МІНІСТЕРСТВО ОСВІТИ І НАУКИ,
МОЛОДІ ТА СПОРТУ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ
імені В. Н. КАРАЗІНА

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ENGLISH FOR STUDENTS OF BIOLOGICAL DEPARTMENTS

Навчальний посібник

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Дані навчальні матеріали призначені для студентів І курсу біологічного факультету університету. У посібнику подані оригінальні тексти та вправи до них, які спрямовані на закріплення лексичного та граматичного матеріалу. Структура посібника дозволяє обрати оптимальні способи організації роботи для ефективного засвоєння матеріалу та аналітичної обробки інформації.

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INTRODUCTORY LESSON 1. BIOLOGY

Wordbuilding: suffixes -er, -or; -ist, -ian
Grammar:
I. The verbs "to be", "to have"
II. There is (are)
III. The possessive case of the nouns
Text A: Biology
Text B: The Main Branches of Biology

WORDBUILDING

v → n -or, -er: occupation *to drive – driver, to report – reporter*
to act – actor, to visit – visitor
things *to mix – mixer, to react – reactor*

I. Make nouns from the following verbs and translate them into Ukrainian:

to lead, to write, to read, to visit, to speak, to sleep, to act, to direct, to conduct, to drive, to fight, to mine, to report, to sing, to skate, to swim, to teach, to travel, to sail, to invent, to found, to compose.

n + -ist, -ian = n: *biology – biologist, chemistry – chemist*
library – librarian, Ukraine – Ukrainian

II. Make nouns with the help of suffixes - ist, -ian and translate them into Ukrainian:

special, social, art, capital, economy, botany, Italy, science, physics, technic, mathematics, statistics, politics, music, electric, Russia, Hungary, Canada, India.

PRE-TEXT EXERCISES:

I. Read and memorize the following words:

science	наука	branch	галузь
discovery	відкриття	to divide	розділяти
difference	відмінність	likeness	схожість
important	важливий	resemblance	подібність
property	властивість	unit	одиниця
certain	певний	vital	життєвий
manner	спосіб	respiration	дихання
digestion	травлення	assimilation	асиміляція
growth	ріст	reproduction	розмноження
moderate	помірний	amount	кількість
heat	тепло	external	зовнішній
size	розмір	shape	форма

structure	структура	function	функція
namely	а саме	chemical	хімічний
conscious	свідомий	although	хоча

II. Read the text and do the exercises that follow it.

BIOLOGY

Biology is the science of life. People who study the secrets of living organisms are called biologists. Their discoveries are of great value to all mankind.

Biology is the study of living things. When we study them, we learn the relations of plants and animals to one another, with the world about them and how we can control them. We can divide biology into two branches – botany and zoology. Both animal and plant life have great differences and likenesses between them.

Their important points of resemblance are: 1) Protoplasm is the basic material of all living systems and its general properties are fundamentally the same in each system both in plants and animals. 2) The living matter is organized in both plants and animals into microscopic units called cells. 3) Certain vital processes take place in plant bodies in the same manner as in animal bodies. These processes are respiration, digestion, assimilation, growth and reproduction. 4) They both cannot live without water, air, food, light and moderate amount of heat.

In external appearance, plants are usually green. Some plants have varied and colourful flowers and others have no apparent blossoms. Among animals there is a great variety of sizes, shapes and colours. The basic difference between plants and animals lies in the unit of structure and function of each, namely, the cell. Plant cells have a cell wall which is actually non-living in chemical nature. Animal cells do not have this.

In fact, the differences are not so many as the likenesses, although they are more apparent. There are three important differences, namely: 1) plants are not conscious; 2) they are unable to move about; 3) they make their own food.

Notes to the texts:

to be of great value – мати велику цінність

both … and – як …, так і …
a great variety of – велика кількість

III. Answer the following questions to check how carefully you have read the text:

1. What is biology? 2. How do we call people who study the secrets of living organisms? 3. What do we find out when we study living thinks? 4. How many branches are there in biology? What are they? 5. What vital processes take place in plant and animal bodies? 6. What is the basic difference between plants and animals? 7. Are plants or animals conscious?

VOCABULARY EXERCISES

I. Choose the synonyms of the following words from the right hand column. Translate them:

to control, resemblance, discovery, mankind, branch, basic, property, unit, manner, certain, amount, appearance, varied, shape	specific, humanity, item, find, division, likeness, way, to regulate, feature, fundamental, look, quantity, form, diverse

II. Choose the antonyms of the following words from the right hand column. Translate them:

external, important, microscopic, same, to divide, difference, vital, apparent	likeness, inessential, insignificant, hidden, to join, internal, enormous, different, hidden

III. Translate the following sentences into Ukrainian using the words from the text:

1. I like both of these plants. 2. I like both the flowers and the leaves of this plant. 3. Both functions of this organ are important. 4. Both water and air are necessary for the living organisms. 5. General properties of protoplasm are the same both in plans and animals. 6. Both plants and animals cannot live without water. 7. Both these plants are of the same shape and size.

IV. Translate the following sentences into English using the words from the text:

1. Результати досліджень біологів мають велике значення для розвитку багатьох галузей науки.
2. Досліджень біологів допомагають зрозуміти взаємозв’язок між усіма організмами та оточуючим середовищем.
3. Біологія вивчає життєві процеси як у тварин, так і у рослин.
4. Як рослини, так і тварини мають однакові життєві процеси, а саме: дихання, травлення, ріст та розмноження.

5. Існує два підрозділи біології – ботаніка та зоологія.

V. Retell the text "Biology" using the questions after it as a plan.

VI. Read the text using a dictionary and tell your partner what branch you are interested in and why:

The Main Branches of Biology

These are the main branches of biology, a natural science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy:

- Aerobiology – the study of airborne organic particles.
- Agriculture – the study of producing crops from the land, with an emphasis on practical applications.
- Anatomy – the study of form and function, in plants, animals, and other organisms, or specifically in humans.
- Arachnology – the study of arachnids.
- Astrobiology – the study of evolution, distribution, and future of life in the universe—also known as exobiology, exopaleontology, and bioastronomy.
- Biochemistry – the study of the chemical reactions required for life to exist and function, usually a focus on the cellular level.
- Bioengineering – the study of biology through the means of engineering with an emphasis on applied knowledge and especially related to biotechnology.
- Biogeography – the study of the distribution of species spatially and temporally.
- Bioinformatics – the use of information technology for the study, collection, and storage of genomic and other biological data.
- Biomathematics (or Mathematical biology) – the quantitative or mathematical study of biological processes, with an emphasis on modeling.
- Biomechanics – often considered a branch of medicine, the study of the mechanics of living beings, with an emphasis on applied use through prosthetics or orthotics.
- Biomedical research – the study of the human body in health and disease.
- Biomusicology - study of music from a biological point of view.
- Biophysics – the study of biological processes through physics, by applying the theories and methods traditionally used in the physical sciences.
- Biotechnology – a new and sometimes controversial branch of biology that studies the manipulation of living matter, including genetic modification and synthetic biology.
- Building biology – the study of the indoor living environment.
- Botany – the study of plants.
- Cell biology – the study of the cell as a complete unit, and the molecular and chemical interactions that occur within a living cell.

- Conservation biology – the study of the preservation, protection, or restoration of the natural environment, natural ecosystems, vegetation, and wildlife.
- Cryobiology – the study of the effects of lower than normally preferred temperatures on living beings.
- Developmental biology – the study of the processes through which an organism forms, from zygote to full structure.
- Ecology – the study of the interactions of living organisms with one another and with the non-living elements of their environment.
- Embryology – the study of the development of embryo (from fecundation to birth).
- Entomology – the study of insects.
- Environmental biology – the study of the natural world, as a whole or in a particular area, especially as affected by human activity.
- Epidemiology – a major component of public health research, studying factors affecting the health of populations.
- Epigenetics – the study of heritable changes in gene expression or cellular phenotype caused by mechanisms other than changes in the underlying DNA sequence.
- Ethology – the study of animal behavior.
- Evolutionary biology – the study of the origin and descent of species over time.
- Genetics – the study of genes and heredity.
- Hematology (also known as Haematology) - the study of blood and blood - forming organs.
- Herpetology – the study of reptiles and amphibians.
- Histology – the study of cells and tissues, a microscopic branch of anatomy.
- Ichthyology – the study of fish.
- Integrative biology – the study of whole organisms.
- Limnology – the study of inland waters.
- Mammalogy – the study of mammals.
- Marine biology (or Biological oceanography) – the study of ocean ecosystems, plants, animals, and other living beings.
- Microbiology – the study of microscopic organisms (microorganisms) and their interactions with other living things.
- Molecular biology – the study of biology and biological functions at the molecular level, some cross over with biochemistry.
- Mycology – the study of fungi.
- Neurobiology – the study of the nervous system, including anatomy, physiology and pathology.
- Oncology – the study of cancer processes, including virus or mutation oncogenesis, angiogenesis and tissues remoldings.
- Ornithology – the study of birds.
- Population biology – the study of groups of conspecific organisms, including.
    - Population ecology – the study of how population dynamics and extinction.

- Population genetics – the study of changes in gene frequencies in populations of organisms.

- Paleontology – the study of fossils and sometimes geographic evidence of prehistoric life.
- Pathobiology or pathology – the study of diseases, and the causes, processes, nature, and development of disease.
- Parasitology – the study of parasites and parasitism.
- Pharmacology – the study and practical application of preparation, use, and effects of drugs and synthetic medicines.
- Physiology – the study of the functioning of living organisms and the organs and parts of living organisms.
- Phytopathology – the study of plant diseases (also called Plant Pathology).
- Psychobiology – the study of the biological bases of psychology.
- Sociobiology – the study of the biological bases of sociology.
- Structural biology – a branch of molecular biology, biochemistry, and biophysics concerned with the molecular structure of biological macromolecules.
- Synthetic Biology- research integrating biology and engineering; construction of biological functions not found in nature.
- Virology – the study of viruses and some other virus-like agents.
- Zoology – the study of animals, including classification, physiology, development, and behavior (branches include: Entomology, Ethology, Herpetology, Ichthyology, Mammalogy, and Ornithology).

VII. Compose short dialogues for the following imaginary situations:

1. Your friend studies at the faculty of Chemistry. He/she urges you to transfer to this faculty. Reject his/her proposal and tell him/her that biology is your dream.
2. Students of various faculties meet at a touristic camp. Everybody speaks about the importance of the science he/she studies. Prove that biology is the most vital of all the sciences.
3. One of your friends believes that only animals are living organisms, another one thinks that both animals and plants are alive with no difference whatsoever. Are they right? Why? Discuss the ways in which living things differ from lifeless objects.

GRAMMAR EXERCISES

I. Complete the sentences using a positive, negative or question form of the verb *to be*:

1. It _____ a very cold day today.
2. They _____ very happy at the hotel. It's lovely and cheap.
3. He _____ from Paris. He is from Warsaw.
4. _____ the shops next to the hotel?
5. We _____ in the café between the library and the post office.

6. _____ Istanbul a big city?
7. I _____ very happy in London. It's very dirty.
8. The cars _____ cheap. They are expensive.
9. _____ Brazil in South America?
10. The bank _____ opposite the post office. It's opposite the university.

II. Write the correct form of the verb *to be*. Translate the sentences:

1. Where (to be) Lisa and John? – They (to be) at the university. 2. You (to be) busy? - No, I (to be) not. 3. It (to be) twelve o'clock. He (to be) late for the test. 4. Mary (to be) afraid of snakes. 5. They (to be) interested in biology. 6. The game (to be) not worth the candle. 7. Two heads (to be) better than one. 8. You (to be) right. That (to be) a lot of money! 9. Coffee (to be) really very expensive in this country. 10. We (to be) fond of genetics. 11. My knowledge of German (to be) very limited. 12. The news (to be) too good to be true.

III. Choose the right answer. Translate the sentences:

1. *There is/ There are* some milk in my coffee. 2. *There is/ There are* no interesting stories in that book. 3. *There is/ There are* some bread in the kitchen. 4. *There is/ There are* ten desks in the classroom. 5. *There is/ There are* two supermarkets in this street. 6. *There is/ There are* a present for you. 7. *There is/ There are* some mistakes in your homework. 8. *There is/ There are* a lot of snow outdoors. 9. *There is/ There are* tomatoes and cucumbers in this salad. 10. *There is/ There are* not any water in the glass.

IV. Ask questions to the words *in italics*:

1. There's *a nice lake* near our town. 2. There are *20 copybooks* in our bag. 3. There are some *new words* in this text. 4. There are *lots of* cars on the road. 5. There are *no* mistakes in my homework. 6. There's *a big supermarket* near here. 7. There are *three bedrooms* in our house.

V. Make sentences; choose the correct form of the verb *to have*:

1. He /have got/ some cards in his bag. 2. These girls /have got/ the key. 3. You /have got/ money? 4. Tom and Mary /have got/ a lot of friends. 5. Natalie /have got/ a sandwich and a cup of tea for breakfast. 6. Their cat /have got/ six kittens. 7. France /have got/ mountains and forests. 8. She /have got/ grandparents? 9. We /have got/ free time today? 10. Andrew /have got/ sweets? 11. They /have got/ pictures of whales? 12. You /have got/ friends?

VI. Translate the sentences; mind the Possessive Case of the Nouns:

1. Mr. Smith's children are at the university, they study biophysics. 2. My friend's sister is a laboratory assistant. 3. What is the Browns' telephone number? 4. Are you our lecturer's son? 5. I don't know my teachers' addresses. 6. Educational establishments of all kinds, including colleges and universities, have approximately one fourth of this country's population. 7. Do you know my brothers' wives? 8. There are many problems in today's world.

VII. Replace the of-phrase by the noun in the possessive case:

1. The friend of my mother. 2. The speech of the President. 3. The farm of old McDonald. 4. The novels by D. Steel. 5. The hobbies of the children. 6. The poems by Burns. 7. The duties of a man. 8. A conference of doctors. 9. The life of a bodyguard. 10. The policy of France. 11. The streets of London. 12. The bank of the river. 13. The rays of the sun. 14. The way of Nature. 15. The teas of India. 16. The history of the world. 17. The difficulties of the companies. 18. The crew of a ship. 19. The research of the students. 20. The experiment of the scientist.

Test your grammar:

1. What _____ in the glass of water?
   a) is there
   b) there is
   c) are there
   d) there are
2. _____ money Ann's or yours?
   a) these are
   b) are these
   c) this is
   d) is this
3. _____ the ticket to the next football match?
   a) has you got
   b) have you got
   c) you have got
   d) you has got
4. Who _____ at the fireplace?
   a) is there
   b) there is
   c) are there
   d) there are
5. This information _____ essential for us.
   a) is
   b) are
   c) have
   d) has
6. Is there much orange juice in the glass? – No, _____.
   a) there is
   b) thare isn't
   c) there are
   d) there aren't
7. The _____ was spacious and cozy.
   a) children room's
   b) children rooms'

c) children’s room
d) childrens’ room

8. _____ a nice view from her balcony?
a) she has got
b) has she got
c) she have got
d) have she got

9. Have his sons got money? – No, they _____.
a) has
b) hasn’t
c) have
d) haven’t

10. The _____ books are on the desk.
a) student
b) student’s
c) students
d) students’

UNIT 2. THE CELL

Wordbuilding: suffixes -able, -ible; -ful, -less
Grammar:
I. The plural forms of the noun
II. Pronouns. Indefinite pronouns (many/much; (a) little/(a) few)
III. Adjectives. Degrees of comparison
IV. The Indefinite Tenses (Active Voice)
Text A: The Cell
Text B: The Cell Theory

WORDBUILDING

v → adj -able *to understand – understandable*
-ible *to compress – compressible*

I. Make adjectives from the following verbs and translate them into Ukrainian:
to change, to convert, to prevent, to break, to compare, to desire, to profit, to read, to comfort, to respect, to expect, to rely, to move, to eat.

n → adj -ful *care – careful, meaning – meaningful*
-less *brain – brainless, weight – weightless*

II. Make adjectives with the help of suffixes -ful, -less and translate them into Ukrainian:
beauty, thank, hope, doubt, aim, use, shape, fruit, power, thought, harm, colour, event, help, taste, odour, water.

PRE-TEXT EXERCISES:

I. Read and memorize the following words and word combinations:

to generate	спричиняти	compound	сполука
to convert	перетворювати	to exist	існувати
Archaea	археї	Bacteria	бактерії
protists	найпростіші	fungi	гриби
vesicle	пухирець	energy	енергія
complex	складний	continuity	цілісність
semifluid	напіврідкий	jellylike	желеподібний
physical	фізичний	cytosol	цитозоль
detoxification	детоксикація	to contain	містити
solar	сонячний	to carry	містити (у собі)
particularly	дуже	prominent	помітний
tiny	крихітний	movement	рух
major	головний	poison	отрута

nucleoid	нуклеоїд	phospholipids	фосфоліпіди
term	термін	sac	мішечок
to absorb	поглинати	complexity	комплексність
a variety of	різноманіття	unique	незвичайний
disparity	відмінність	layer	шар, пласт
specialized	спеціальний	rate	відсоток
surprisingly	дивовижно	site	місце розташування

II. Read the following biological terms and international words. Translate them without a dictionary paying attention to the part of speech:

cell [sel] *n*, cellular [ˈseljʊlə] *adj*, unicellular [ˌjuːnɪˈseljʊlə] *adj*, prokaryote [prəʊˈkærɪəʊt] *n*, eukaryote [juːˈkærɪə(ʊ)t] *n*, domain [dəˈmeɪn] *n*, cytoplasm [ˈsaɪtəplæz(ə)m] *n*, oxygen [ˈɒksɪdʒ(ə)n] *n*, synthesis [ˈsɪnθəsɪs] *n*, photosynthesis [ˌfəʊtəʊˈsɪnθɪsɪs] *n*, lipid [ˈlɪpɪd] *n*, metabolism [məˈtæbəlɪz(ə)m] *n*, carbon [ˈkɑːbən] dioxide [daɪˈɒks(a)ɪd] *n*, substance [ˈsʌbstəns] *n*, organelle [ˌɔːgəˈnel] *n*, chromosome [ˈkrəʊməsəʊm] *n*, gene [dʒiːn] *n*, ribosome [ˈraɪbəsəʊm] *n*, protein [ˈprəʊtiːn] *n*, structural [ˈstrʌktʃ(ə)rəl] *adj*, functional [ˈfʌŋkʃ(ə)nəl] *adj*, plasma [ˈplæzmə] *n*, membrane [ˈmembreɪn] *n*, instruction [ɪnˈstrʌkʃ(ə)n] *n*.

