行了英文解释，能帮助读者学会用多种方式解释和理解生物学专业词汇，提高自学和表达、交流能力。

为了促进生物学专业英语与实验研究相结合，本书以附录形式提供了部分生物学教学、研究中常用的理化参数资料，便于读者参阅。此外，作者采用书后附综合图解的方式，总结了近十年生命科学研究的部分新成果和新进展。本部分不仅可以作为读者了解有关领域研究进展的资料，也可作为读者用生物学专业英语知识解注和总结有关问题的作业。

编写过程中，得到了许多专家和同事的指导和帮助。成稿后，美国Emporia州立大学J. R. Schrock教授和英国皇家医学院S. Rahman博士又对全书进行了认真审校，并提出了许多建设性修改意见。在此一并致以衷心的感谢！

考虑到语言规范和贴近英语表达习惯，本书尽量采用英文原版书籍的表述方式和资料，但由于时间仓促、编者知识水平有限和经验不足，错误之处在所难免，恳切希望读者批评指正。

编　者

2001年5月于英国伦敦

Contents 目　　录

Unit 1

Life on Earth

In nature, you can see trees, bushes, grass and moss. You may also see honeybees flitting from flower to flower, earthworms or their winding tracks at the edges of a small pond, a spider spinning its web, glistening mushrooms in grass or beneath a bush. If you listen carefully, you may hear creatures you don't see: insects humming, birds calling in the distance, perhaps a frog croaking. But these are only the obvious organisms. Countless tiny ones, most too small to be seen with the naked eye, swim in the puddles left by last night's rain. A whole community of microscopic living things thrive in the soil. And living on, in and around all these organisms, and the humans observing them, are billions of bacteria——simple, single-celled organisms that have survived nearly unchanged for billions of years.

Levels of Organization of Matter on Earth

Subatomic Particle	Particles that make up an atom
Atom	The smallest part of an element that retains the properties of that element
Molecule	A combination of atoms
Organelle	A structure within a cell that performs a specific function
Cell	The smallest unit of life
Tissue	A group of similar cells that perform a specific function
Organ	A structure within an organism usually composed of several tissue types that form a functional unit
Organ System	Two or more organs working together in the execution of a specific bodily function
Multicellular Organism	An individual living thing composed of many cells
Species	Very similar, potentially interbreeding organisms
Population	Members of one species inhabiting the same area
Community	Two or more populations of different species living and interacting in the same area
Ecosystem	A community together with its nonliving surroundings
Biosphere	That part of Earth inhabited by living organisms; includes both the living and nonliving components

The Characteristics of Living Things

Life is a fundamentally intangible quality that defies any simple definition. We can, however, describe some of the characteristics of living things that, taken together, are not shared by nonliving objects. These characteristics are as follows.

1. Living things have a complex, organized structure based on organic (carbon - based) molecules.

Even the tiny waterflea contains dozens of different elements linked together in thousands of specific combinations that are further organized into ever larger and more complex assemblies to form structures such as eyes, legs, a digestive tract, and a brain.

Life on earth is composed of a hierarchy of structures, with each level of the hierarchy based on the level below it and providing the foundation for the one above it.

All of life is built on a chemical foundation, based on elements, each of which is a unique type of matter, atoms may combine in specific ways to form assemblies called molecules.

Although many simple molecules form spontaneously, extremely large and complex molecules are manufactured only by living things. The bodies of living things are composed primarily of complex molecules. The molecules of life, which are based on carbon, are called organic molecules.

All the organ systems functioning cooperatively make up an individual living thing, the organism.

2. Living things acquire materials and energy from their environment and convert them into different forms.

Organisms need materials and energy to maintain their high level of complexity and organization, to grow, and to reproduce. The atoms and molecules of which all organisms are made may be acquired from the air, water, soil or from other living things. Organisms extract these materials, called nutrients, from the environment and incorporate them into the molecules of their own bodies. The sum total of all the chemical reactions needed to sustain life is called metabolism.

3. Living things actively maintain their complex structure and their internal environment, a process called homeostasis.

Maintaining homeostasis is accomplished by a variety of automatic mechanisms; in the case of temperature regulation these include sweating during hot weather, metabolizing more food when it's cold, and behaviors such as basking in the sun or even (for modern humans) adjusting the thermostat in the room.

4. Growth is a property of all living organisms.

At some time in its life cycle, every living thing becomes larger, that is, it grows. This feature is obvious for plants, birds, and animals, all of which start out very small and undergo tremendous growth during their lives. Even single - celled bacteria are small when they are first formed and grow to about double their orginal size before they divide. In all cases, growth involves the conversion of materials acquired from the environment into the specific molecules of the organism's own body.

5. Living things respond to stimuli from their environment.

Living organisms perceive and respond to stumuli in their internal and external environments. Animals have evolved elaborate sensory organs and muscular systems that allow them to detect and respond to light, sound, chemicals, and many other stimuli from their surroundings. Internal stimuli are perceived by receptors for stretch, pain, and various chemicals.

6. Living things reproduce themselves, using a molecular blueprint called DNA.

The continuity of life occurs because organisms reproduce, giving rise to offspring of the same type. The processes for producing offspring are varied, but as a result, the perpetuation of the parents' genetic material is the same. The diversity of life occurs in part because the offspring, though arising from the genetic material provided by the parents, are usually somewhat different from their parents.

7. DNA is the molecule of heredity.

When an organism reproduces, it passes a copy a its DNA to its offspring. The accuracy of the DNA copying process is astonishingly high but chance accidents to the genetic material also bring about changes in the DNA. The occasional errors and accidental changes, called mutations, are crucial. Without mutations, all life forms might be identical.

8. Living things, taken as a whole, have the capacity to evolve.

Although the genetic makeup of a single organism remains essentially the same over its lifetime, the genetic composition of a species as a whole changes over many lifetimes. Over time, mutations and variable offspring provide diversity in genetic material of species. In other words, the species evolves. The most important force in evolution is natural selection, the process by which organisms with adaptive traits survive and reproduce more successfully than to others that lack those traits. The adaptive traits arising from genetic mutation that enhance survival are thereby passed on to the next generation.

The Diversity of Life

Although all living things share the general characteristics, evolution has brought forth an amazing variety of life forms. Living organisms can be grouped into five major categories, called kingdoms: Monera, Protista, Fungi, Plantae, and Animalia. Some features used to classify organisms into kingdoms are type of cell the organism possesses, the number of cells in each organism, and the mode of acquiring energy.

Biology: The science of life

Biology is based on the scientific principles of natural causality, uniformity in space and time, and common perception. These principles are assumptions that can not be directly proved but that are validated by experience. Knowledge in biology is acquired through the application of the scientific method. First, on observation is made. Then a hypothesis is formulated that suggests a natural cause for the observation. The hypothesis is used to predict the outcome of further observations or experiments. A conclusion is then drawn about the validity of the hypothesis. A hypothesis becomes a scientific theory when repeated tests have confirmed it and none have refuted it.

Biology was coined by Lamarck in 1802. The branch of science dealing with properties and interactions of physico – chemical systems of sufficient complexity for the term living (or 'dead') to be applied. These are usually cellular or acellular in organization; but since viruses share some of the same properties and are parasitic, they are regarded as biological systems but not usually as organisms.

Glossary and Explanation

community [kə'mju:niti] 群落

all the populations of different kinds of organisms living in the place

hierarchy ['haiəra:ki] 阶层系统

a ranking system

homeostasis [ˌhəumiə'steisis] 内环境稳定

the maintenance of relatively constant environment required for optimal functioning of cells or organisms, maintained by the coordinated activity of numerous regulatory mechanisms, including the respiratory, endocrine, circulatory, and excretory systems.

stimulus ['stimjuləs] (pl) stimuli ['stimjulai] 刺激(物)

something in the environment detected by a receptor

receptor [ri'septə] 受体,感受器

(1)a cell that responds to an environmental stimulus (chemical, sound, light, pH, etc) by changing its electrical potential; (2)a protein molecule in a cell membrane that binds to another molecule (hormone, neurotransmitter) triggering metabolic or electrical changes in a cell

offspring ['ɔfˌspriŋ] 后代

child, children; young of animals

perpetuation [pəˌpetʃu'eiʃn] 永存,持续

causing (sth) to continue

diversity [dai'və:səti] 多样性

variety

heredity [hi'rediti] 遗传

tendency of living things to pass their characteristics on to offspring etc.