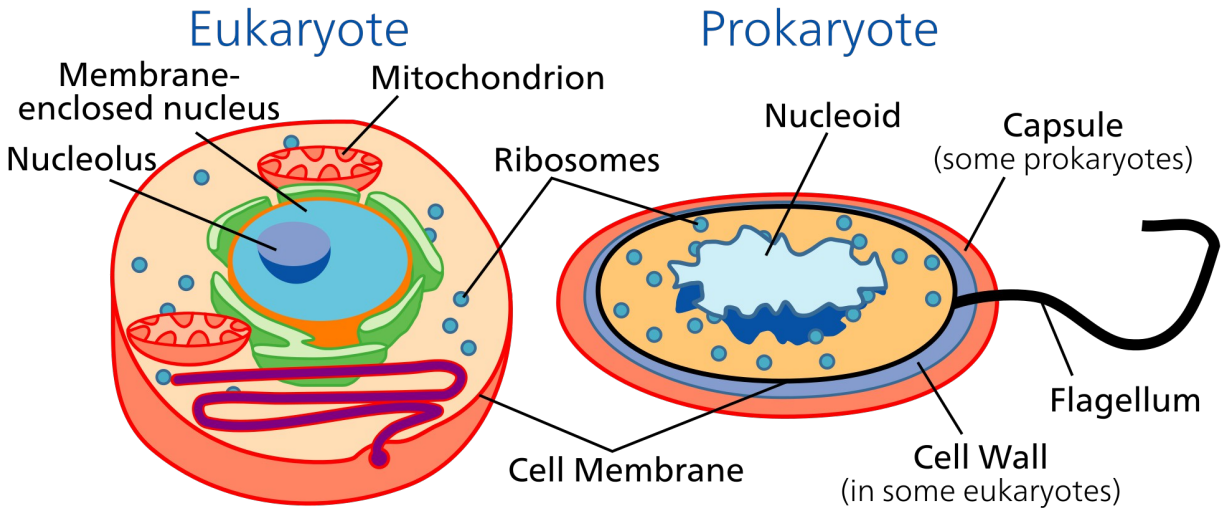
III. Pay attention to the formation of some plurals of Latin and Greek origin:

species [ˈspiːʃiːz] – species [ˈspiːʃiːz] – вид, рід, різновид
analysis [əˈnælɪsɪs] – analyses [əˈnælɪsiːz] – аналіз
nucleus [ˈnjuːk|lɪəs] – nuclei [ˈnjuːklɪaɪ] – ядро
nucleolus [njuːˈkliːələs] – nucleoli [njuːˈkliːəlaɪ] – ядерце
stimulus [ˈstɪmjʊləs] – stimuli [ˈstɪmjʊlaɪ] – стимул, подразник
genus [ˈdʒiːnəs] – genera [ˈdʒenərə] – рід, сорт, вид
phenomenon [fɪˈnɒmɪnən] – phenomena [fɪˈnɒmɪnə] – явище
datum [ˈdeɪtəm] – data [ˈdeɪtə,ˈdɑːtə] – дана величина
criterion [kraɪˈtɪ(ə)|rɪən] – criteria [kraɪˈtɪ(ə)rɪə] – критерій
hypothesis [haɪˈpɒθɪsɪs] – hypotheses [haɪˈpɒθɪsiːz] – гіпотеза
maximum [ˈmæksɪməm] – maxima [ˈmæksɪmə] – максимальне значення
alga [ˈælgə] – algae [ˈældʒiː] – водорість
bacterium [hækˈtɪ(ə)rɪəm] – bacteria [bækˈtɪ(ə)rɪə] – бактерія
medium [ˈmiːdɪəm] – media [ˈmiːdɪə] – середовище
stoma [ˈstəʊmə] – stomata [ˈstəʊmətə] – устячко
bacillus [bəˈsɪləs] – bacilli [bəˈsɪlaɪ] – бацила, паличка
fungus [ˈfʌŋ|gəs] – fungi [ˈfʌŋg(a)ɪ] – гриб, грибок
mitochondrion [ˌmaɪtəʊˈkɒndrɪən] – mitochondria [ˌmaɪtəʊˈkɒndrɪə] – мітохондрія
cactus [ˈkæktəs] – cacti [ˈkæktaɪ] – кактус
flagellum [flə'dʒə|ləm] – flagella [flə'dʒelə] – джгутик; війка
cilium [ˈsɪlɪəm] – cilia [ˈsɪlɪə] – війка (епітелію); джгутик

IV. Read the text below using a dictionary where necessary.

The Cell

The basic structural and functional unit of every organism is one of two types of cells – prokaryotic or eukaryotic. Only organisms of the domains Bacteria and Archaea consist of prokaryotic cells. Protists, fungi, animals, and plants all consist of eukaryotic cells. Indeed, many forms of life exist as single-celled or unicellular organisms. More complex organisms, including plants and animals, are multicellular.



All cells have several basic features in common: they are all bounded by a selective barrier, called the plasma membrane. It is a semifluid, jellylike substance called cytosol which consists of organelles and other components. All cells contain chromosomes that carry genes in the form of DNA. And all cells have ribosomes, tiny complexes which make proteins according to instructions from the genes.

A major difference between prokaryotic and eukaryotic cells is the location of their DNA. In a eukaryotic cell, most of the DNA is in an organelle called the nucleus which is bounded by a double membrane. In a prokaryotic cell, the DNA is concentrated in a region that is not membrane-enclosed, called the nucleoid.

The interior of a prokaryotic cell is called the cytoplasm; this term is also used for the region between the nucleus and the plasma membrane of a eukaryotic cell. Within the cytoplasm of a eukaryotic cell, there is a variety of organelles of specialized form and function. These membrane-bounded structures are absent in prokaryotic cells. Thus, the presence or absence of a true nucleus is just one example of the disparity in structural complexity between the two types of cells.

Membranes are fundamental to the organization of the cell. In general, biological membranes consist of a double layer of phospholipids and other lipids. However, each type of membrane has a unique composition of lipids and proteins according to that membrane's specific functions.

Ribosomes, which are complexes made of ribosomal RNA and protein, are the cellular components that carry out protein synthesis. Cells that have high rates of protein synthesis have particularly large numbers of ribosomes. For instance, a

human pancreas cell has a few million ribosomes. Not surprisingly, cells active in protein synthesis also have prominent nucleoli.

Many of the different membranes of the eukaryotic cell are part of an endomembrane system, which carries out a variety of tasks in the cell. These tasks include synthesis of proteins and their transport into membranes and organelles or out of the cell, metabolism and movement of lipids, and detoxification of poisons. The membranes of this system are related either through direct physical continuity or by the transfer of membrane segments as tiny vesicles (sacs made of membrane).

In eukaryotic cells, mitochondria and chloroplasts are the organelles that convert energy to forms that cells can use for work. Mitochondria are the sites of cellular respiration, the metabolic process that generates ATP by extracting energy from sugars, fats, and other fuels with the help of oxygen. Chloroplasts, found in plants and algae, are the sites of photosynthesis. They convert solar energy to chemical energy by absorbing sunlight and using it to drive the synthesis of organic compounds such as sugars from carbon dioxide and water.

Notes to the texts:

DNA – abbreviation for deoxyribonucleic acid. DNA is the doublestranded molecule in the nucleus of all cells that contains genetic information / Дезоксирибонуклеїнова кислота (ДНК).

RNA – abbreviation for ribonucleic acid. RNA is similar to a single strand of DNA, and transfers information from the DNA in the nucleus out into the cell to make proteins / Рибонуклеїнова кислота (РНК).

ATP – abbreviation for adenosine triphosphate. ATP is a nucleoside triphosphate used in cells as a coenzyme / Аденозинтрифосфат (АТФ) або аденозинтрифосфорна кислота, аденілпірофосфорна кислота.

Either … or – або … або

V. Answer the following questions to check how carefully you have read the text:

1. What is the basic structural and functional unit of every organism? 2. How many types of cells are there? What are they? 3. What organisms consist of prokaryotic cells? 4. What organisms consist of eukaryotic cells? 5. What are the basic features of all cells? 6. What is a major difference between prokaryotic and eukaryotic cells? 7. What is the cytoplasm? 8. What do biological membranes consist of? 9. What are the cellular components that carry out protein synthesis? 10. What are the tasks of an endomembrane system in the cell? 11. What process do we call cellular respiration? 12. What role do chloroplasts play in plants and algae?

VOCABULARY EXERCISES

I. Translate the following words and word combinations into Ukrainian and use them in the sentences of your own:

to consist of; to include; unicellular/multicellular organisms; basic features; substance; to contain; to carry; according to; a major difference; location; a variety of tasks; to be absent; two types of cells; an example of the disparity; to have high rates; a few million; tiny; with the help of.

II. Choose the synonyms of the following words from the right hand column. Translate them:

unicellular, major, substance, location, rate, particularly, prominent, to convert	percentage, main, position, matter, multicellular, noticeable, especially, to turn

III. Choose the antonyms of the following words from the right hand column. Translate them:

complex, to contain, tiny, double, presence, unique, high, active, direct, to extract, to absorb	low, indirect, to insert, single, passive, common, to exude, enormous, absence, to exclude, easy

IV. Match the word (1-18) and its definition (a-r):

1. Ribosomes	**a.** A lipid made up of glycerol joined to two fatty acids and a phosphate group
2. Nucleolus	**b.** A macromolecule serving as a catalyst
3. Chromosomes	**c.** One of two prokaryotic domains, the other being Bacteria
4. Chloroplasts	**d.** The contents of the cell bounded by the plasma membrane; in eukaryotes, the portion exclusive of the nucleus
5. Mitochondria	**e.** Site of genes for rRNA synthesis
6. Nucleus	**f.** Small, complex assemblies of protein and RNA, often bound to endoplasmic reticulum
7. Archaea	**g.** Long threads of DNA that form a complex with protein
8. Eukaryotic cell	**h.** Bacteria-like elements with membranes containing chlorophyll, a photosynthetic pigment
9. Prokaryotic cell	**i.** The semifluid portion of the cytoplasm
10. Protist	**j.** The membrane at the boundary of every cell that acts as a selective barrier, regulating the cell's chemical composition
11. Organelle	**k.** A type of cell lacking a membrane-enclosed nucleus and membrane-enclosed organelles
12. Plasma membrane	**l.** The catabolic pathways of aerobic and anaerobic respiration, which break down organic molecules
13. Cytoplasm	**m.** Any of a group of large biological molecules,

	including fats, phospholipids, and steroids, that mix poorly, if at all, with water
14. Cytosol	**n.** Any of several membrane-enclosed structures with specialized functions, suspended in the cytosol of eukaryotic cells
15. Enzyme	**o.** Bacteria-like elements with double membrane
16. Cellular respiration	**p.** An informal term applied to any eukaryote that is not a plant, animal, or fungus
17. Phospholipid	**q.** Structure (usually spherical) surrounded by double membrane that contains chromosomes
18. Lipid	**r.** A type of cell with a membrane-enclosed nucleus and membrane-enclosed organelles

V. Put the words in the right order to make a sentence.

1. properties, a, The, unit, cell, is, tiny, that, essential, of, contains, life.
2. organelles, component, all, of, Membranes, are, an, almost, essential, cells.
3. that, Cytoplasm, different, a variety of, have, organelles, contains, functions.
4. essential, both, Nucleus, the, and, of, are, cytoplasm, the, organism, to, life.
5. chlorophyll, the, have, green, Scientists, that, know, algae.
6. bacteria, kinds, and, share, There, prokaryotes:, two, that, are, similar, of, archaea, a, structure.
7. plants, of, inorganic, and, contain, Bodies, animals, substances.
8. every, body, Certain, processes, take, in, place, vital, plant, season.
9. In, experiments, we, laboratories, different, carry out.
10. two, consists, Any, nucleus, ordinary, the, central, and, cell, of, – a, parts, cytoplasm.

VI. Translate the following text into English using the words from the text:

Клітина – елементарна жива система, яка складається з двох основних частин – цитоплазми та ядра. Вона є основою будови, розвитку життєдіяльності усіх тваринних та рослинних організмів. Клітинна будова є на різних рівнях організації живої природи. Таки чином, клітини, які складають тіло бактерій та простіших, є самостійними організмами; на відміну від цього, клітини, що входять до складу тканей багатоклітинних організмів, являють собою елементи, що повністю підкорені цілісному організму. Основний план будови тваринних та рослинних клітин схожий, проте останні відрізняються деякими особливими рисами.

VII. Retell the text "The Cell" using the questions after it as a plan.

VIII. Read the text using a dictionary and speak on it:

The Cell Theory

A general characteristic of cells is their microscopic size. Because cells are so small, no one observed them until scientists invented microscopes in the mid-seventeenth century. Robert Hooke first described cells in 1665, when he used a microscope that he had built to examine a thin slice of cork, a non-living tissue found in the bark of certain trees. Hooke observed a honeycomb of tiny, empty (because the cells were dead) compartments. He called the compartments in the cork *cellulae* (Latin, "small rooms"), and the term has come down to us as *cells*. A few years later the Dutch naturalist Antonie van Leeuwenhoek observed the first living cells and called the tiny organisms that he observed "animalcules," meaning little animals. For another century and a half, however, biologists failed to recognize the importance of cells. In 1838, botanist Matthias Schleiden made a careful study of plant tissues and developed the first statement of the cell theory. He stated that all plants "are aggregates of fully individualized, independent, separate beings, namely the cells themselves." In 1839, Theodor Schwann reported that all animal tissues also consist of individual cells.

The cell theory, in its modern form, includes the following three principles:

1. All organisms are composed of one or more cells, and the life processes of metabolism and heredity occur within these cells.

2. Cells are the smallest living things, the basic units of organization of all organisms.

3. Cells arise only by division of a previously existing cell. Although life likely evolved spontaneously in the environment of the early earth, biologists concluded that no additional cells are originating spontaneously at present. Rather, life on earth represents a continuous line of descent from those early cells.

Notes to the texts:

cork – кора пробкового дерева
tissue ['tɪʃu:, 'tɪsju:] – тканина
bark – кора
honeycomb ['hʌnɪkəʊm] – медові стільники

IX. Look through the text and decide whether the following sentences are true or false, correct the wrong ones:

1. A tiny size is a basic feature of all cells.
2. Robert Hooke was the first who examined cells.
3. The first attempt to state the cell theory was in the 18th century.
4. According to the modern version of the cell theory cells exist not in all organisms.
5. Tissues are the place where metabolism and heredity take place.
6. Nowadays cells appear voluntarily.

X. Put as many questions as possible to the text and be ready to answer them.

XI. Compose short dialogues for the following imaginary situations:

1. Your younger sister comes up to you and asks what a cell is. Explain her what it is.
2. Ask your friend if there is any difference between a green plant cell and an animal cell, and between a cell membrane and a cell wall. Discuss his/her answer.
3. Your friend says that the words “protoplasm” and “cytoplasm” are synonyms. Explain the difference and prove that.

GRAMMAR EXERCISES

I. Write the plural form of the following nouns. Translate them:

child, goose, wolf, phenomenon, fish, man, mouse, loaf, leaf, family, dress, tooth, fly, shelf, woman, tomato, match, glass, bush, nucleus.

II. Write the comparative and superlative degrees of adjectives. Translate them:

hot, expensive, deep, dirty, interesting, wet, brave, good, beautiful, thin, talented, busy, bad, pale, important, difficult, big, sharp, fat, heavy.

III. Complete the sentences using the comparative or superlative form of the adjectives given in brackets:

1. — Boris is certainly (clever) than his brother. — Yes, and he is (attractive) than his brother Peter. In fact, he is (smart) boy I’ve ever taught. 2. Nothing could be (extravagant) than buying such an expensive car. You will have to be (careful) with your money in future. 3. Life is getting (hard) and (complicated) with every passing day. 4. It is (effective) method of all, but it is naturally costly. 5. Stephen is (intelligent) than any other boy in his group. 6. It has been (cold) day in Moscow for thirty years. 7. It’s (little) I can do for you, I’m afraid. 8. That was (bad) than he had expected. 9. That was indeed (bad) experience in his career. 10. They naively think that things can only get (good). 11. This is (unbelievable) news I have ever heard. 12. He ate (few) French fries than you did at the picnic. 13. Angela is (little) organized than Mike. 14. If you ask me, Moscow is (beautiful) than any other city in the world. 15. They had (little) and (little) to talk about. 16. It is axiomatic that (great) the student’s individual effort, (much) thorough will be his learning. 17. The (much) original a discovery, the (much) obvious it seems afterwards.

IV. Translate the following sentences into Ukrainian bearing in mind the various meanings of the words in *italics*:

1. *The finer* is the soil, *the easier* will the roots penetrate into it. 2. *The longer* the days, *the shorter* the nights. 3. *The more* scientists learn about protoplasm, *the more* interesting is its further investigation. 4. *The longer* the man lives, *the more* he learns. 5. *The nearer* the temperature approaches the freezing point of water, *the less* biological activities will take place in the soil. 6. *The more* you read, *the better*. 7. *The sooner* we learn it, *the better* it will be for us.

V. Insert *(a) few, (a) little*:

1. Wait, I'll pick ___ roses for you from my garden. 2. ___ people could resist such a temptation. 3. The patient has made ___ progress in the last couple of weeks. 4. There is ___ progress in the business. We must take some measures to improve it. 5. – Could you give me ___ information on the trip? – There is ___ I can tell you, sir. It's out of the list. 6. Paul put ___ coins in the slot, thought ___, and then dialed the number. 7. Let's go to the market and buy ___ fruit and ___ carrots. 8. There is ___ furniture in our country house. We need to buy ___ more things. 9. I'm still hungry. I think I'll have ___ more fish. 10. When I was a child, we kept ___ pigeons in our back yard. 11. If I accept that job, I'll make ___ more money. 12. There are ___ cars on the road today. It's Sunday. 13. Many questions were asked, but ___ were answered. 14. Wait ___, there are still ___ things to attend to. 15. Even now there is ___ we can do to improve the weather.

VI. Make the following sentences interrogative and negative. Don't forget to use *many* or *much* in them:

1. There is a lot of fruit this year. 2. There are a lot of apple trees in our garden. 3. There are a lot of slang words in his vocabulary. 4. There is a lot of interesting news in today's e-mail. 5. There are a lot of things which you still don't understand. 6. There is a lot of snow in winter in Siberia. 7. There are a lot of sights in every capital. 8. There is a lot of pollution in big cities. 9. We had a lot of fun at the party. 10. There is a lot of sunny weather in Italy. 11. Helen has a lot of good ideas. 12. My elder brother helps me a lot. 13. One should have a lot of patience to catch fish. 14. English people send a lot of cards on Christmas. 15. This journalist wrote a lot of books about famous people.