mutation [mju(:)'teiʃən] 突变

in the broad sense, any discontinuous change in the genetic constitution of an organism. In the narrow sense, the word usually refers to a " point mutation", a change along a very narrow portion of the nucleic acid sequence

evolution [i:vəlju:ʃən] 进化

gradual development of the characteristics of plants and animals over many generations, esp. the development of more complicated forms from earlier, simpler forms

natural selection [nætʃərəl si'lekʃən] 自然选择

the unequal survival and reproduction of organisms due to environmental forces, resulting in the preservation of favorable adaptation. Usually, natural selection refers specifically to differential survival and reproduction based on genetic differences among individuals

kingdom ['kiŋdəm] 动(植)物界

the broadest taxonomic category consisting of phyla or divisions. We recognize five kingdoms in this text: Monera, Protista, Fungi, Plantae, and Animalia

Monera [mə'nirə] 原核生物界

a taxonomic kingdom consisting of unicellular prokaryotic organisms, including bacteria, archaebacteria, and cyanobacteria

Protista ['prəutistə] 原生生物界

a taxonomic kingdom including unicellular, eukaryotic organisms

fungus [fʌŋgəs] (**pl**) **fungi** [ˈfʌŋgai] 真菌

any of various types of life growing on plants or decaying matter

Plantae [ˈplænˌti] 植物界

kingdom comprising eukaryotic organisms (mostly autotrophs) usually with an embryonic stage and clearly defined cellulose-containing cell walls

Animalia [ænəˈmeiljə] 动物界

animal kingdom containing those heterotrophic eukaryotes lacking cell wall material and having a blastula stage in their development

natural causality [ˈnætʃərəl kɔːˈzæliti] 自然诱发

the scientific principle that natural events occur as a result of preceding natural causes

uniformity [ˌjuːniˈfɔmiti] 均生性

in ecology, the tendency of the component species of an association to be evenly distributed within it

perception [pəˈsepʃən] 知觉

the mental interpretation of physical sensation produced by stimuli

Unit 2

From Molecules to Cells

In the world, all matter, including the living things and the non - living things, is composed of molecules.

§ 1 Matter

Matter is the physical material of the universe. Energy is the capacity to do work. Energy can exist in several forms that may be converted from one to another. The two major forms of energy are kinetic energy and potential energy.

The Structure of Matter

An element is a substance that can neither be broken down nor converted to different substances by ordinary chemical means. The smallest possible particle of an element is the atom, which is itself composed of a central nucleus containing protons and neutrons and outer electron shells. All atoms of a given element have the same number of protons, which is different from the number found in the atoms of any other element.

A compound is a substance composed of precise proportion of two more elements, joined together in a specific geometric pattern. Water, for example, consists of one part oxygen and two parts hydrogen in a precise arrangement.

A mixture is composed of two or more compounds or elements in variable proportions. For example, a can of soda is a mixture that contains, among other things, water, sugar and variable amounts of carbon dioxide, depending on how long ago you popped open the top.

Table 1 shows the main elements in the living organisms. In comparison with the elements exsiting in nature, it can be suggested that the elements in the living things are from nature.

Biological Molecule Bonding

Chemical bonds: Joining atoms to make molecules

Atoms combine together to form molecules by chemical bonds. There are two principal types of chemical bonds. called ionic and covalent bonds. When one atom fills its outer. Most shell by acquiring electrons while another atom empties its shell by losing electrons, the results are negatively and positively charged particles called ions. Ionic bonds are electrical attractions between charged ions, holding them together in crystals.

Covalent bonds involve the sharing of electrons by two atoms, in which neither atom completely gains or loses an electron. In a nonpolar covalent bond, the two atoms share electrons equally. In a polar covalent bond, one atom may attract the electron more strongly than the other atom does; in this case, the strongly attracting atom bears a slightly negative charge, and the weakly attracting atom bears a slightly positive charge. Some polar covalent bonds give rise to hydrogen bonding, which is the attraction between charged regions of individual polar covalent bonds give rise to hydrogen bonding, which is the attraction between charged regions of individual polar molecules or distant parts of a large polar molecule.