VII. Write the correct form of the verb using the Indefinite Tenses. Translate the sentences:

1. What time Andrea usually (to get) up? 2. I (not to go) to the shop yesterday. 3. My friend (to help) me with Maths tomorrow. 4. He (not to play) any musical instrument. 5. In 1990 they (to go) to Australia. 6. My elder brother (to be) a student next year. 7. Andrew (not to know) her. 8. Everybody (to have) a good time last Saturday? 9. Where you (to go) in a month? 10. They rarely (to visit) their grandparents. 11. This man (to know) from his experience what it (to mean). 12. Nothing (to happen) by accident. 13. My great-grandmother is very old, but she (to hear, to see and to understand) everything quite well. 14. They (to carry out) a huge survey last week. 15. It (to happen) many centuries ago. 16. The conference (to start) in a minute or two. 17. These first-year students (to want) to know if there (to be) any tests on Thursday.

Test your grammar:

1. Ben doesn't work very hard; Bill works _____.
   a) more harder
   b) harder

c) more hard
d) the hardest

2. Can you tell me the shortest way to _____ bookstore?
a) near
b) nearer
c) nearest
d) the nearest

3. David wants to be strong and healthy that's why he _____ every morning.
a) jog
b) jogs
c) jogged
d) has jogged

4. Paul says he is 56 years old, but nobody _____ him.
a) believe
b) believes
c) don't believe
d) doesn't believe

5. How many _____ of bread do you want me to buy?
a) loafs
b) loafes
c) loaves
d) loavs

6. A typical English scenery includes green slopes with _____ and a castle in the background.
a) sheep
b) sheeps
c) sheepes
d) sheepps

7. When I first _____ to England in 1938, I thought I knew English fairly well.
a) come
b) has come
c) had come
d) came

8. In 1912 the Titanic _____ an iceberg on its first trip across the Atlantic, and it sank four hours later.
a) hits
b) hit
c) will hit
d) hitted

9. I don't know when Professor Johnson _____ to his office, but when he comes, I'll speak to him about it.
a) will come
b) come
c) comes
d) came

10. It's too late to telephone Tom now. I think I _____ him in the morning.
    a) called
    b) call
    c) will call
    d) calls

UNIT 3. THE MOLECULAR DIVERSITY OF LIFE

Wordbuilding: conversion; the change of stress in some nouns and verbs
Grammar:
I. The Article
II. Pronouns. Indefinite pronouns (some/any; one/ones)
III. The Continuous Tenses (Active Voice)
Text A: Molecules of life
Text B: Amino Acids

WORDBUILDING

n → v: *a play – to play; a doctor – to doctor*
water – to water; a tie – to tie
trouble – to trouble; work – to work
a master – to master; a house – to house

I. Make verbs from the following nouns. Translate them into Ukrainian:

Turn, smile, smoke, snow, start, stay, step, stop, study, talk, visit, rest, air, paper, cover, handle, cause, watch, act, address, answer, brush, clean, cross, crowd, wave, wish, work, dance, doubt, dress, end, fight, help, hope, joke, laugh, lift, light, love, mind, paper, pencil, place, plan, play, post, reply, report, return, sail, show.

II. Read the following words paying attention to the stress. Translate them into Ukrainian:

An accent [ˈæks(ə)nt] – to accent [əkˈsent], a contract [ˈkɒntrækt] – to contract [kənˈtrækt], a content [ˈkɒntent] – to content [kənˈtent], a contest [ˈkɒntest] – to contest [kənˈtest], a convict [ˈkɒnvɪkt] – to convict [kənˈvɪkt], a perfect [ˈpɜ:fɪkt] – to perfect [pəˈfekt], a record [ˈrekɔ:d] – to record [rɪˈkɔ:d], export [ˈekspɔ:t] – to export [ɪkˈspɔ:t], a present [ˈprez(ə)nt] – to present [prɪˈzent], a contact [ˈkɒntækt] – to contact [ˈkɒntækt,kənˈtækt], contrast [ˈkɒntrɑ:st] – to contrast [kənˈtrɑ:st], an increase [ˈɪŋkri:s] – to increase [ɪnˈkri:s], a decrease [ˈdi:kri:s] – to decrease [di:ˈkri:s], an object [ˈɒbdʒ|ekt,-ˈɒbdʒɪkt] – to object [əbˈdʒekt], a subject [ˈsʌbdʒɪkt] – to subject [səbˈdʒekt], a process [ˈprəʊsəs] – to process [prəˈses], affect [ˈæfekt] – to affect [əˈfekt].

III. Say what verbs were these words made from. Translate them into Ukrainian:

Protection, show, writer, worker, movement, investigation, achievement, statement, reader, department, equipment, construction, organization, reporter, arrival, improvement, conductor, establishment, development, education, definition, regulation, assistance, agreement.

PRE-TEXT EXERCISES:

I. Read and memorize the following words and word combinations:

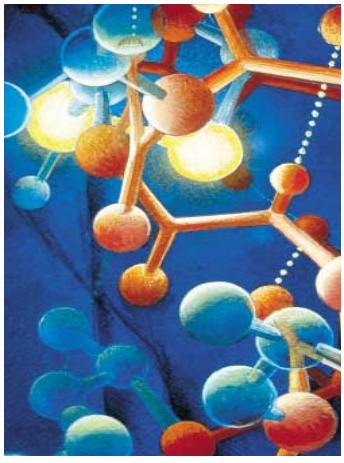
to enable	уможливлювати	vast	численний
diversity	різноманіття	immense	колосальний
enough	достатньо	roughly	приблизно
to share	поділяти	emergent	новий
nucleic	нуклеїнова	trait	властивість
scale	масштаб	to mix	змішуватися
to consider	брати до уваги	wax	віск
biochemist	біохімік	dynamic	динамічний
to determine	визначати	covalent	ковалентний
architecture	архітектура	bond	зв'язок
to vary	відрізнятися	to depend on	залежати від
to underscore	підкреслювати	to mean	позначати
to account for	складати	dry	сухий
to speed up	пришвидшувати	consistent	який узгоджується
generation	покоління	defense	захист
selectively	вибірково	sophisticated	складний
storage	зберігання	support	підтримка

II. Read the following biological terms. Translate them without a dictionary paying attention to the part of speech:

molecule ['mɒlɪkju:l] *n*, molecular [mə'lekjʊlə] *adj*, macromolecule [ˌmækrə(ʊ)'mɒlɪkju:l] *n*, carbohydrate [ˌkɑ:bə(ʊ)'haɪdr(e)ɪt] *n*, lipid ['lɪpɪd] *n*, acid ['æsɪd] *n*, sugars ['ʃʊgə] *n*, polysaccharide [ˌpɒlɪ'sækəraɪd] *n*, glucose ['glu:kəʊs] *n*, polymer ['pɒlɪmə] *n*, hydrophobic [ˌhaɪdrə'fəʊbɪk] *adj*, hydrocarbon [ˌhaɪdrə(ʊ)'kɑ:bən] *n*, steroid ['ster|ɔɪd,'stɪ(ə)rɔɪd-] *n*, catalyst ['kæt(ə)lɪst] *n*, chemical ['kemɪk(ə)l] *adj* agent ['eɪdʒ(ə)nt] *n*.

III. Read the text below using a dictionary where necessary.

Molecules of Life



There is rich complexity of life on Earth, so one can think that organisms have an enormous diversity of molecules. Remarkably, however, the critically important large molecules of all living things – from bacteria to elephants fall into just four main classes: *carbohydrates, lipids, proteins, and nucleic acids*. On the molecular scale, members of three of these classes – carbohydrates, proteins, and nucleic adds – are huge and are thus called macromolecules. Considering the size and complexity of macromolecules, it is noteworthy that biochemists have

determined the detailed structures of so many of them. The architecture of a large biological molecule helps to explain how that molecule works.

Each cell has thousands of different kinds of macromolecules; the collection varies from one type of cell to another even in the same organism. The diversity of macromolecules in the living world is vast, and the possible variety is effectively limitless.

Despite the immense diversity, molecular structure and function can still be grouped roughly by class. Let's look at each of the four major classes of large biological molecules. For each class, these molecules have emergent properties not found in their individual building blocks.

Carbohydrates include both sugars and polymers of sugars. The simplest carbohydrates are the monosaccharides (from the Greek monos, single, and sacchar, sugar), also known as simple sugars. Disaccharides are double sugars, consisting of two monosaccharides joined by a covalent bond. Carbohydrates also include macromolecules called polysaccharides, polymers composed of many sugar building blocks. Glucose, the most common monosaccharide, is of central importance in the chemistry of life.

Lipids are the one class of large biological molecules that does not include true polymers, and they are generally not big enough to be considered macromolecules. The compounds called lipids are grouped together because they share one important trait: they mix poorly, if at all, with water. The hydrophobic behavior of lipids is based on their molecular structure. Although they may have some polar bonds associated with oxygen, lipids consist mostly of hydrocarbon regions. Lipids are varied in form and function. They include waxes and certain pigments, but the most biologically important types of lipids are fats, phospholipids, and steroids.

Nearly every dynamic function of a living being depends on *proteins*. In fact, the importance of proteins is underscored by their name, which comes from the Greek word proteios, meaning "first place". Proteins account for more than 50% of the dry mass of most cells, and they are instrumental in almost everything organisms do. Some proteins speed up chemical reactions, while others play a role in structural support, storage, transport, cellular communication, movement, and defense against foreign substances. Life would not be possible without enzymes, most of which are proteins. Enzymatic proteins regulate metabolism by acting as catalysts, chemical agents that selectively speed up chemical reactions without being consumed by the reaction. Because an enzyme can perform its function over and over again, these molecules can be thought of as workhorses that keep cells running by carrying out the processes of life. A human has tens of thousands of different proteins, each with a specific structure and function; proteins, in fact, are the most structurally sophisticated molecules. Consistent with their diverse functions, they vary extensively in structure – each type of protein has a unique three-dimensional shape.

The two types of *nucleic acids*, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), enable living organisms to reproduce their complex components from one generation to the next. Unique among molecules, DNA provides directions for its own replication. DNA also directs RNA synthesis and, through RNA, controls protein synthesis.

Notes to the texts:

It is noteworthy… – Заслуговує на увагу…
composed of… – що складаються з…
to be considered – для того, щоб вважатися
without being consumed – таким чином, що вони не поглинаються
three-dimensional – трьох-мірний

IV. Answer the following questions to check how carefully you have read the text:

1. How many main classes of large biological molecules are there? What are they? 2. What helps to explain how a molecule works? 3. Is the diversity of macromolecules in the living world enormous? 4. What do carbohydrates include? 5. What are the simplest carbohydrates? 6. What are polysaccharides? 7. What are lipids? 8. Can lipids mix with water? 9. What are the most biologically important types of lipids? 10. What role do proteins play in an organism? 11. What are the most structurally complex molecules? 12. What kind of shape does each type of protein have? 13. What are the two types of nucleic acids?

VOCABULARY EXERCISES

I. Translate the following words and word combinations into Ukrainian and use them in the sentences of your own:

it is noteworthy that …; different kinds of; to vary from … to; also known as; common; to be not … enough; some …, while others …; to play a role; to enable; from one generation to the next; to provide.

II. Choose the synonyms of the following words from the right hand column. Translate them:

to vary, vast, diversity, enough, to determine, trait, to mix, to mean, to speed up, defense	sufficiently, to identify, feature, to combine, variety, to differ, enormous, to stand for, to accelerate, protection

III. Choose the antonyms of the following words from the right hand column. Translate them:

rich, immense, dynamic, roughly, individual, dry, sophisticated, to enable, direct, different, foreign	tiny, indirect, accurately, collective, similar, native, poor, inactive, wet, to forbid, simple

VI. Translate the following sentences into Ukrainian paying attention to the word *mean*:

1. We have all *means* to produce good results in our work. 2. We improve soil structure *by means* of proper crop rotation. 3. What does this word *mean*? 4. If the lecture takes place I will come *by all means*. 5. Like some people you didn't understand the *meaning* of this work. 6. His colleagues thought he looked terribly aged, although he was *by no means* an old man.

V. Match the word (1-10) and its definition (a-j):

1. Molecule	**a.** A polymer (polynucleotide) consisting of many nucleotide monomers; the two types are DNA and RNA
2. Carbohydrate	**b.** The simplest carbohydrate, active alone or serving as a monomer for disaccharides and polysaccharides
3. Lipid	**c.** A polymer of many monosaccharides, formed by dehydration reactions
4. Protein	**d.** A type of lipid characterized by a carbon skeleton consisting of four fused rings with various chemical groups attached
5. Nucleic acid	**e.** Any of a group of large biological molecules, including fats, phospholipids, and steroids, that mix poorly, if at all, with water
6. Macromolecule	**f.** A biologically functional molecule consisting of one or more polypeptides folded and coiled into a specific three-dimensional structure
7. Monosaccharide	**g.** A sugar (monosaccharide) or one of its dimers (disaccharides) or polymers (polysaccharides)
8. Disaccharide	**h.** Two or more atoms held together by covalent bonds
9. Polysaccharide	**i.** A giant molecule formed by the joining of smaller molecules, usually by a dehydration reaction
10. Steroid	**j.** A double sugar, consisting of two monosaccharides joined by a glycosidic linkage formed by a dehydration reaction

VI. Put the words in the right order to make a sentence.

1. chemical, organisms, in, All, of, their, are, cells, living, similar, composition.
2. form, the, Life, of, protein, is, the, existence, of, bodies.
3. is, full, thousands, of, different, Our, catalysts, body, of.
4. room, all, they, for, enzymes, the, have, Cells, enough, need.
5. of, A, all, very, simply, protoplasm, water, large, is, part.
6. than, proceeding, before, Biological, more, research, is, rapidly.
7. proteins, There, a, of, is, tremendous, variety.
8. acid, Average, contains, molecule, protein, 500, molecules, amino, about.

VII. Translate the following text into English using the words from the text:

1. Ліпіди – не група органічних речовин, що входять до складу живих організмів.

2. Жири є формою запасання енергії, а фосфоліпіди та стероїди входять до складу біологічних мембран.
3. Хоча генетичний код більшості організмів визначає лише 20 «стандартних» амінокислот, їхнє комбінування уможливлює створення великого різноманіття білків із різними властивостями.
4. Функції білків в клітині різноманітніші, ніж функції інших біополімерів – полісахаридів і нуклеїнових кислот.
5. Регуляція транспорту й метаболізму амінокислот – складний процес.
6. Природні нуклеїнові кислоти – ДНК і РНК – виконують у всіх живих організмах роль передачі і експресії генетичної інформації.
7. Вуглеводи є складовою частиною клітин усіх живих організмів.
8. Вуглеводи є найпоширенішими органічними сполуками.
9. Дисахариди – вуглеводи, що розкладаються на дві молекули моносахаридів.
10. Ліпіди – не є макромолекулами, оскільки вони не створюють великих ковалентно зв'язаних молекул.

VIII. Retell the text “Molecules of Life” using the questions after it as a plan.

IX. Read the text using a dictionary and speak on it:

Amino Acids

All proteins, whether from the most ancient lines of bacteria or from the most complex forms of life, are constructed from the same set of 20 amino acids, covalently linked in characteristic linear sequences. What is most remarkable is that cells can produce proteins with strikingly different properties and activities by joining the same 20 amino acids in many different combinations and sequences. From these building blocks different organisms can make such widely diverse products as enzymes, hormones, antibodies, muscle fibers, feathers, spider webs, rhinoceros horn, milk proteins, antibiotics, mushroom poisons, and thousand other substances that have distinct biological activities. Among these protein products, the enzymes are the most varied and specialized.

All amino acids share a common structure. They are organic molecules that possess both carboxyl and amino groups. At the center of the amino acid there is an asymmetric carbon atom called the alpha carbon. Its four different partners are an amino group, a carboxyl group, a hydrogen atom, and the side chain that differs with each amino acid.

The physical and chemical properties of the side chain determine the unique characteristics of a particular amino acid, thus affecting its functional role in a polypeptide. The amino acids are grouped according to the properties of their side chains. One group consists of amino acids with non-polar side chains, which are hydrophobic. Another group consists of amino acids with polar side chains, which are hydrophilic. Acidic amino acids are those with side chains that are generally negative in charge owing to the presence of a carboxyl group, which is usually

dissociated (ionized) at cellular pH. Basic amino acids have amino groups in their side chains that are generally positive in charge. Because they are charged, acidic and basic side chains are also hydrophilic.

When two amino acids are positioned so that the carboxyl group of one is adjacent to the amino group of the other, they can become joined by a dehydration reaction, with the removal of a water molecule. The resulting covalent bond is called a peptide bond. This process produces a polypeptide, a polymer of many amino acids linked by peptide bonds. At one end of the polypeptide chain there is a free amino group; at the opposite end there is a free carboxyl group. Thus, the chain has an amino end and a carboxyl end. Polypeptides range in length from a few monomers to a thousand or more. Each specific polypeptide has a unique linear sequence of amino acids. The immense variety of polypeptides in nature illustrates an important concept – that cells can make many different polymers by linking a limited set of monomers into diverse sequences.

Animals require 20 amino acids to make proteins. The majority of animal species can synthesize about half of these amino acids, as long as their diet includes organic nitrogen. The remaining amino acids must be obtained from food in prefabricated form and are therefore called essential amino acids. Most animals, including adult humans, require eight amino acids in their diet. A diet that provides insufficient amounts of one or more essential amino acids causes protein deficiency, the most common type of malnutrition among humans. The proteins in animal products such as meat, eggs, and cheese are 'complete', which means that they provide all the essential amino acids in their proper proportions. In contrast, most plant proteins are 'incomplete' – they are deficient in one or more essential amino acids. To prevent protein deficiency, vegetarian diets must include combinations of plant products that together provide all of the essential amino acids.

Notes to the texts:

muscle [ˈmʌs(ə)l] **fibers** [ˈfaɪbə] – м’язові волокна
owing to – завдяки, внаслідок
dissociated [dɪˈsəʊʃɪeɪtɪd] – роздвоєний
dehydration [ˌdi:haɪˈdreɪʃ(ə)n] – зневоднювання, дегідратація
as long as – доки, до тих пір

X. Look through the text and decide whether the following sentences are true or false, correct the wrong ones:

1. Muscle fibers are the most diverse and specialized of protein products.
2. Amino acids are organic molecules that possess either carboxyl or amino groups.
3. The alpha carbon is at the periphery of the amino acid.
4. The amino acids are grouped according to the features of their side chains.
5. Acidic and basic side chains are hydrophobic.
6. Cells can make many different polymers by linking a limitless set of monomers into varied sequences.

7. If there is organic nitrogen in their diet, the majority of animals can synthesize about ten amino acids.

XI. Put as many questions as possible to the text and be ready to answer them.

XII. Compose short dialogues for the following imaginary situations:

1. Imagine that you are a teacher of biology. The subject of your lesson is molecules. Explain the difference between monosaccharides, disaccharides and polysaccharides.
2. Imagine that you are the Dean of the biological faculty. Tomorrow you are to speak to the first-year students. What will you tell them? What will you wish your future students?
3. Imagine that you are working at a biological laboratory. Suddenly the door opens and s man comes in. "It's a chemical laboratory, isn't it?", he asks. Tell him about your laboratory and its peculiarities.