Table 2 summarizes bonding patterns and functions of biological molecules. The atoms in most biological molecules are joined by covalent bonds. Hydrogen, carbon, oxygen, nitrogen, phosphorus, and sulfur are the most common atoms found in biological molecules. Except for hydrogen, each of these atoms lacks two or more electrons to fill its outermost electron shell and can share electrons with two or more other atoms. Hydrogen can share electrons with two or more other atoms. Hydrogen can form a covalent bond with one other atom, oxygen and sulfur with two, nitrogen with three, and phosphorus and carbon with up to four other atoms. This diversity of bonding arrangements permits biological molecules to be constructed in almost infinite variety and complexity.

Table 1 Common Elements Important in Living Organisms

Element	Symbol	Atomic number	Percent in universe	Percent in earth	Percent in human body
Hydrogen	H	1	91	0.14	9.5
Helium	He	2	9	Trace	Trace
Carbon	C	6	0.02	0.03	18.5
Nitrogen	N	7	0.04	Trace	3.3
Oxygen	O	8	0.06	47	65
Sodium	Na	11	Trace	2.8	0.2
Magnesium	Mg	12	Trace	2.1	0.1
Phosphorus	P	15	Trace	0.07	1
Sulfur	S	16	Trace	0.03	0.3
Chlorine	Cl	17	Trace	0.01	0.2
Potassium	K	19	Trace	2.6	0.4
Calcium	Ca	20	Trace	3.6	1.5
Iron	Fe	26	Trace	5	Trace

Table 2 Binding Patterns of Biological Molecules

Atom	Capacity of outer electron shell	Electrons in outer shell	Number of covalent bonds usually formed
Hydrogen	2	1	1
Carbon	8	4	4
Nitrogen	8	5	3
Oxygen	8	6	2
Phosphorus	8	5	5
Sulfur	8	6	2

The organic molecules are the molecules which are composed of carbon and hydrogen. Most organic molecules are large with complex structures. Inorganic molecules include carbon dioxide and all molecules without carbon.

It's usually said that organic molecules comprise living organisms. However, many inorganic molecules are important to living organisms, including, for instance, minerals in the soil and carbon dioxide in the air which are the raw materials that plants use to construct their bodies. One inorganic molecule, however, is extraordinarily abundant on Earth, has unusual properties, and is so essential to life that it merits special consideration. That molecule is water.

Water and Life

Properties of the water molecule that are important to the processes that occur within living organisms include its ability to dissolve many polar and charged substances. To force nonpolar substances to assume certain types of physical organization, to participate in chemical reactions, to maintain fairly stable temperatures in the face of wide temperature fluctuations in the environment, and to cohere to itself.

§ 2 Nucleic Acids

Nucleic acid molecules are chains of nucleotides. Each nucleotide is composed of a phosphate group, a sugar group, and a nitrogen - containing base. Two types of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Other nucleotides include intracellular messengers (cAMP, cGMP), energy - carrier molecule (ATP), and coenzymes.

Nucleic acids are long chains composed of nucleotides. All nucleotides have a three - part structure: a five - carbon sugar (ribose of deoxyribose), a phosphate group, and a nitrogen - containing base that differs among nucleotides.

DNA

Deoxyribose nucleotides form chains millions of units long called deoxyribonucleic acid or DNA. DNA is found in the chromosomes of all living things, and its sequence of nucleotides spells out the genetic information needed to construct the proteins of each organism. DNA is composed of just four kinds of subunits, called nucleotides, strung together in a long chain. Each nucleotide consists of three parts: a phosphate group; deoxyribose, a five - carbon sugar; and a nitrogen - containing base.

Biochemists have assigned numbers to the carbon and nitrogen atoms that make up the skeletons of the sugar and the base (the numbers for the sugar are given as 1' ["one prime"], 2', etc., to distinguish them from the numbers for the base).

The four different DNA nucleotides have the same phosphate and sugar but different bases. The bases come in two types: pyrimidines, thymine (abbreviated T) and cytosine (C), which consist of a single ring; and the two - ringed purines, adenine (A) and guanine (G):

In a single strand of DNA, the phosphate group of one nucleotide bonds to the sugar of another. This arrangement forms a long strand consisting of a "backbone" of sugars and phosphates, with the bases protruding from the backbone. Four features summarize the molecular architecture of DNA. The DNA molecule is (1) a double - stranded helix, (2) of uniform diameter, (3) that twists to the right (that is, twists in the same direction as the threads on most screws), and (4) with the two strands running in opposite directions. The sugar - phosphate backbones of the polynucleotide chains coil around the outside of the helix, and the nitrogenous bases point toward the center. The two chains are held together by hydrogen bonding between specifically paired bases.

Consistent with Chargaff's studies, adenine (A) pairs with thymine (T) by forming two hydrogen bonds, and guanine (G) pairs with cytosine (C) by forming three hydrogen bonds. Every base pair consists of one purine (A or G) and one pyrimidine (C or T). Because the AT and GC pairs, like rungs of a ladder, are of equal length and fit identically into the double helix, the diameter of the helix is uniform. The center of the molecule is stabilized by hydrophobic interactions, contributing to the overall stability of the double helix.

What does it mean to say that the two DNA strands run in opposite directions? The direction of a polynucleotide can be defined by looking at the linkages between adjacent nucleotides. In the sugar - phosphate backbone of DNA, the phosphate groups connect to the 3' carbon of one deoxyribose, ribose molecule and the 5' carbon of the next, linking successive sugars together. The prime (') designates the position of a carbon atom in the 5 - carbon sugar, deoxyribose, in each nucleotide in DNA.

RNA

Chains of ribose nucleotides, called ribonucleic acid, or RNA, are copied from the central repository of DNA in the nucleus of each cell. RNA carries DNA's genetic code into the cytoplasm and directs the synthesis of proteins.

All RNA molecules are synthesized using molecules of DNA as a template. As we saw earlier in this chapter, RNA nucleotides are chemically very similar to DNA nucleotides. Because the two "languages" are so much alike, RNA synthesis has been named transcription, meaning "the process of copying over."

RNA is similar to DNA but differs in three respects: (1) RNA is usually single stranded; (2) RNA has a different type of sugar in its backbone – ribose instead of deoxyribose; and (3) the base thymine in DNA is replaced by uracil in RNA.

Base in DNA	Base in RNA
adenine	uracil
cytosine	guanine
guanine	cytosine
thymine	adenine

According to RNA function, RNA can be divided into three classes.

mRNA: Messenger RNA (mRNA) carries the code for the amino acid sequences of proteins from the genes in DNA to the ribosomes, the actual sites of protein synthesis. In contrast, ribosomal RNA (rRNA) and transfer RNA (tRNA) do not carry information to be translated into protein. Instead, these RNA molecules are the final products of certain genes and thus are an exception to the generalization that genes code for proteins.

Messenger RNA is a long, single - stranded molecule that includes the codons that will be translated into the amino acid sequence of a protein. In prokaryotes, mRNA is directly transcribed from the DNA of a gene, and translation into proteins often begins even before transcription is complete. In eukaryotes, things are a bit more complicated because the RNA transcribed from DNA contains more nucleotides than will ultimately be translated into protein. We will examine the formation of eukaryotic mRNA in more detail a bit later in this chapter.

In eukaryotic cells mRNA molecules are synthesized in the nucleus and enter the cytoplasm through the pores in the nuclear envelope. In the cytoplasm, mRNA binds to ribosomes, where the codons of mRNA are translated into the language of amino acids in proteins. You might think of mRNA as a "molecular photocopy" of the DNA of the gene. The gene itself remains safely stored in the nucleus, like a valuable document in a library, while copies are sent to the cytoplasm to be used in protein synthesis.

rRNA: Ribosomes are composites of ribosomal RNA and a variety of proteins. Each rixbosome is composed of two subunits. In eukaryotic cells, the small subunit consists of one molecule of rRNA and about 30 proteins. It recognizes and binds mRNA and part of tRNA. The large ribosomal subunit consists of three rRNA molecules, that is, 23s rRNA, 18s rRNA and 5s rRNA.

tRNA: Transfer RNA molecules bind amino acids and deliver them to the ribosome, where they are incorporated into a protein chain. A tRNA molecule is small, consisting of only about 75 to 80 nucleotides. At the 3' end of every tRNA molecule is a site to which the amino acid attaches. At about the midpoint is a group of three bases, called the anticodon, that constitutes the point of contact with mRNA. At contact, the tRNA and mRNA are antiparallel to each other. Each tRNA species has a unique anticodon, allowing it to unite by complementary base pairing with a particular condon. Complementary base pairing is what enables translation to be so specific.