GRAMMAR EXERCISES

I. Use the necessary form of the indefinite article (*a* or *an*):

___ academy, ___ album, ___ bright album, ___ actor, ____ great actress, ___ arch, ___ marble arch, ___ chance, ___ unlucky chance, ___ dove, ___ ear, ___ elf, ___ tiny elf, ___ horse, ___ hour, ___ long hour, ___ institute, ___ lemon, ___ mill, ___ university, ___ opera, ___ Italian opera, ___ owl, ___ paper, ___ rabbit, ___ quarter, ___ train, ___ wing, ___ voyage, ___ year, ___ example, ___ good example.

II. Insert the right article:

1. Maxim left ___ Ritz Hotel after their dinner at ___ Annabel's and walked home crossing ___ Picadilly and heading through ___ Half Moon Street into ___ Mayfair. 2. ___ Easter Island in ___ Pacific Ocean was discovered in 1722. It is one of ___ most mysterious spots on ___ earth. 3. I flew to ___ UK on the Concorde. I had hardly had a chance to eat a snack, relax and read my book when we were landing at ___ Heathrow. 4. ___ Gulf Stream is a warm ocean current which flows from ___ Gulf of Mexico, along ___ south-east coast of ___ United States, and north-eastwards in ___ Atlantic Ocean. 5. The waters of ___ Seine trembled in the hazy sunshine. 6. In the vicinity of the house were ___ Rodin Museum, ___ French Academy, and ___ Hotel des Invalides, housing ___ tomb of Napoleon I. 7. George had planned ___ cruise to ___ Greek islands as ___ surprise for his family. They would be sailing around ___ Aegean Sea for about a fortnight. 8. The two young women had attended ___ Sorbonne at the same time. Their fathers, as it turned out, had been at ___ Oxford University. 9. The highest peak in ___ North America is ___ Mount McKinley. 10. ___ Monterey Peninsula juts out into ___ Pacific Ocean halfway up ___ California coast. 11. The travellers saw an oasis in ___ Gobi, but it was a mirage. 12. If you

want to see ___ Lake Victoria and ___ Mount Kilimanjaro, go to ___ Kenya. 13. There is a project to turn ___ Baikal area into ___ Russian Alps.

III. Insert the right article paying attention to proper names:

1. The hunters got lost in ___ Rocky Mountains. 2. ___ Buckingham Palace, ___ Trafalgar Square, ___ Houses of Parliament, ___ Tower of London, ___ Tower Bridge, ___ National Gallery are the usual sights in ___ English capital. 3. The six island countries of ___ West Indies are ___ Bahamas, ___ Barbados, ___ Cuba, ___ Dominican Republic, ___ Haiti and ___ Jamaica. 4. In the mornings she used to read ___ "Vogue" and he usually read ___ "Mirror". 5. ___ Berlin she had been born in, and where she had grown up, no longer existed. 6. ___ Low Countries include ___ Netherlands, ___ Belgium, and ___ Luxembourg. 7. ___ Colorado River flows through ___ Grand Canyon. 8. The names of the following streets have the definite article: ___ Mall, ___ Strand, ___ Wall Street, ___ Unter den Linden. 9. ___ England of the 21st century will be very different from ___ England of our days. 10. This producer got ___ Nika for this film. 11. Chaucer would have had difficulty in recognizing ___ London of Queen Elizabeth, just as Shakespeare would have been lost in ___ brick-and-stone London of D.R. Johnson, while Dickens, well as he knew ___ London, would have been bewildered by ___ steel and concrete London of today.

IV. Insert *some* or *any* where necessary:

1. My teacher lives ___ distance away from the school. 2. You should buy ___ new clothes for the New Year, I think. 3. Ruth still has ___ doubts about her marriage, but her boyfriend John hasn't got any. 4. Mum was sure we had ___ honey left. At breakfast it turned out we didn't have ___. 5. — Has there been ___ discussion of the project? — Yes, ___ people are against it, I'm sorry to say. 6. There must be ___ way to get in touch with them, but so far I haven't found ___. 7. – Is there ___ reliable source of information you'll use in your investigation, inspector? – I definitely have ___, though I am not going to reveal ___ to you, sir. 8. ___ people hate seafood. 9. Let's talk about it ___ other time. 10. There aren't ___ markets on Monday. 11. – There is ___ dust on the furniture. – Oh, I haven't got ___ time for this. 12. – Do you speak ___ French? – No, but I speak ___ English.

V. Make the following sentences interrogative and negative:

1. People usually have some free time on weekends. 2. Some of my friends also teach English. 3. There is some snow in the streets. 4. Wait, I'll make some coffee for us. 5. There's some soup left. 6. I think I need some help. 7. She has some relatives in England. 8. Some people are so annoying! 9. We have some new contracts this year. 10. I can get you some bread when I go shopping.

VI. Use *some-*, *any-*, *every-*, *no-* + *one* / *body* / *thing* / *where*:

1. Never trust ___ with such manners. 2. Let me see if there is ___ we can do for you. 3. Is there ___ at home? 4. If ___ happens to the car, how shall I get to the

country? 5. There should be ___ behind all this. 6. Barbara was a teacher from ___ near Newcastle. 7. Emily refuses to have ___ to do with Jim. 8. Shall I bring you ___ to drink? 9. Nobody can find out ___ about that man. 10. Yesterday we couldn't find you ___. Where were you? 11. Hardly ___ knew how to respond to this. 12. Many people think that the bad weather has ___ to do with all the satellites in space. 13. You're wrong. There's ___ strange about the man. He is a decent chap. 14. — What's the matter? – ___ is the matter. 15. We looked for a policeman, but there was ___ around. 16. – Do you have any clue to this? – ___ whatsoever. 17. I answered every single question. My opponent answered ___. 18. ___ of us understood the play. 19. Mind, I'm having ___ of that language here! 20. Don't be so nosy! It's ___ of your business. 21. ___ comes to those who hustle while he waits. 22. ___ should believe in ___. 23. Kindness, I've discovered, is ___. 24. Considering how dangerous ___ is, ___ is really very frightening.

VII. Use *one* or *ones* instead of the nouns in *italics* where possible:

1. These oranges are tired. Have you got fresher *oranges*? 2. These gloves are a bit tight. Can you show bigger *gloves*? 3. This shirt is too bright. I need a darker *shirt.* 4. I looked through the files and took the *file* which I hadn't seen before. 5. I have had enough ice cream. Give me no more *ice cream.* 6. – Which case is Fred's? – The *case* with a tag. 7. The difference between a good doctor and a bad *doctor* lies in his competence. 8. This advice is more useful than the *advice* you gave me last week. 9. The new manager is much more competent than the *manager* we had last year. 10. Today's news is much more encouraging than the *news* we got yesterday. 11. I've lost my purse. I'm going to buy a new *purse* one of these days. 12. The weather this week is no better than the *weather* we had last week.

VIII. Translate the sentences, mind the verbs in the Continuous Tenses:

1. Ann is in the laboratory and she will be staying there for another hour. 2. The professor was asking many additional questions during the exam. 3. The number of new equipment in university laboratories is growing from year to year. 4. We were performing the experiment from early in the morning till 6 p.m. 5. They are discussing experimental data right now. 6. The students will be working in the laboratory at 3 p.m. tomorrow.7. I will be sleeping at 11 a.m. tomorrow. 8. The lab assistant was teaching students to use the new equipment for two hours.

Test your grammar:

1. Look here! I simply refuse to believe what you _____ me now.
   a) tell
   b) are telling
   c) have told
   d) has told
2. A strong wind _____ and I decided to put on a warm coat.
   a) is blowing

b) has been blowing
c) was blowing
d) had been blowing

3. Her family _____ from town to town ever since she can remember.
a) moves
b) is moving
c) has moved
d) has been moving

4. Robert didn't answer the phone when Mary called. He _____ a shower and didn't hear the phone ring.
a) is taking
b) was taking
c) had been taking
d) have been taking

5. _____ British drive on the left-hand side in their country.
a) –
b) a
c) an
d) the

6. _____ Pacific Ocean is the largest ocean on _____ Earth.
a) – , the
b) a, an
c) the, –
d) the, the

7. Do you speak _____ foreign language?
a) any
b) some
c) anything
d) something

8. The museum is free. It doesn't cost _____ to go in.
a) somewhere
b) nothing
c) anything
d) something

9. _____ can answer this question. It is very simple.
a) anyone
b) someone
c) no one
d) nowhere

10. David's house is full of books. There are books _____.
a) somewhere
b) everywhere
c) nowhere
d) something

UNIT 4. CHEMICALS OF LIFE

Wordbuilding: suffixes -ly; -ment
Grammar:
I. Numerals
II. Adverbs. Degrees of comparison
III. The Perfect Tenses (Active Voice)
Text A: Enzymes
Text B: Vitamins and Minerals

WORDBUILDING

adj
n **+ -ly = adv**
num

bad – badly
friend – friendly
first – firstly

I. Make adverbs from the following words and translate them into Ukrainian:

bad, second, part, quick, strong, short, silent, rapid, wide, extreme, cruel, kind, happy, active, direct, easy, final, natural, normal, slow, serious, usual, sudden, love, day, hour, month, week, name, slight, high, exact, regular, artificial, ready.

v + -ment = n *to manage – management, to pay – payment*

II. Make nouns from the following verbs with the help of suffix -ment and translate them into Ukrainian:

to develop, to achieve, to move, to arrange, to treat, to state, to improve, to agree, to equip, to govern, to require, to measure, to announce, to pave, to establish.

PRE-TEXT EXERCISES:

I. Read and memorize the following words and word combinations:

condition	умова	self-replicate	реплікуватися
to carry out	виконувати	enzyme	фермент
temporary	тимчасовий	degree	ступень
to undergo	піддаватися	tremendously	надзвичайно
solution	розчин	to facilitate	полегшувати
to contribute	сприяти	blood	кров
array	сукупність	disease	хвороба
inheritable	спадковий	disorder	хвороба
total	повний	to cause	спричиняти
excessive	надмірний	measurement	вимір
sample	зразок	illness	хвороба
drug	ліки	tool	інструмент
agriculture	землеробство	to prove	доводити

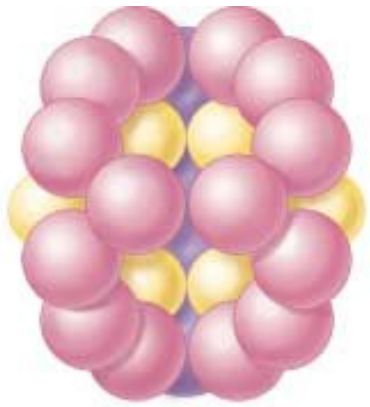
urease	уреаза	to elucidate	пояснювати
controversial	спірний	discovery	відкриття
to accept	приймати	pure	чистий
to purify	очищати	conclusion	висновок
exception	виключення	to receive	отримувати

II. Read the following biological terms. Translate them without a dictionary paying attention to the part of speech:

Enzyme ['enzaɪm] *n*, to stabilize ['steɪbɪlaɪz] *v*, substrate ['sʌbstreɪt] *n*, specificity [ˌspesɪ'fɪsɪtɪ]*n*, aqueous ['ækwɪəs,'eɪkwɪəs] *adj*, blood [blʌd] *n*, nerve [nɜ:v] *n*, erythrocyte [ɪ'rɪθrəsaɪt] *n*, technology [tek'nɒlədʒɪ] *n*, agriculture ['ægrɪˌkʌltʃə] *n*, to isolate ['aɪsəleɪt] *v*, idea [aɪ'dɪə] *n*, mechanism ['mekənɪz(ə)m] *n*.

III. Read the text below using a dictionary where necessary.

Enzymes



There are two fundamental conditions for life. First, the organism must self-replicate; second, it must catalyze chemical reactions efficiently and selectively. The agents that carry out most of the catalysis in living organisms are proteins called enzymes. They are the most remarkable and highly specialized proteins that control body chemistry. Enzymes have extraordinary catalytic power, often far greater than that of synthetic or inorganic catalysts. The unique three-dimensional shape of an enzyme enables it to stabilize a temporary association between substrates, the molecules that will undergo the reaction. They have a high degree of specificity for their substrates; they accelerate chemical reactions tremendously, and they function in aqueous solutions under very mild conditions of temperature and pH. Few non-biological catalysts have all these properties.

Thousands of different kinds of enzymes are known, each catalyzing one or a few specific chemical reactions. When they facilitate particular chemical reactions, the enzymes in a cell determine the course of metabolism – the collection of all chemical reactions – in that cell. Different types of cells contain different sets of enzymes, and this difference contributes to structural and functional variations among cell types. The chemical reactions taking place within a red blood cell differ from those that occur within a nerve cell, in part because the cytoplasm and membranes of red blood cells and nerve cells contain different arrays of enzymes.

The study of enzymes has immense practical importance. In some diseases, especially inheritable genetic disorders, there may be a deficiency or even a total absence of one or more enzymes. Other disease conditions may be caused by excessive activity of an enzyme. Measurements of the activities of enzymes in blood

plasma, erythrocytes, or tissue samples are important in diagnosing certain illnesses. Many drugs act through interactions with enzymes. Enzymes are also important practical tools in chemical engineering, food technology and agriculture.

Much of the history of biochemistry is the history of enzyme research. That all enzymes are proteins was proved only in 1926 when the American biochemist James Sumner isolated an enzyme called urease in the form of pure crystals. He had collected enough of it to work on and only then he showed that this enzyme was definitely a protein. In the absence of other examples, this idea remained controversial for some time. Only in the 1930s Sumner's conclusion was widely accepted and he received a Nobel Prize in Chemistry for his discovery.

Since the latter part of the twentieth century, thousands of enzymes have been purified, their structures elucidated, and their mechanisms explained. With the exception of a small group of catalytic RNA molecules, nowadays we know for sure that all enzymes are proteins.

Notes to the texts:

under … conditions – при … умовах
Nobel Prize – Нобелівська премія

IV. Answer the following questions to check how carefully you have read the text:

1. What are the two fundamental conditions for life? 2. What are enzymes? 3. What do enzymes control? 4. What are substrates? 5. What roles do substrates play? 6. What process do enzymes determine in a cell? Give its definition. 7. Why do the chemical reactions taking place within a red blood cell differ from those that occur within a nerve cell? 8. What practical significance does the study of enzymes have? 9. When and by whom was it proved that all enzymes are proteins? 10. What did James Sumner receive for his discovery?

VOCABULARY EXERCISES

I. Translate the following words and word combinations into Ukrainian and use them in the sentences of your own:

to control; extraordinary; to stabilize; a degree; under … conditions; to take place; to differ from; to have immense practical importance; excessive; to collect; to remain controversial; for some time; with the exception of; to know for sure.

II. Choose the synonyms of the following words from the right hand column. Translate them:

to facilitate, particular, to occur, array, disease, excessive, pure, to collect, controversial, to elucidate	to happen, immoderate, collection, specific, illness, to gather, to ease, unmixed, to explain, disputable

III. Choose the antonyms of the following words from the right hand column. Translate them:

extraordinary, temporary, total, to remain, widely, to accept, to receive, exception, to purify	narrowly, to refuse, partial, to leave, to pollute, ordinary, rule, to give, permanent

IV. Match the word (1-10) and its definition (a-e):

1. Enzyme	**a.** A blood cell that contains hemoglobin, which transports oxygen; also called a red blood cell
2. Substrate	**b.** An integrated group of cells with a common structure, function, or both
3. Metabolism	**c.** The reactant on which an enzyme works
4. Erythrocyte	**d.** The totality of an organism's chemical reactions, consisting of catabolic and anabolic pathways, which manage the material and energy resources of the organism
5. Tissue	**e.** A macromolecule serving as a catalyst, a chemical agent that increases the rate of a reaction without being consumed by the reaction

V. Put the words in the right order to make a sentence.

1. biological, all, need, Almost, chemical, a, reactions, enzymes, cell, in.
2. any, activity, Some, need, components, enzymes, to show, don't, additional, full.
3. act on, Most, much, enzymes, than, are, substrates, larger, the, they.
4. of, enzymes, amino, Like, are, all, linear, proteins, long, chains, acids.
5. functions, inside, Enzymes, living, serve, of, wide, a, organisms, variety.
6. are, to, enzymes, Many, substrate, specific, one.
7. catalyze, type, only, of, enzymes, reaction, The, of, majority, one.
8. additional, to, Enzymes, function, sometimes, non-protein, require, properly, components.
9. pH, effectively, within, most, of, Enzymes, and, work, ranges, narrow, temperature.
10. environment, need, All, the, for, enzymes, function, right, effective.
11. than, now, more, Scientists, identified, have, 1,500, enzymes, different.
12. central, Enzymes, process, are, occurs, to, biochemical, in, every, body, that, the.

VI. Translate the following text into English using the words from the text:

1. Ферменти каталізують більшість хімічних реакцій, які відбуваються у живих організмах.
2. Всі біохімічні реакції відбуваються за участю ферментів за нормальним тиском, температурою та у певному середовищі.

3. Ферменти є біологічними каталізаторами, вони наявні в усіх живих клітинах і сприяють перетворенню одних речовин (субстратів) на інші (продукти).
4. Ферменти виступають в ролі каталізаторів практично в усіх біохімічних реакціях, що відбуваються в живих організмах.
5. Ферменти грають найважливішу роль у всіх процесах життєдіяльності, бо вони скеровують та регулюють обмін речовин організму.
6. Ферменти зазвичай проявляють високу специфічність по відношенню до своїх субстратів.
7. Метаболізм – сукупність хімічних реакцій, що відбуваються в живих організмах.

VII. Retell the text "Enzymes" using the questions after it as a plan.

VIII. Read the text using a dictionary and speak on it:

Minerals and Vitamins

The materials that an animal's cells require but cannot synthesize are called essential nutrients. Obtained from dietary sources, these nutrients include both minerals and preassembled organic molecules. Some nutrients are essential for all animals, whereas others are needed only by certain species. For instance, ascorbic acid (vitamin C) is an essential nutrient for humans and other primates, guinea pigs, and some birds and snakes, but not for most other animals. There are four classes of essential nutrients: essential amino acids, essential fatty acids, vitamins, and minerals. Let's focus on two latter groups.

Vitamins are organic molecules with diverse functions that are required in the diet in very small amounts. Vitamin B_2, for example, is converted in the body to FAD, a coenzyme used in many metabolic processes, including cellular respiration. Scientists have identified 13 essential vitamins for humans. Vitamins are classified as water-soluble or fat-soluble. The water-soluble vitamins include the B-complex, which are compounds that generally function as coenzymes, and vitamin C which is required to produce connective tissue. Among the fat-soluble vitamins there are vitamin A, which is incorporated into visual pigments of the eye, and vitamin K, which functions in blood clotting. Another one is vitamin D, which aids in calcium absorption and bone formation. Our dietary requirement for vitamin D is variable because we synthesize this vitamin from other molecules when the skin is exposed to sunlight. For people with poorly balanced diets, taking vitamin supplements that provide recommended daily levels is certainly reasonable. It is much less clear whether massive doses of vitamins confer any health benefits or are, in fact, safe.

Dietary minerals are inorganic nutrients that are usually required in small amounts. Mineral requirements vary among animal species. For example, humans and other vertebrates require relatively large quantities of calcium and phosphorus for building and maintaining bone. In addition, calcium is necessary for the functioning of nerves and muscles, and phosphorus is an ingredient of ATP and

nucleic acids. Iron is a component of the cytochromes that function in cellular respiration and of hemoglobin, the oxygen-binding protein of red blood cells. Many minerals are cofactors built into the structure of enzymes.

Determining the ideal diet for the human population is an important but difficult problem for scientists. As objects of study, people present many challenges. Unlike laboratory animals, humans are genetically diverse. They also live in settings far more varied than the stable and uniform environment that scientists use to facilitate comparisons in laboratory experiments. Ethical concerns present an additional barrier. For example, it is not acceptable to investigate the nutritional needs of children in a way that might harm a child's growth or development.

The methods used to study human nutrition have changed dramatically over time. To avoid harming others, several of the researchers who discovered vitamins a century ago used themselves as subject animals. Today, an important approach is the study of genetic defects that disrupt food uptake, storage, or use. For example, a genetic disorder called hemochromatosis causes iron buildup in the absence of any abnormal iron consumption or exposure. Fortunately, this common disorder is remarkably easy to treat. By studying the defective genes that can cause the disease, scientists have learnt a great deal about the regulation of iron absorption.

Many insights into human nutrition have come from epidemiology, the study of human health and disease at the population level. By tracking the causes and distribution of a disease among many individuals, epidemiologists can identify potential nutritional strategies for preventing and controlling diseases and disorders.

Notes to the texts:

nutrient [ˈnju:trɪənt] – поживна речовина
primate [ˈpraɪmɪt] – примат
blood clotting – згущення крові
is exposed to sunlight – піддається дії сонця
to confer – надавати
vertebrates [ˈvɜ:tɪbr(e)ɪt] – хребетні
cytochrome [ˈsaɪtəkrəum] – цитохром
challenge [ˈtʃælɪndʒ] – виклик

IX. Look through the text and decide whether the following sentences are true or false, correct the wrong ones:

1. Essential nutrients include either minerals or preassembled organic molecules.
2. Vitamin C is a vital nutrient for all humans and animals.
3. Both vitamins and dietary minerals are required in the diet in tiny amounts.
4. There are thirty essential vitamins for humans.
5. Our dietary requirement for vitamin D is inconstant.
6. The problem of determining the ideal diet for the human population is quite sophisticated for scientists.
7. People are genetically different as laboratory animals.
8. A genetic disorder called hemochromatosis is not difficult to treat.

X. Put as many questions as possible to the text and be ready to answer them.

XI. Compose short dialogues for the following imaginary situations:

1. You are a teacher of biology. The subject of your lesson is enzymes. Give a short account of the history of enzyme research to your students.
2. An international conference on Biochemistry will be held next month in your university. You are invited to speak there. Prepare a report were you should compare the state of biochemistry last century and at present.
3. Your friend is going to take part in a conference. Ask him/her when the conference will be held, when he/she is leaving, how he/she is going to get there and what will be the topic of his/her report.

GRAMMAR EXERCISES

I. Give the right form of the figures in brackets in letters:

1. My birthday is on ___ of ___. 2. They got flat (40) on (5) floor in house (123). 3. Find file (11) and correct (2) sentence. 4. Catherine (2) put a monument to Peter (1) in St. Petersburg. 5. – What's the date today? – It's ___ of ___ today. 6. Read (3) paragraph. 7. My son is (21) today. 8. They are celebrating their (15) anniversary on Saturday. 9. Take (1) turning to the right. 10. You'll find text (12) on (30) page. 11. We live on (6) floor. 12. Is (2) o'clock all right with you? 13. There are more than (200) languages spoken in Nigeria. 14. A (1000) is a (1000) years. 15. In the jungle we were attacked by (1 000 000) of mosquitoes. 16. If you need money badly, we can give you a loan of (200) dollars. 17. Will you give me (2) chance? 18. (2) song will certainly become a hit. 19. He was said to have salted away (4 000 000) dollars. 20. There are (300) kinds of macaroni in Italy. 21. Statistics say that more than (4 000 000) adults in Britain have trouble with reading and writing.

II. Answer the following questions. Write your answers in words:

1. When were you born? 2. How much do you weigh? 3. What is the number of the flat or the house where you live? 4. Is that an odd or an even number? 5. What is the approximate population of your town? 6. What is the approximate population of your country? 7. What is the normal temperature of a healthy person? 8. How many kilometres are there in a mile? 9. How any years are there in a millennium?

III. Choose the right word (either an adjective or an adverb):

1. By nature all people are alike, but by education widely ___. Do you think ___ about it? (different, differently) 2. My teacher taught me ___ as he used the latest, most ___ methods of teaching. (effective, effectively) 3. Men talk ___, but live ___. Even ___ men make ___ mistakes. (wise, wisely, foolish, foolishly) 4. The children's presentation was very ___. The events developed ___. (dynamic, dynamically) 5. Life is too ___ to learn more than one business well. They returned ___ afterwards. (short, shortly) 6. – Act ___ and go ___. –

But I am neither ___ nor ___. (honest, honestly, bold, boldly) 7. She is walking so ___. How ___ this ballerina is! (graceful, gracefully) 8. – We must have a ___ talk. – Is it so necessary to discuss all this ___? (confidential, confidentially) 9. His name can be ___ seen in many papers. What's the ___ news? (current, currently) 10. – Charles and Diana were very ___ matched. – Yes, it was a ___ match from start to finish. (bad, badly) 11. Make haste ___. He is as ___ as a snail. (slow, slowly) 12. Computers have ___ made a difference in our lives. She is ___ to arrive on time. (sure, surely) 13. On the new stereo, many of the records sounded ___. This time we: shall do it ___. (different, differently) 14. The age difference between the brothers is really quite ___. Her husband was ___ shorter than she was. (slight, slightly) 15. She paused ___. Landing on the moon was one of the most ___ scientific adventures of the twentieth century. (dramatic, dramatically)

IV. Put the words in brackets into the right form:

1. Statistics say that women drive (carefully) than men. 2. Please talk a bit (quietly) and (little) aggressively. 3. There's nothing (annoying) than losing your door key. 4. Tom prefers to be alone. He is (sociable) person in the office. 5. This time he tried (hard) than last time. 6. A big car can be parked (easily) than a small one. 7. We walked (far) than we had planned. 8. Today David acted (generously) than ever before. 9. The final exam was (little) difficult of all. 10. This month Caroline worked (badly) of all, though actually she works (well) of all the pupils of her class. 11. You don't remember some details. You should study the papers (closely). 12. They can get here at 7 o'clock at (early). It's a long way from here. 13. Changes will become necessary by the autumn, at (late). 14. Really, Alex, you could work (efficiently)!

V. Translate the sentences, mind the verbs in the Perfect Tenses:

1. The scientists have obtained valuable information on the cancer problem in recent years. 2. By the time we got to the shopping centre it had closed. 3. We have recently collected interesting biological material. 4. The laboratory assistant has attempted some statistical studies this year. 5. Our young lecturer has gained some experience in lecturing on biophysics. 6. We have had such seminars regularly since 2010. 7. We will have held our meeting by his coming back from Kyiv. 8. The scientists have lately recommended a few improvements to facilitate the experiments on cell adhesion. 9. When I come back home, my family had already had dinner. 10. The scientists have made some progress in many areas of biological research. 11. By the end of the seminar the experimenters had suggested two new techniques. 12. I will have shown the students a few illustrative examples by the end of the lecture.

VI. Fill in the gaps using *since* or *for*:

1. I haven't been to the city _____ October.
2. Mary has been a nurse _____ seven years.
3. We have been happier _____ we moved to the country.

4. I haven't seen you _____ ages!
5. It has been extremely hot _____ more than five says.
6. I haven't been to this park _____ I was a child.

VII. Link part of the sentence in Column A with the correct part in Column B bearing in mind the meaning of the sentence:

Column A	Column B
Tom hasn't spoken	five times this morning.
Have you ever been	since I was 12 tears old.
Sam has called me	his homework.
How long have you	to Lee for there years.
I haven't seen my grandmother	eaten dinner yet.
Jason has already finished	lived in Chicago?
We are hungry because we haven't	failed an exam.
Molly is an excellent student and has never	to Singapore?

VIII. Finish the following situations using Past Perfect:

1. When Sarah arrived at the party, Paul wasn't there. He _____ home.
2. When we got home last night, we found that somebody _____ into our apartment.
3. Karen didn't want to come to the cinema because she _____ the film.
4. The man sitting next to me was nervous because he _____ before.
5. I didn't know who she was. I _____ before the accident.
6. We weren't hungry. We _____ lunch.
7. The house was dirty. They _____ for weeks.
8. Ann was at home when I called. She _____ in London all this time.
9. When we came to her house, she _____.
10. When I came back to Kiev in 1996, I saw that it _____ a lot.

Test your grammar:

1. Willy _____ from his Uncle Alex since the latter immigrated to Canada.
   a) had not hear
   b) has not heard
   c) have not heard
   d) did not heard
2. He was at the police station because he _____ into a car in front of him.
   a) has crashed
   b) had crashed
   c) have crashed
   d) will have crashed
3. Ted is looking for a job. I hope that by the end of the month he _____ a good job.
   a) has found

b) will find
c) will have found
d) had found

4. My father is repairing our car. We hope that by Sunday he _____ it.
a) had repaired
b) will have repaired
c) have repaired
d) has repaired

5. You are _____ who asks me this question.
a) five
b) fifth
c) the fifth
d) the five

6. OK! See you on _____ of September.
a) twenty-seven
b) the twenty-seven
c) twenty-seventh
d) the twenty-seventh

7. I speak English _____ now than last year.
a) fluently
b) more fluently
c) the most fluently
d) fluent

8. What are you looking for? – I _____ my umbrella somewhere, and now I don't know where it is.
a) has left
b) have left
c) had left
d) will have left

9. I looked everywhere for my car keys and then I remembered that my son _____ the car to work.
a) has taken
b) have taken
c) had taken
d) will have taken

10. I am reading an English book now. It is so interesting that by the end of the day I _____ reading it.
a) has finished
b) have finished
c) had finished
d) will have finished

TEXTS FOR SUPPLEMENTARY READING

All Living Things Share Key Characteristics

The earth formed as a hot mass of molten rock about 4.6 billion years ago. As the earth cooled, much of the water vapor present in its atmosphere condensed into liquid water, which accumulated on the surface in chemically rich oceans. One scenario for the origin of life is that it originated in this dilute, hot smelly soup of ammonia, formaldehyde, formic acid, cyanide, methane, hydrogen sulfide, and organic hydrocarbons. Whether at the oceans' edge, in hydrothermal deep-sea vents, or elsewhere, the consensus among researchers is that life arose spontaneously from these early waters less than 4 billion years ago. While the way in which this happened remains a puzzle, one cannot escape a certain curiosity about the earliest steps that eventually led to the origin of all living things on earth, including ourselves. How did organisms evolve from the complex molecules that swirled in the early oceans?

What Is Life? Before we can address this question, we must first consider what qualifies something as "living." What is life? This is a difficult question to answer, largely because life itself is not a simple concept. If you try to write a definition of "life," you will find that it is not an easy task, because of the loose manner in which the term is used. Imagine a situation in which two astronauts encounter a large, amorphous blob on the surface of a planet. How would they determine whether it is alive?

Movement. One of the first things the astronauts might do is observe the blob to see if it moves. Most animals move about, but movement from one place to another in itself is not diagnostic of life. Most plants and even some animals do not move about, while numerous nonliving objects, such as clouds, do move. The criterion of movement is thus neither necessary (possessed by all life) nor sufficient (possessed only by life).

Sensitivity. The astronauts might prod the blob to see if it responds. Almost all living things respond to stimuli. Plants grow toward light, and animals retreat from fire. Not all stimuli produce responses, however. Imagine kicking a redwood tree or singing to a hibernating bear. This criterion, although superior to the first, is still inadequate to define life.

Death. The astronauts might attempt to kill the blob. All living things die, while inanimate objects do not. Death is not easily distinguished from disorder, however; a car that breaks down has not died because it was never alive. Death is simply the loss of life, so this is a circular definition at best. Unless one can detect life, death is a meaningless concept, and hence a very inadequate criterion for defining life.

Complexity. Finally, the astronauts might cut up the blob, to see if it is complexly organized. All living things are complex. Even the simplest bacteria into many complex structures. However a computer is also complex, but not alive. Complexity is a necessary criterion of life, but it is not sufficient in itself to identify living things because many complex things are not alive. To determine whether the blob is alive, the astronauts would have to learn more about it. Probably the best

thing they could do would be to examine it more carefully and determine whether it resembles the organisms we are familiar with, and if so, how.

What are the fundamental properties of life? All known organisms share certain general properties. To a large degree, these properties define what we mean by life. The following fundamental properties are shared by all organisms on earth.

Cellular organization. All organisms consist of one or more cells—complex, organized assemblages of molecules enclosed within membranes.

Sensitivity. All organisms respond to stimuli — though not always to the same stimuli in the same ways.

Growth. All living things assimilate energy and use it to grow, a process called metabolism. Plants, algae, and some bacteria use sunlight to create covalent carboncarbon bonds from CO2 and H2O through photosynthesis. This transfer of the energy in covalent bonds is essential to all life on earth.

Development. Multicellular organisms undergo systematic gene-directed changes as they grow and mature.

Reproduction. All living things reproduce, passing on traits from one generation to the next. Although some organisms live for a very long time, no organism lives forever, as far as we know. Because all organisms die, ongoing life is impossible without reproduction.

Regulation. All organisms have regulatory mechanisms that coordinate internal processes.

Homeostasis. All living things maintain relatively constant internal conditions, different from their environment.

Theories about the Origin of Cells

The evolution of cells required early organic molecules to assemble into a functional, interdependent unit. Cells, discussed in the next chapter, are essentially little bags of fluid. What the fluid contains depends on the individual cell, but every cell's contents differ from the environment outside the cell. Therefore, an early cell may have floated along in a dilute "primordial soup," but its interior would have had a higher concentration of specific organic molecules.

Cell Origins: The Importance of Bubbles. How did these "bags of fluid" evolve from simple organic molecules? As you can imagine, the answer to this question is a matter for debate. Scientists favoring an "ocean's edge" scenario for the origin of life have proposed that bubbles may have played a key role in this evolutionary step. A bubble, such as those produced by soap solutions, is a hollow spherical structure. Certain molecules, particularly those with hydrophobic regions, will spontaneously form bubbles in water. The structure of the bubble shields the hydrophobic regions of the molecules from contact with water. If you have ever watched the ocean surge upon the shore, you may have noticed the foamy froth created by the agitated water. The edges of the primitive oceans were more than likely very frothy places bombarded by ultraviolet and other ionizing radiation, and exposed to an atmosphere that may have contained methane and other simple organic molecules.

Oparin's Bubble Theory. The first bubble theory is attributed to Alexander Oparin, a Russian chemist with extraordinary insight. In the mid-1930s, Oparin suggested that the present-day atmosphere was incompatible with the creation of life. He proposed that life must have arisen from nonliving matter under a set of very different environmental circumstances some time in the distant history of the earth. His was the theory of primary abiogenesis (primary because all living cells are now known to come from previously living cells, except in that first case). At the same time, J. B. S. Haldane, a British geneticist, was also independently espousing the same views. Oparin decided that in order for cells to evolve, they must have had some means of developing chemical complexity, separating their contents from their environment by means of a cell membrane, and concentrating materials within themselves. He termed these early, chemical-concentrating bubblelike structures protobionts.

Oparin's theories were published in English in 1938, and for awhile most scientists ignored them. However, Harold Urey, an astronomer at the University of Chicago, was quite taken with Oparin's ideas. He convinced one of his graduate students, Stanley Miller, to follow Oparin's rationale and see if he could "create" life. The Urey-Miller experiment has proven to be one of the most significant experiments in the history of science. As a result Oparin's ideas became better known and more widely accepted.

A Host of Bubble Theories. Different versions of "bubble theories" have been championed by numerous scientists since Oparin. The bubbles they propose go by a variety of names; they may be called microspheres, protocells, protobionts, micelles, liposomes, or coacervates, depending on the composition of the bubbles (lipid or protein) and how they form. In all cases, the bubbles are hollow spheres, and they exhibit a variety of cell-like properties. For example, the lipid bubbles called coacervates form an outer boundary with two layers that resembles a biological membrane. They grow by accumulating more subunit lipid molecules from the surrounding medium, and they can form budlike projections and divide by pinching in two, like bacteria. They also can contain amino acids and use them to facilitate various acid-base reactions, including the decomposition of glucose. Although they are not alive, they obviously have many of the characteristics of cells.

A Bubble Scenario. It is not difficult to imagine that a process of chemical evolution involving bubbles or microdrops preceded the origin of life. The early oceans must have contained untold numbers of these microdrops, billions in a spoonful, each one forming spontaneously, persisting for a while, and then dispersing. Some would, by chance, have contained amino acids with side groups able to catalyze growthpromoting reactions. Those microdrops would have survived longer than ones that lacked those amino acids, because the persistence of both proteinoid microspheres and lipid coacervates is greatly increased when they carry out metabolic reactions such as glucose degradation and when they are actively growing.

Over millions of years, then, the complex bubbles that were better able to incorporate molecules and energy from the lifeless oceans of the early earth would have tended to persist longer than the others. Also favored would have been the

microdrops that could use these molecules to expand in size, growing large enough to divide into "daughter" microdrops with features similar to those of their "parent" microdrop. The daughter microdrops have the same favorable combination of characteristics as their parent, and would have grown and divided, too. When a way to facilitate the reliable transfer of new ability from parent to offspring developed, heredity—and life—began.

Current Thinking. Whether the early bubbles that gave rise to cells were lipid or protein remains an unresolved argument. While it is true that lipid microspheres (coacervates) will form readily in water, there appears to be no mechanism for their heritable replication. On the other hand, one *can* imagine a heritable mechanism for protein microspheres. Although protein microspheres do not form readily in water, Sidney Fox and his colleagues at the University of Miami have shown that they can form under dry conditions.

The discovery that RNA can act as an enzyme to assemble new RNA molecules on an RNA template has raised the interesting possibility that neither coacervates nor protein microspheres were the first step in the evolution of life. Perhaps the first components were RNA molecules, and the initial steps on the evolutionary journey led to increasingly complex and stable RNA molecules. Later, stability might have improved further when a lipid (or possibly protein) microsphere surrounded the RNA. At present, those studying this problem have not arrived at a consensus about whether RNA evolved before or after a bubblelike structure that likely preceded cells.

Eventually, DNA took the place of RNA as the replicator in the cell and the storage molecule for genetic information. DNA, because it is a double helix, stores information in a more stable fashion than RNA, which is single-stranded.

Little is known about how the first cells originated. Current hypotheses involve chemical evolution within bubbles, but there is no general agreement about their composition, or about how the process occurred.

DNA Fingerprinting

DNA fingerprinting, also known as DNA typing, is a method of isolating and making images of sequences of DNA. The technique was developed in 1984 by the British geneticist Alec Jeffreys, after he noticed the existence of certain sequences of DNA (called minisatellites) that do not contribute to the function of a gene but are repeated within the gene and in other genes of a DNA sample. Jeffreys also determined that each organism has a unique pattern of these minisatellites, the only exception being multiple individuals from a single zygote (e.g., identical twins).

The procedure for creating a DNA fingerprint consists of first obtaining a sample of cells containing DNA (e.g., from skin, blood, or hair), extracting the DNA, and purifying it. The DNA is then cut at specific points along the strand with substances called restriction enzymes. This produces fragments of varying lengths that are sorted by placing them on a gel and then subjecting the gel to an electric current (electrophoresis): the shorter the fragment the more quickly it will move toward the positive pole (anode). The sorted, double-stranded DNA fragments are then subjected to a blotting technique in which they are split into single strands and

transferred to a nylon sheet. The fragments undergo autoradiography in which they are exposed to DNA probes—pieces of synthetic DNA that have been made radioactive and that bind to the minisatellites. A piece of X-ray film is then exposed to the fragments, and a dark mark is produced at any point where a radioactive probe has become attached. The resultant pattern of these marks can then be analyzed.

An early use of DNA fingerprinting was in legal disputes, notably to help solve crimes and to determine paternity. The technique was challenged, however, over concerns about sample contamination, faulty preparation procedures, and erroneous interpretation of the results. Efforts were made to improve reliability, and today the technique has been refined through the use of more specific and more sensitive probes and better blotting membranes. It also has been recognized that DNA fingerprinting, similar to other DNA analysis techniques, is limited by the quality of the sample obtained. DNA samples that are degraded or collected postmortem typically produce less reliable results than do samples that are obtained from a living individual.

If only a small amount of DNA is available for fingerprinting, PCR may be used to create thousands of copies of a DNA segment. Once an adequate amount of DNA has been produced, the exact sequence of nucleotide pairs in a segment of DNA can be determined using one of several biomolecular sequencing methods. Automated equipment has greatly increased the speed of DNA sequencing and has made available many practical applications, including pinpointing segments of genes that cause genetic diseases, mapping the human genome, engineering drought-resistant plants, and producing biological drugs from genetically altered bacteria.

Behaviour Genetics and Methods of its Strudy

Behaviour genetics, or psychogenetics, is the study of the influence of an organism's genetic composition on its behaviour and the interaction of heredity and environment insofar as they affect behaviour. The question of the determinants of behavioral abilities and disabilities has commonly been referred to as the "nature-nurture" controversy.

The relationship between behaviour and genetics, or heredity, dates to the work of the English scientist Sir Francis Galton (1822–1911), who coined the phrase "nature and nurture." Galton studied the families of outstanding men of his day and concluded, like his cousin Charles Darwin, that mental powers run in families. Galton became the first to use twins in genetic research and pioneered many of the statistical methods of analysis that are in use today. In 1918 British statistician and geneticist Ronald Aylmer Fisher published a paper that showed how Gregor Mendel's laws of inheritance applied to complex traits influenced by multiple genes and environmental factors.

The first human behavioral genetic research on intelligence and mental illness began in the 1920s, when environmentalism (the theory that behaviour is a result of nongenetic factors such as various childhood experiences) became popular and before Nazi Germany's abuse of genetics made the notion of hereditary influence abhorrent. Although genetic research on human behaviour continued throughout the following decades, it was not until the 1970s that a balanced view came to prevail in

psychiatry that recognized the importance of nature as well as nurture. In psychology, this reconciliation did not take hold until the 1980s. Much behavioral genetic research today focuses on identifying specific genes that affect behavioral dimensions, such as personality and intelligence, and disorders, such as autism, hyperactivity, depression, and schizophrenia.

Quantitative genetic methods are used to estimate the net effect of genetic and environmental factors on individual differences in any complex trait, including behavioral traits. In addition, molecular genetic methods are used to identify specific genes responsible for genetic influence. Research is carried out in both animals and humans; however, studies using animal models tend to provide more accurate data than studies in humans because both genes and environment can be manipulated and controlled in the laboratory.

By mating related animals such as siblings for many generations, nearly pure strains are obtained in which all offspring are genetically highly similar. It is possible to screen for genetic influence on behaviour by comparing the behaviour of different inbred strains raised in the same laboratory environment. Another method, known as selective breeding, evaluates genetic involvement by attempting to breed for high and low extremes of a trait for several generations. Both methods have been applied to a wide variety of animal behaviours, especially learning and behavioral responses to drugs, and this research provides evidence for widespread influence of genes on behaviour.

Because genes and environments cannot be manipulated in the human species, two quasi-experimental methods are used to screen for genetic influence on individual differences in complex traits such as behaviour. The twin method relies on the accident of nature that results in identical (monozygotic) twins or fraternal (dizygotic) twins. Monozygotic twins are like clones, genetically identical to each other because they came from the same fertilized egg. Dizygotic twins, on the other hand, developed from two eggs that happened to be fertilized at the same time. Like other siblings, dizygotic twins are only half as similar genetically as monozygotic twins. To the extent that behavioral variability is caused by environmental factors, dizygotic twins should be as similar for the behavioral trait as are monozygotic twins because both types of twins are reared by the same parents in the same place at the same time. If the trait is influenced by genes, then dizygotic twins ought to be less similar than monozygotic twins. For schizophrenia, for example, the concordance (risk of one twin's being schizophrenic if the other is) is about 45 percent for monozygotic twins and about 15 percent for dizygotic twins. For intelligence as assessed by IQ tests, the correlation, an index of resemblance (0.00 indicates no resemblance and 1.00 indicates perfect resemblance), is 0.85 for monozygotic twins and 0.60 for dizygotic twins for studies throughout the world of more than 10,000 pairs of twins. The twin method has been robustly defended as a rough screen for genetic influence on behaviour.

The adoption method is a quasi-experimental design that relies on a social accident in which children are adopted away from their biological (birth) parents early in life, thus cleaving the effects of nature and nurture. Because the twin and adoption methods are so different, greater confidence is warranted when results from

these two methods converge on the same conclusion—as they usually do. An influential adoption study of schizophrenia in 1966 by American behavioral geneticist Leonard Heston showed that children adopted away from their schizophrenic biological mothers at birth were just as likely to become schizophrenic (about 10 percent) as were children reared by their schizophrenic biological mothers. A 20-year study begun in the 1970s in the United States of intelligence of adopted children and their biological and adoptive parents showed increasing similarity from infancy to childhood to adolescence between the adopted children and their biological parents but no resemblance between the adopted children and their adoptive parents.

In contrast to traditional molecular genetic research that focused on rare disorders caused by a single genetic mutation, molecular genetic research on complex behavioral traits and common behavioral disorders is much more difficult because multiple genes are involved and each gene has a relatively small effect. However, some genes identified in animal models have contributed to an improved understanding of complex human behavioral disorders such as reading disability, hyperactivity, autism, and dementia.

Adult Stem Cells

Some tissues in the adult body, such as the epidermis of the skin, the lining of the small intestine, and bone marrow, undergo continuous cellular turnover. They contain stem cells, which persist indefinitely, and a much larger number of "transit amplifying cells," which arise from the stem cells and divide a finite number of times until they become differentiated. The stem cells exist in niches formed by other cells, which secrete substances that keep the stem cells alive and active. Some types of tissue, such as liver tissue, show minimal cell division or undergo cell division only when injured. In such tissues there is probably no special stem-cell population, and any cell can participate in tissue regeneration when required.

Bone marrow contains cells called hematopoietic stem cells, which generate all the cell types of the blood and the immune system. Hematopoietic stem cells are also found in small numbers in peripheral blood and in larger numbers in umbilical cord blood. In bone marrow, hematopoietic stem cells are anchored to osteoblasts of the trabecular bone and to blood vessels. They generate progeny that can become lymphocytes, granulocytes, red blood cells, and certain other cell types, depending on the balance of growth factors in their immediate environment.

Work with experimental animals has shown that transplants of hematopoietic stem cells can occasionally colonize other tissues, with the transplanted cells becoming neurons, muscle cells, or epithelia. The degree to which transplanted hematopoietic stem cells are able to colonize other tissues is exceedingly small. Despite this, the use of hematopoietic stem cell transplants is being explored for conditions such as heart disease or autoimmune disorders. It is an especially attractive option for those opposed to the use of embryonic stem cells.

Bone marrow transplants (also known as bone marrow grafts) represent a type of stem cell therapy that is in common use. They are used to allow cancer patients to survive otherwise lethal doses of radiation therapy or chemotherapy that destroy the

stem cells in bone marrow. For this procedure, the patient's own marrow is harvested before the cancer treatment and is then reinfused into the body after treatment. The hematopoietic stem cells of the transplant colonize the damaged marrow and eventually repopulate the blood and the immune system with functional cells. Bone marrow transplants are also often carried out between individuals (allograft). In this case the grafted marrow has some beneficial antitumour effect. Risks associated with bone marrow allografts include rejection of the graft by the patient's immune system and reaction of immune cells of the graft against the patient's tissues (graft-versus-host disease).

Bone marrow is a source for mesenchymal stem cells (sometimes called marrow stromal cells, or MSCs), which are precursors to non-hematopoietic stem cells that have the potential to differentiate into several different types of cells, including cells that form bone, muscle, and connective tissue. In cell cultures, bone-marrow-derived mesenchymal stem cells demonstrate pluripotency when exposed to substances that influence cell differentiation. Harnessing these pluripotent properties has become highly valuable in the generation of transplantable tissues and organs. In 2008 scientists used mesenchymal stem cells to bioengineer a section of trachea that was transplanted into a woman whose upper airway had been severely damaged by tuberculosis. The stem cells were derived from the woman's bone marrow, cultured in a laboratory, and used for tissue engineering. In the engineering process, a donor trachea was stripped of its interior and exterior cell linings, leaving behind a trachea "scaffold" of connective tissue. The stem cells derived from the recipient were then used to recolonize the interior of the scaffold, and normal epithelial cells, also isolated from the recipient, were used to recolonize the exterior of the trachea. The use of the recipient's own cells to populate the trachea scaffold prevented immune rejection and eliminated the need for immunosuppression therapy. The transplant, which was successful, was the first of its kind.

Research has shown that there are also stem cells in the brain. In mammals very few new neurons are formed after birth, but some neurons in the olfactory bulbs and in the hippocampus are continually being formed. These neurons arise from neural stem cells, which can be cultured
in vitro in the form of neurospheres—small cell clusters that contain stem cells and some of their progeny. This type of stem cell is being studied for use in cell therapy to treat Parkinson disease and other forms of neurodegeneration or traumatic damage to the central nervous system.

Epigenetics

Epigenetics is the study of the chemical modification of specific genes or gene-associated proteins of an organism. Epigenetic modifications can define how the information in genes is expressed and used by cells. The term *epigenetics* came into general use in the early 1940s, when British embryologist Conrad Waddington used it to describe the interactions between genes and gene products, which direct development and give rise to an organism's phenotype (observable characteristics). Since then, information revealed by epigenetics studies has revolutionized the fields of genetics and developmental biology. Specifically, researchers have uncovered a

range of possible chemical modifications to DNA and to proteins called histones that associate tightly with DNA in the nucleus. These modifications can determine when or even if a given gene is expressed in a cell or organism.

It is clear that at least some epigenetic modifications are heritable, passed from parents to offspring, although they are not inherited by the same mechanism as is typical genetic information. Typical genetic information is encoded in the sequences of nucleotides that make up the DNA; this information is therefore passed from generation to generation as faithfully as the DNA replication process is accurate. Epigenetic information, however, is inherited only if the chemical modifications that constitute it are regenerated on newly synthesized DNA or proteins. Some forms of epigenetic modification are faithfully transmitted; however, others may be "erased" or "reset," depending on a variety of factors.

The principal type of epigenetic modification that is understood is methylation (addition of a methyl group). Methylation can be transient and can change rapidly during the life span of a cell or organism, or it can be essentially permanent once set early in the development of the embryo. Other largely permanent chemical modifications also play a role; these include histone acetylation (addition of an acetyl group), ubiquitination (the addition of a ubiquitin protein), and phosphorylation (the addition of a phosphoryl group). The specific location of a given
chemical modification can also be important. For example, certain histone modifications distinguish actively expressed regions of the genome from regions that are not highly expressed. These modifications may correlate with chromosome banding patterns generated by staining procedures common in karyotype analyses. Similarly, specific histone modifications may distinguish actively expressed genes from genes that are poised for expression or genes that are repressed in different kinds of cells.

Epigenetic changes not only influence the expression of genes in plants and animals but also enable the differentiation of pluripotent stem cells (cells having the potential to become any of many different kinds of cells). In other words, epigenetic changes allow cells that all share the same DNA and are ultimately derived from one fertilized egg to become specialized—for example, as liver cells, brain cells, or skin cells.

As the mechanisms of epigenetics become better understood, researchers recognize that the epigenome—chemical modification at the level of the genome—also influences a wide range of biomedical conditions. This new perception has opened the door to a deeper understanding of normal and abnormal biological processes and has offered the possibility of novel interventions that might prevent or ameliorate certain diseases.

Epigenetic contributions to disease fall into two classes. One class involves genes that are themselves regulated epigenetically, such as the imprinted (parent-specific) genes associated with Angelman syndrome or Prader-Willi syndrome. Clinical outcomes in cases of these syndromes depend on the degree to which an inherited normal or mutated gene is or is not expressed. The other class involves genes whose products participate in the epigenetic machinery and thereby regulate the expression of other genes. For example, the gene *MECP2* (methyl CpG binding

protein 2) encodes a protein that binds to specific methylated regions of DNA and contributes to the silencing of those sequences. Mutations that impair the *MECP2* gene can lead to Rett syndrome.

Many tumours and cancers are believed to involve epigenetic changes attributable to environmental factors. These changes include a general decrease in methylation, which is thought to contribute to the increased expression of growthpromoting genes, punctuated by gene-specific increases in methylation that are thought to silence tumour-suppressor genes. Epigenetic signaling attributed to environmental factors has also been associated with some characteristics of aging by researchers that studied the apparently unequal aging rates in genetically identical twins.

One of the most promising areas of epigenetic investigation involves stem cells. Researchers have understood for some time that epigenetic mechanisms play a key role in defining the "potentiality" of stem cells. As those mechanisms become clearer, it may become possible to intervene and effectively alter the developmental state and even the tissue type of given cells. The implications of this work for future clinical regenerative intervention for conditions ranging from trauma to neurodegenerative disease are profound.

Genetic Engineering

The field of genetic engineering encompasses the artificial manipulation, modification, and recombination of DNA or other nucleic acid molecules in order to modify an organism or population of organisms. The term *genetic engineering* initially meant any of a wide range of techniques for the modification or manipulation of organisms through the processes of heredity and reproduction. As such, the term embraced both artificial selection and all the interventions of biomedical techniques, among them artificial insemination, in vitro fertilization (e.g., "test-tube" babies), sperm banks, cloning, and gene manipulation. Today, however, the term denotes the narrower field of recombinant DNA technology, or gene cloning, in which DNA molecules from two or more sources are combined either within cells or in vitro and are then inserted into host organisms in which they are able to propagate. Gene cloning is used to produce new genetic combinations that are of value to science, medicine, agriculture, or industry.

DNA is the carrier of genetic information; it achieves its effects by directing the synthesis of proteins. Most recombinant DNA technology involves the insertion of foreign genes into the plasmids of common laboratory strains of bacteria. Plasmids are small rings of DNA; they are not part of the bacterium's chromosome (the main repository of the organism's genetic information). Nonetheless, they are capable of directing protein synthesis, and, like chromosomal DNA, they are reproduced and passed on to the bacterium's progeny. Thus, by incorporating foreign DNA (for example, a mammalian gene) into a bacterium, researchers can obtain an almost limitless number of copies of the inserted gene. Furthermore, if the inserted gene is operative (i.e., if it directs protein synthesis), the modified bacterium will produce the protein specified by the foreign DNA.

A key step in the development of genetic engineering was the discovery of restriction enzymes in 1968 by the Swiss microbiologist Werner Arber. However, type II restriction enzymes, which are essential to genetic engineering for their ability to cleave a specific site within the DNA (as opposed to type I restriction enzymes, which cleave DNA at random sites), were not identified until 1969, when the American molecular biologist Hamilton O. Smith purified this enzyme. Drawing on Smith's work, the American molecular biologist Daniel Nathans helped advance the technique of DNA recombination in 1970–71 and demonstrated that type II enzymes could be useful in genetic studies. Genetic engineering itself was pioneered in 1973 by the American biochemists Stanley N. Cohen and Herbert W. Boyer, who were among the first to cut DNA into fragments, rejoin different fragments, and insert the new genes into *E. coli* bacteria, which then reproduced.

Genetic engineering has advanced the understanding of many theoretical and practical aspects of gene function and organization. Through recombinant DNA techniques, bacteria have been created that are capable of synthesizing human insulin, human growth hormone, alpha interferon, a hepatitis B vaccine, and other medically useful substances. Plants may be genetically adjusted to enable them to fix nitrogen, and genetic diseases can possibly be corrected by replacing "bad" genes with "normal" ones. Nevertheless, special concern has been focused on such achievements for fear that they might result in the introduction of unfavourable and possibly dangerous traits into microorganisms that were previously free of them—e.g., resistance to antibiotics, production of toxins, or a tendency to cause disease.

The "new" microorganisms created by recombinant DNA research were deemed patentable in 1980, and in 1986 the U.S. Department of Agriculture approved the sale of the first living genetically altered organism—a virus, used as a pseudorabies vaccine, from which a single gene had been cut. Since then hundreds of patents have been awarded for genetically altered bacteria and plants.

What Causes Cancer?

The nucleus of every cell in the human body contains 23 pairs of chromosomes that are made of DNA molecules. Long sections of DNA molecules carry units of information called genes. These genes control all the processes in a cell by producing different kinds of proteins. When a cell divides, the DNA molecules duplicate themselves, and each new cell receives identical copies of the original genes so that it can continue to function normally.

But sometimes things go wrong. In 1914 German biologist Theodor Boveri proposed the idea that cancer was the result of abnormal chromosomes. The idea that cancer was somehow a genetic disease slowly gathered evidence through the twentieth century. Today we believe that changes in genes, called mutations, can convert normal cells into cancer cells. Then, when the cancer cells divide, the mutations in the genes are copied, so more cancer cells are produced. Mutations in perhaps 10 genes out of the 24,000 genes in the human body can cause a cell to become cancerous. These mutations can occur in two kinds of genes: oncogenes and tumor suppressor genes.

Oncogenes are mutations of normal genes that regulate cell growth and cell division, and can cause cancer cells to divide without stopping. In 1976 Michael Bishop and Harold Varmus of the University of California at San Francisco first isolated an oncogene, named *src*, from a type of chicken cancer. The normal *src* gene produces a protein that passes on signals that control cell growth. When this normal gene mutates (changes) to form the *src* oncogene, it produces a different protein that sends continual signals for the cell to grow. This protein is found in certain kinds of lung, colon, and breast cancers. More than 100 oncogenes have now been discovered and linked to specific forms of cancer.

Tumor suppressor genes are normal genes that produce proteins to control cell division and prevent cells with damaged DNA from dividing. If these genes are working properly, cells with mutations that could cause them to become cancer cells are prevented from dividing and forming tumors. In 1986 cancer researchers Thaddeus Dryja, Stephen Friend, and Robert Weinberg found the first tumor suppressor gene, *RB*. Mutations of the *RB* gene cause retinoblastoma, a rare cancer of the eye that occurs in infants. In 1989, researchers found the *p53* tumor suppressor gene, which produces a protein that prevents damaged DNA from being copied during cell division and orders the cell to commit suicide by apoptosis. If the *p53* gene mutates and can't function, cancer cells will divide continually, even when their DNA is damaged, and produce a tumor. Mutations in the *p53* gene are found in more than half of all cancers.

Can X-rays Cause Cancer?

X-rays are common in today's world and are used for everything from screening baggage at airports to making images of organs and bones inside the body. Today we know that X-rays are electromagnetic radiation just like visible light, but the eye cannot see them because their wavelength is too short. They can, however, make an image on film and on special screens.

There is no doubt that X-rays and other forms of radiation can cause cancer. Yet people routinely have diagnostic X-rays at visits to their dentist and doctor, and radiation therapy is prescribed for about half of all cancer patients. Is there a contradiction here?

We are all exposed to radiation from natural sources. This background radiation includes electromagnetic radiation and high-energy particles from the sun, from radioactive elements such as radon, and from cosmic rays coming from space. The background radiation that a person receives each year is greater than what a person receives from routine dental and medical X-rays. A routine X-ray is equivalent to a few days of background radiation. Nevertheless, low doses of radiation from any source do increase the risk of cancer very slightly; however, medical scientists believe that the benefits of routine X-rays outweigh the risk of cancer.

Radiation therapy involves much higher doses of radiation than routine X-rays, so is the risk of cancer greater? The answer is yes. Leukemia, breast cancer, lung cancer, and other cancers may occur 5, 10, or 20 years after radiation therapy has cured the original cancer. Although the risk of developing a secondary cancer from radiation therapy is difficult to measure, it appears to be low. Some cancer patients

worry about radiation therapy giving them cancer. However, the risk of dying from cancer that is not treated is much greater than the risk of developing cancer from radiation therapy.

Radiation therapy is effective in treating cancer because it damages the DNA of cancer cells to the point where it can no longer reproduce itself. Once bombarded by X-rays, gamma rays, or other forms of radiation, cancer cells stop dividing and die off. Radiation therapy can be done externally, with X-rays or a beam of electrons directed into the body, or internally, with radioactive isotopes inserted into or near the tumor. Certain kinds of cancer of the larynx, lung, cervix, prostate, thyroid, and brain are usually treated with radiation therapy.

Thomas Hunt Morgan and his Work on *Drosophila*

American zoologist and geneticist Thomas Hunt Morgan was known for his experimental research with the fruit fly (*Drosophila*) by which he established the chromosome theory of heredity. He showed that genes are linked in a series on chromosomes and are responsible for identifiable, hereditary traits. Morgan's work played a key role in establishing the field of genetics. He received the Nobel Prize for Physiology or Medicine in 1933.

Morgan apparently began breeding *Drosophila* in 1908. In 1909 he observed a small but discrete variation known as white-eye in a single male fly in one of his culture bottles. Aroused by curiosity, he bred the
fly with normal (red-eyed) females. All of the offspring were redeyed. Brother-sister matings among the F1 generation produced a second generation with some white-eyed flies, all of which were males. To explain this curious phenomenon, Morgan developed the hypothesis of sex-limited—today called sex-linked—characters, which he postulated were part of the X chromosome of females.

Other genetic variations arose in Morgan's stock, many of which were also found to be sex-linked. Because all the sex-linked characters were usually inherited together, Morgan became convinced that the X chromosome carried a number of discrete hereditary units, or factors. He adopted the term *gene*, which was introduced by the Danish botanist Wilhelm Johannsen in 1909, and concluded that genes were possibly arranged in a linear fashion on chromosomes. Much to his credit, Morgan rejected his skepticism about both the Mendelian and chromosome theories when he saw from two independent lines of evidence—breeding experiments and cytology—that one could be treated in terms of the other.

In collaboration with American geneticists Alfred Henry Sturtevant, Calvin Blackman Bridges, and Hermann Joseph Muller, who were graduates at Columbia, Morgan quickly developed the *Drosophila* work into a large-scale theory of heredity. Particularly important in this work was the demonstration that each Mendelian gene could be assigned a specific position along a linear chromosome "map." Further cytological work showed that these map positions could be identified with precise chromosome regions, thus providing definitive proof that Mendel's factors had a physical basis in chromosome structure. A summary and presentation of the early phases of this work was published by Morgan, Sturtevant, Bridges, and Muller in

1915 as the influential book *The Mechanism of Mendelian Heredity*. To varying degrees Morgan also accepted the Darwinian theory by 1916.

In 1928 Morgan was invited to organize the division of biology of the California Institute of Technology. He was also instrumental in establishing the Marine Laboratory on Corona del Mar as an integral part of Caltech's biology training program. In subsequent years, Morgan and his coworkers, including a number of postdoctoral and graduate students, continued to elaborate on the many features of the chromosome theory of heredity.

In 1924 Morgan received the Darwin Medal, and in 1939 he was awarded the Copley Medal by the Royal Society of London. Among Morgan's most important books are *Evolution and Adaptation* (1903), *A Critique of the Theory of Evolution* (1916), *Heredity and Sex* (1913), and *The Theory of the Gene*.

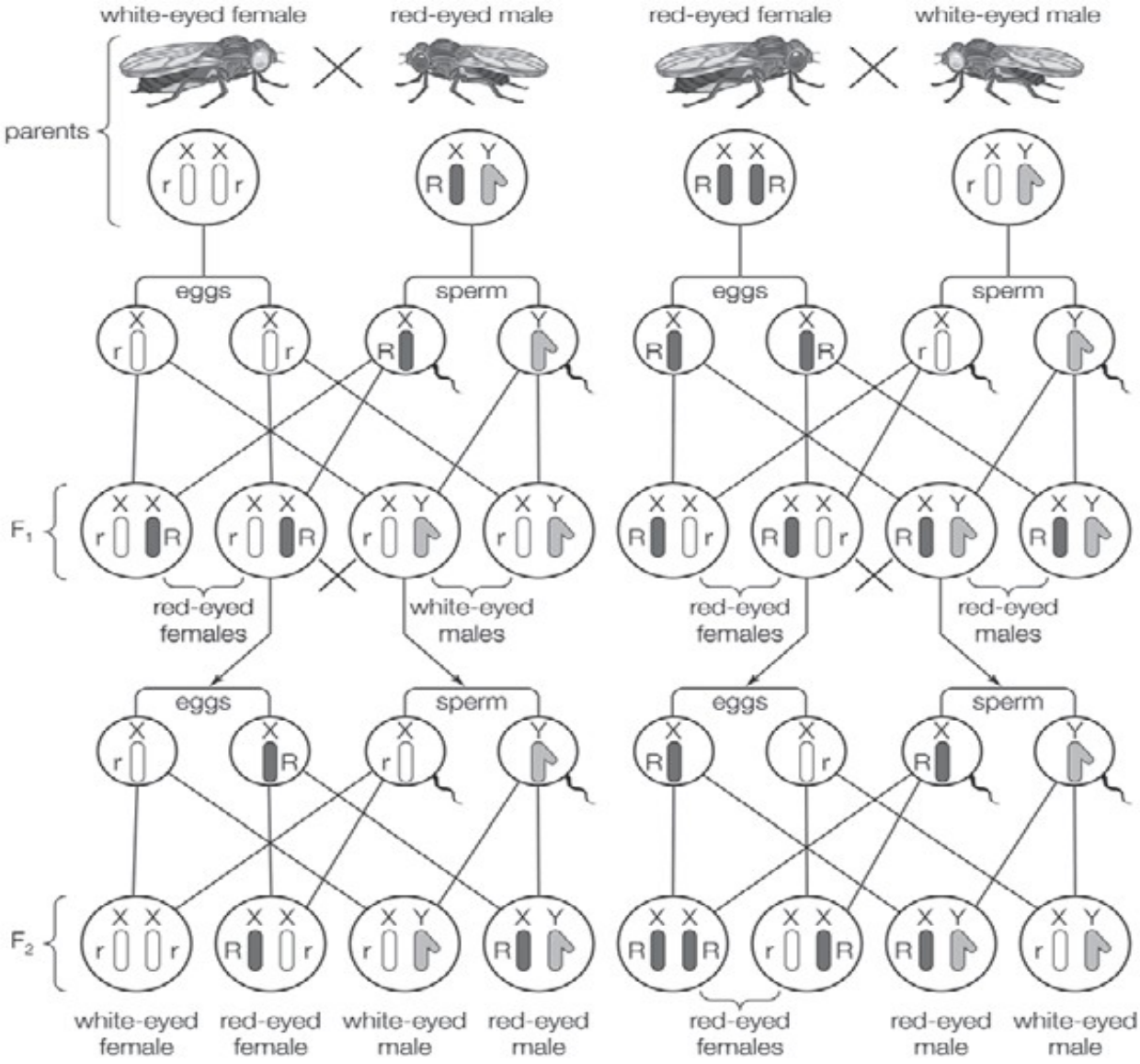


Fig. 1. Sex-linked inheritance of white eyes in Drosophila *flies.* Encyclopedia Britannica, Inc.

Genetically Modified Organisms

A genetically modified organism (GMO) contains a genome that has been engineered in the laboratory in order to favour the expression of desired physiological traits or the production of desired biological products. In conventional livestock production, crop farming, and even pet breeding, it has long been the practice to breed select individuals of a species in order to produce offspring that have desirable traits. In genetic modification, however, recombinant genetic technologies are employed to produce organisms whose genomes have been precisely altered at the molecular level, usually by the inclusion of genes from unrelated species of organisms that code for traits that would not be obtained easily through conventional selective breeding.

GMOs are produced using scientific methods that include recombinant DNA technology and reproductive cloning. Reproductive cloning technology generates offspring that are genetically identical to the parent by the transfer of an entire donor nucleus into the enucleated cytoplasm of a host egg. The first animal produced using this cloning technique was a sheep named Dolly, born in 1996. Since then a number of other animals, including pigs, horses, and dogs, have been generated using reproductive cloning technology. Recombinant DNA technology, on the other hand, involves the insertion of one or more individual genes from an organism of one species into the DNA of another. Whole-genome replacement, involving the transplantation of one bacterial genome into the "cell body," or cytoplasm, of another microorganism, has been reported, although this technology is still limited to basic scientific applications.

GMOs produced through genetic technologies have become a part of everyday life, entering into society through agriculture, medicine, research, and environmental management. However, while GMOs have benefited human society in many ways, some disadvantages exist; therefore, the production of GMOs remains a highly controversial topic in many parts of the world.

Genetically modified (GM) foods were first approved for human consumption in the United States in 1995, and by 1999 almost 50 percent of the corn, cotton, and soybeans planted in the United States were GM. The introduction of these crops dramatically increased per area crop yields and, in some cases, reduced the use of chemical insecticides. For example, the application of wide-spectrum insecticides declined in many areas growing plants, such as potatoes, cotton, and corn, that were endowed with a gene from the bacterium *Bacillus thuringiensis*, which produces a natural insecticide called Bt toxin.

Field studies conducted in India in which Bt cotton was compared with non-Bt cotton demonstrated a 30–80 percent increase in yield from the GM crop. This increase was attributed to marked improvement in the GM plants' ability to overcome bollworm infestation, which was otherwise common. Studies of Bt cotton production in Arizona, U.S., demonstrated only small gains in yield—about 5 percent —with an estimated cost reduction of $25–65 (USD) per acre due to decreased pesticide applications. In China, a seven-year study of farms planting Bt cotton demonstrated initial success of the GM crop, with farmers who had planted Bt cotton reducing their pesticide use by 70 percent and increasing their earnings by 36

percent. However, after four years, the benefits of Bt cotton eroded as populations of insect pests other than bollworm increased, and farmers once again were forced to spray broad-spectrum pesticides. While the problem was not Bt-resistant bollworms, as had been feared initially, it nonetheless became clear that much more research was needed for communities to realize sustainable and environmentally responsible benefits from planting GM crops.

Other GM plants were engineered for resistance to a specific chemical herbicide, rather than resistance to a natural predator or pest. Herbicide-resistant crops (HRC) have been available since the mid-1980s; these crops enable effective chemical control of weeds, since only the HRC plants can survive in fields treated with the corresponding herbicide. However, because these crops encourage increased application of chemicals to the soil, rather than decreased application, they remain controversial with regard to their environmental impact.

By 2002 more than 60 percent of processed foods consumed in the United States contained at least some GM ingredients. Despite the concerns of some consumer groups, especially in Europe, numerous scientific panels, including the U.S. Food and Drug Administration, have concluded that consumption of GM foods is safe, even in cases involving GM foods with genetic material from very distantly related organisms. Indeed, foods containing GM ingredients do not require special labeling in the United States, although some groups have continued to lobby to change this ruling. By 2006, although the majority of GM crops were still grown in the Americas, GM plants tailored for production and consumption in other parts of the world were in field tests. For example, sweet potatoes intended for Africa were modified for resistance to sweet potato feathery mottle virus (SPFMV) by inserting into the sweet potato genome a gene encoding a viral coat protein from the strain of virus that causes SPFMV. The premise for this modification was based on earlier studies in other plants such as tobacco in which introduction of viral coat proteins rendered plants resistant to the virus.

The so-called “golden” rice intended for Asia was genetically modified to produce almost 20 times the betacarotene of previous varieties. Golden rice was created by modifying the rice genome to include a gene from the daffodil *Narcissus pseudonarcissus* that produces an enzyme known as phyotene synthase and a gene from the bacterium *Erwinia uredovora* that produces an enzyme called phyotene desaturase. The introduction of these genes enabled beta-carotene, which is converted to vitamin A in the human liver, to accumulate in the rice endosperm—the edible part of the rice plant—thereby increasing the amount of beta-carotene available for vitamin A synthesis in the body.

Another form of modified rice was generated to help combat iron deficiency, which impacts close to 30 percent of the world population. This GM crop was engineered by introducing into the rice genome a ferritin gene from the common bean, *Phaseolus vulgaris*, that produces a protein capable of binding iron, as well as a gene from the fungus *Aspergillus fumigatus* that produces an enzyme capable of digesting compounds that increase iron bioavailability via digestion of phytate (an inhibitor of iron absorption). The iron-fortified GM rice was engineered to

overexpress an existing rice gene that produces a cysteine-rich metallothioneinlike (metal-binding) protein that enhances iron absorption.

A variety of other crops modified to endure the weather extremes common in other parts of the globe are also in production.

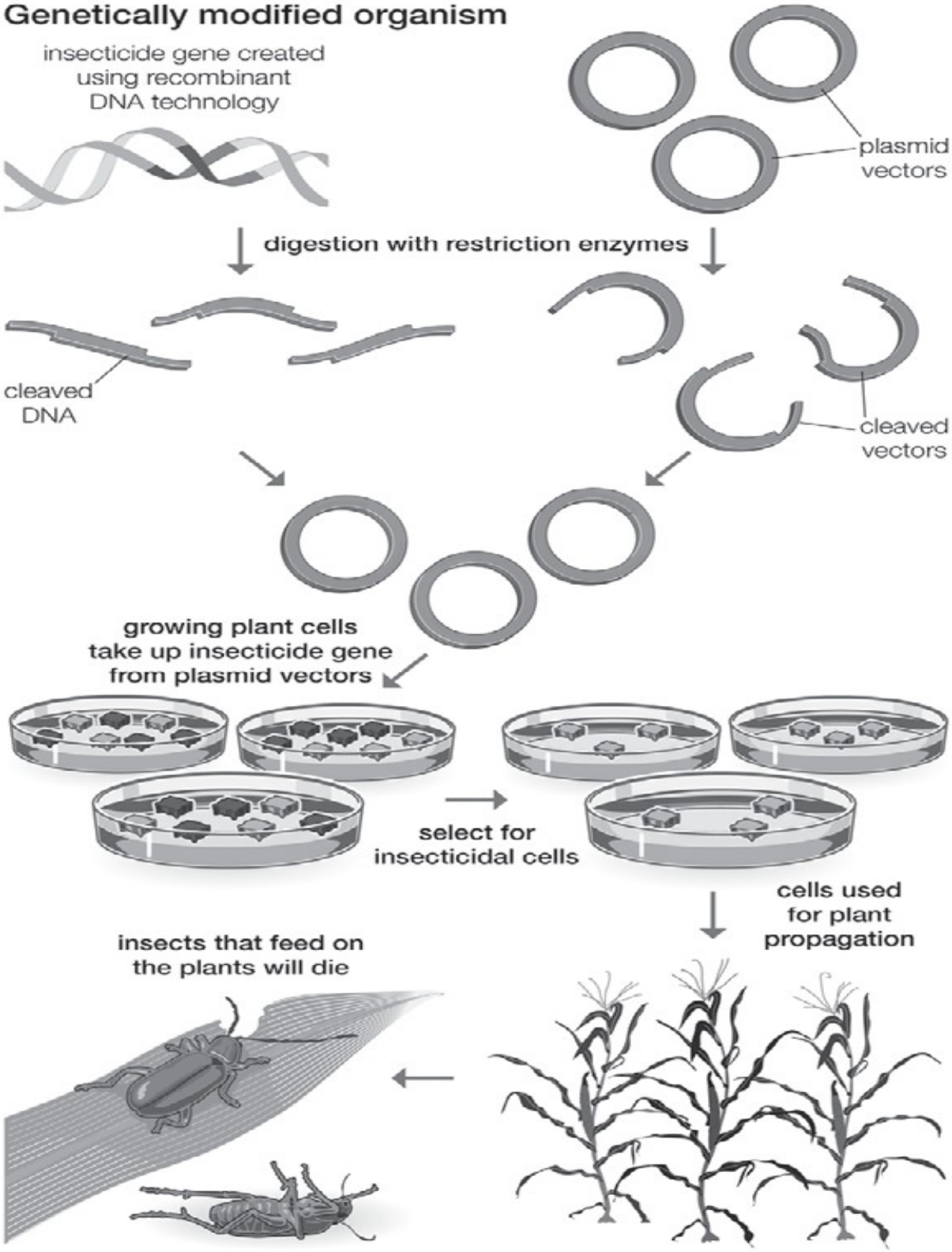


Fig. 1. Genetically modified organisms are produced using scientific methods that include recombinant DNA technology. Encyclop.dia Britannica, Inc.

Early Cloning Experiments

Cloning is the process of generating a genetically identical copy of a cell or an organism. Cloning happens all the time in nature—for example, when a cell replicates itself asexually without any genetic alteration or recombination. Prokaryotic organisms (organisms lacking a cell nucleus), such as bacteria and yeasts, create genetically identical duplicates of themselves using binary fission or budding. In eukaryotic organisms such as humans, all the cells that undergo mitosis, such as skin cells and cells lining the gastrointestinal tract, are clones; the only exceptions are gametes (eggs and sperm), which undergo meiosis and genetic recombination.

In biomedical research cloning is broadly defined to mean the duplication of any kind of biological material for scientific study, such as a piece of DNA or an individual cell. For example, segments of DNA are replicated exponentially by a process known as polymerase chain reaction, or PCR, a technique that is used widely in basic biological research. The type of cloning that is the focus of much ethical controversy involves the generation of cloned embryos, particularly those of humans, which are genetically identical to the organisms from which they are derived, and the subsequent use of these embryos for research, therapeutic, or reproductive purposes.

Reproductive cloning was originally carried out by artificial "twinning," or embryo splitting, which was first performed on a salamander embryo in 1902 by German embryologist Hans Spemann. In 1928, Spemann, who was later awarded the Nobel Prize for Physiology or Medicine (1935) for his research on embryonic development, theorized about another cloning procedure known as nuclear transfer. This procedure was performed in 1952 by American scientists Robert W. Briggs and Thomas J. King, who used DNA from frog embryonic cells to generate cloned tadpoles. A decade later, British biologist John Gurdon successfully carried out nuclear transfer using DNA from adult frog cells.

Advancements in the field of molecular biology led to the development of techniques that allowed scientists to manipulate cells and to detect chemical markers that signal changes within cells. With the advent of recombinant DNA technology in the 1970s, it became possible for scientists to create transgenic clones—clones with genomes containing pieces of DNA from other organisms. Beginning in the 1980s mammals such as sheep were cloned from early and partially differentiated embryonic cells. In 1996 British developmental biologist Ian Wilmut generated a cloned sheep, named Dolly, by means of nuclear transfer involving an enucleated embryo and a differentiated cell nucleus. This technique, which was later refined and became known as somatic cell nuclear transfer (SCNT), represented an extraordinary advance in the science of cloning because it resulted in the creation of a genetically identical clone of an already grown sheep. It also indicated that it was possible for the DNA in differentiated somatic cells to revert to an undifferentiated embryonic stage, thereby reestablishing pluripotency—the potential of an embryonic cell to grow into any one of the numerous different types of mature body cells that make up a complete organism. The realization that the DNA of somatic cells could be reprogrammed to a pluripotent state significantly impacted research into therapeutic cloning and the development of stem cell therapies.

Soon after the generation of Dolly, a number of other animals were cloned by SCNT, including pigs, goats, rats, mice, dogs, horses, and mules. Despite these successes, the birth of a viable SCNT primate clone has not been achieved. In 2001 a team of scientists cloned a rhesus monkey through a process called embryonic cell nuclear transfer, which is similar to SCNT except that it uses DNA from an undifferentiated embryo. In 2007 macaque monkey embryos were cloned by SCNT; however, these clones lived only to the blastocyst stage of embryonic development. Likewise, SCNT has been carried out with very limited success in humans.

Dolly

Dolly, a female Finn Dorset sheep that lived from 1996 to 2003, was the first successfully cloned mammal and was produced by British developmental biologist Ian Wilmut and colleagues of the Roslin Institute, near Edinburgh. The announcement in February 1997 of the world's first clone of an adult animal was a milestone in science, dispelling decades of presumption that adult mammals could not be cloned and igniting a debate concerning the many
possible uses and misuses of mammalian cloning technology.

In the 1990s the concept of mammalian clones, even humans, was not completely new. Naturally occurring genetic clones, or individuals genetically identical to one another, had long been recognized in the form of monozygotic (identical) twins. Unlike Dolly, however, such clones are derived, as their scientific name indicates, from a single zygote, or fertilized egg. Moreover, clones had been generated previously in the laboratory, but only from embryonic cells or from the adult cells of plants and "lower" animals such as frogs.

Decades of attempts to clone mammals from existing adults had met with repeated failure, which led to the presumption that something special and irreversible must happen to the DNA of mammalian cells during the animal's development. Indeed, until 1997 it had been generally accepted dogma that adult mammalian cells are no longer genetically totipotent, or capable of giving rise to all of the different cell and tissue types (e.g., liver, brain, and bone) required for making a complete and viable animal. It was presumed that somatic-cell differentiation, the process by which a single fertilized egg is converted into all of the different cell types found in an adult, involved some irreversible, likely epigenetic step. That Dolly remained alive and well long after her birth—that she had a functional heart, liver, brain, and other organs, all derived genetically from the nuclear DNA of an adult mammarygland cell —proved otherwise. At the very minimum, the specific tissue from which Dolly's nuclear DNA was derived must have been totipotent. By extension, it was reasonable to suggest that the nuclear DNA of other adult tissues also remains totipotent. With the successful creation of Dolly, this speculation became a testable hypothesis.

Dolly did not spring from the laboratory bench fully formed but developed to term normally in the uterus of a Scottish Blackface ewe. Although Dolly's nuclear genome was derived from a mammary-gland cell taken from an adult Finn Dorset ewe, that nucleus had to be fused by electrical pulses with an unfertilized egg cell, the nucleus of which had been removed. The "host" egg cytoplasm was taken from a Scottish Blackface ewe, and later another Scottish Blackface ewe served as the

surrogate mother. Furthermore, in order for the mammary gland cell nucleus and genomic DNA to be accepted and functional within the context of the host egg, the donor cell first had to be induced to abandon the normal cycle of growth and division and enter a quiescent stage. To do this, researchers deliberately withheld nutrients from the cells. The importance of this step had been determined experimentally, and although a number of hypotheses had been raised to explain its necessity, which, if any, of them was correct remained unclear. Nevertheless, starting with a collection of donor cell nuclei and host egg cytoplasms, a number of fused couplets successfully formed embryos; these were transferred to surrogate ewes. Of 13 recipient ewes, one became pregnant, and 148 days later, which is essentially normal gestation for a sheep, Dolly was born.

On Feb. 14, 2003, Dolly was euthanized by veterinarians after being found to suffer from progressive lung disease. Her body was preserved and displayed at the National Museum of Scotland in Edinburgh.

Ethical Controversies of Cloning

Human reproductive cloning remains universally condemned, primarily for the psychological, social, and physiological risks associated with cloning. A cloned embryo intended for implantation into a womb requires thorough molecular testing to fully determine whether an embryo is healthy and whether the cloning process is complete. In addition, as demonstrated by 100 failed attempts to generate a cloned macaque in 2007, a viable pregnancy is not guaranteed. Because the risks associated with reproductive cloning in humans introduce a very high likelihood of loss of life, the process is considered unethical. There are other philosophical issues that also have been raised concerning the nature of reproduction and human identity that reproductive cloning might violate. Concerns about eugenics, the once popular notion that the human species could be improved through the selection of individuals possessing desired traits, also have surfaced, since cloning could be used to breed "better" humans, thus violating principles of human dignity, freedom, and equality.

There also exists controversy over the ethics of therapeutic and research cloning. Some individuals and groups have an objection to therapeutic cloning because it is considered the manufacture and destruction of a human life, even though that life has not developed past the embryonic stage. Those who are opposed to therapeutic cloning believe that the technique supports and encourages acceptance of the idea that human life can be created and expended for any purpose. However, those who support therapeutic cloning believe that there is a moral imperative to heal the sick and to seek greater scientific knowledge. Many of these supporters believe that therapeutic and research cloning should be not only allowed but also publicly funded, similar to other types of disease and therapeutics research. Most supporters also argue that the embryo demands special moral consideration, requiring regulation and oversight by funding agencies. In addition, it is important to many philosophers and policy makers that women and couples not be exploited for the purpose of obtaining their embryos or eggs.

There are laws and international conventions that attempt to uphold certain ethical principles and regulations concerning cloning. In 2005 the United Nations

passed a nonbinding Declaration on Human Cloning that calls upon member states "to adopt all measures necessary to prohibit all forms of human cloning in as much as they are incompatible with human dignity and the protection of human life." This does provide leeway for member countries to pursue therapeutic cloning. The United Kingdom, through its Human Fertilisation and Embryology Authority, issues licenses for creating human embryonic stem cells through nuclear transfer. These licenses ensure that human embryos are cloned for legitimate therapeutic and research purposes aimed at obtaining scientific knowledge about disease and human development. The licenses require the destruction of embryos by the 14th day of development, since this is when embryos begin to develop the primitive streak, the first indicator of an organism's nervous system.

The United States federal government has not passed any laws regarding human cloning due to disagreement within the legislative branch about whether to ban all cloning or to ban only reproductive cloning. The Dickey-Wicker amendment, attached to U.S. appropriations bills since 1995, has prevented the use of federal dollars to fund the harm or destruction of human embryos for research. It is presumed that nuclear transfer and any other form of cloning is subject to this restriction.

Таблиця неправильних дієслів

Неозначена форма (Infinitive)	Просте минуле (Past Simple)	Дієприкметник II (Past Participle)	Переклад на український
arise [ə'raiz]	arose [ə'rəuz]	arisen [ə'riz(ə)n]	з’являтися, піднімати(ся)
awake [ə'weik]	awoke [ə'wəuk]	awoken [ə'wəukən]	будити
be [bi:]	was [wɔz], were [wɜ:]	been [bi:n]	бути
bear [bɛə]	bore [bɔ:]	born [bɔ:n]	нести, народжувати
beat [bi:t]	beat [bi:t]	beaten ['bi:tn]	бити
become [bi:kʌm]	became [bi:keim]	become[bi:kʌm]	ставати
begin [bi'gin]	began [bi'gæn]	begun [bi'gʌn]	починати(ся)
bend [bend]	bent [bent]	bent [bent]	гнути
bet [bet]	bet [bet]	bet [bet]	битися об заклад
bind [baind]	bound [baund]	bound [baund]	зв’язувати
bite [bait]	bit [bit]	bitten ['bitn]	кусати
bleed [bli:d]	bled [bled]	bled [bled]	сходити кров’ю
blow [blou]	blew [blu:]	blown [bloun]	дути
break [breik]	broke [brouk]	broken ['brouk(e)n]	ламати
breed [bri:d]	bred [bred]	bred [bred]	вирощувати
bring [briŋ]	brought [brɔ:t]	brought [brɔ:t]	приносити
broadcast ['brɔ:dka:st]	broadcast ['brɔ:dka:st]	broadcast ['brɔ:dka:st]	віщати, передавати по радіо / ТБ
build [bild]	built [bilt]	built [bilt]	будувати
burn [bɜ:n]	burnt [bɜ:nt]	burnt [bɜ:nt]	горіти, палити
burst [bɜ:st]	burst [bɜ:st]	burst [bɜ:st]	вибухати
buy [bai]	bought [bɔ:t]	bought [bɔ:t]	купувати
catch [kætʃ]	caught [kɔ:t]	caught [kɔ:t]	ловити, встигати
choose [tʃu:z]	chose [ʃəuz]	chosen [tʃəuz(ə)n]	вибирати
come [kʌm]	came [keim]	come [kʌm]	приходити
cost [cɔst]	cost [cɔst]	cost [cɔst]	коштувати
creep [kri:p]	crept [krept]	crept [krept]	повзти
cut [kʌt]	cut [kʌt]	cut [kʌt]	різати

do [du:]	did [did]	done [dʌn]	робити, виконувати
draw [drɔ:]	drew [dru:]	drawn [drɔ:n]	малювати, звертати (увагу)
dream [dri:m]	dreamt [dremt]	dreamt [dremt]	мріяти, снитися
drink [driŋk]	drank [dræŋk]	drunk [drʌŋk]	пити
drive [draiv]	drove [drouv]	driven ['drivn]	керувати авто
eat [i:t]	ate [et]	eaten ['i:tn]	їсти
fall [fɔ:l]	fell [fel]	fallen ['fɔ:lən]	падати
feed [fi:d]	fed [fed]	fed [fed]	годувати
feel [fi:l]	felt [felt]	felt [felt]	почувати (себе)
fight [fait]	fought [fɔ:t]	fought [fɔ:t]	битися, боротися
find [faind]	found [faund]	found [faund]	знаходити
fly [flai]	flew [flu:]	flown [floun]	літати
forget [fə'get]	forgot [fə'gɔt]	forgotten [fə'gɔt(ə)n]	забувати
forgive [fo'giv]	forgave [fo'geiv]	forgiven [fo'givn]	пробачати
freeze [fri:z]	froze [frouz]	frozen ['frouzn]	замерзати
get [get]	got [gɔt]	got [gɔt]	отримувати, розуміти, добиратися
give [giv]	gave [geiv]	given [givn]	давати
go [gou]	went [went]	gone [gɔn]	іти, їхати
grow [grou]	grew [gru:]	grown [groun]	виростити
hang [hæŋ]	hung [hʌŋ]	hung [hʌŋ]	висіти
have [hæv]	had [hæd]	had [hæd]	мати (щось)
hear [hiə]	heard [hɜ:d]	heard [hɜ:d]	чути
hide [haid]	hid [hid]	hidden ['hidn]	ховатися
hit [hit]	hit [hit]	hit [hit]	ударяти
hold [hould]	held [held]	held [held]	тримати
hurt [hɜ:t]	hurt [hɜ:t]	hurt [hɜ:t]	ранити, травмувати
keep [ki:p]	kept [kept]	kept [kept]	тримати, зберігати
know [nou]	knew [nju:]	known [noun]	знати
lay [lei]	laid [leid]	laid [leid]	класти
lead [li:d]	led [led]	led [led]	вести за собою
learn [lɜ:n]	learnt [lɜ:nt]	learnt [lɜ:nt]	вчити(ся)

leave [li:v]	left [left]	left [left]	залишати, покидати
lend [lend]	lent [lent]	lent [lent]	позичати
let [let]	let [let]	let [let]	дозволяти
lie [lai]	lay [lei]	lain [lein]	лежати
light [lait]	lit [lit]	lit [lit]	світити
lose [lu:z]	lost [lɔst]	lost [lɔst]	втрачати
make [meik]	made [meid]	made [meid]	робити
mean [mi:n]	meant [ment]	meant [ment]	означати
meet [mi:t]	met [met]	met [met]	зустрічати
mistake [mis'teik]	mistook [mis'tuk]	mistaken [mis'teik(e)n]	помилятися
pay [pei]	paid [peid]	paid [peid]	платити
prove [pru:v]	proved [pru:vd]	proven [pru:vn]	доводити
put [put]	put [put]	put [put]	класти
read [ri:d]	read [red]	read [red]	читати
ride [raid]	rode [roud]	ridden ['ridn]	кататися
ring [riŋ]	rang [ræŋ]	rung [rʌŋ]	підніматися
rise [raiz]	rose [rouz]	risen ['rizn]	піднімати(ся)
run [rʌŋ]	ran [ræŋ]	run [rʌŋ]	бігти
say [sei]	said [sed]	said [sed]	сказати
see [si:]	saw [sɔ:]	seen [si:n]	бачити
seek [si:k]	sought [sɔ:t]	sought [sɔ:t]	шукати
sell [sel]	sold [sould]	sold [sould]	продавати
send [send]	sent [sent]	sent [sent]	посилати
set [set]	set [set]	set [set]	встановити
shake [ʃeik]	shook [ʃuk]	shaken ['ʃeik(ə)n]	трясти
show [ʃəu]	showed [ʃəud]	shown [ʃəun]	показувати
shrink [ʃriŋk]	shrank [ʃræŋk]	shrunk [ʃrʌŋk]	зменьшувати
shut [ʃʌt]	shut [ʃʌt]	shut [ʃʌt]	закривати
sing [siŋ]	sang [sæŋ]	sung [sʌŋ]	співати
sink [siŋk]	sank [sæŋk], sunk [sʌŋk]	sunk [sʌŋk]	потонути
sit [sit]	sat [sæt]	sat [sæt]	сидіти

sleep [sli:p]	slept [slept]	slept [slept]	спати
speak [spi:k]	spoke [spouk]	spoken ['spouk(e)n]	говорити, розмовляти
spell [spel]	spelt [spelt]	spelt [spelt]	вимовляти по буквам
spend [spend]	spent [spent]	spent [spent]	тратити, проводити (час)
spill [spil]	spilt [spilt]	spilt [spilt]	розливати
spoil [spɔil]	spoilt [spɔilt]	spoilt [spɔilt]	псувати
spread [spred]	spread [spred]	spread [spred]	поширювати
spring [spriŋ]	sprang [spræŋ]	sprung [sprʌŋ]	стрибати
stand [stænd]	stood [stu:d]	stood [stu:d]	стояти
steal [sti:l]	stole [stoul]	stolen ['stəulən]	красти
stick [stik]	stuck [stʌk]	stuck [stʌk]	приклеювати
sting [stiŋ]	stung [stʌŋ]	stung [stʌŋ]	жалити
sweep [swi:p]	swept [swept]	swept [swept]	підмітати
swim [swim]	swam [swem]	swum [swʌm]	плавати
swing [swiŋ]	swung [swʌŋ]	swung [swʌŋ]	гойдатися
take [teik]	took [tuk]	taken ['teik(ə)n]	брати
teach [ti:tʃ]	taught [tɔ:t]	taught [tɔ:t]	навчати
tear [tɛə]	tore [tɔ:]	torn [tɔ:n]	рвати на шматки
tell [tel]	told [tould]	told [tould]	розповідати
think [θiŋk]	thought [θɔ:t]	thought [θɔ:t]	думати
throw [θrəu]	threw [θru:]	thrown [θrəun]	кидати
understand [ʌndə'stænd]	understood [ʌndə'stud]	understood [ʌndə'stud]	розуміти
wake [weik]	woke [wouk]	woken ['wouk(e)n]	прокидатися
wear [wɛə]	wore [wɔ:]	worn [wɔ:n]	носити, одягатися
weep [wi:p]	wept [wept]	wept [wept]	плакати
wet [wet]	wet [wet]	wet [wet]	мочити
win [win]	won [wʌn]	won [wʌn]	перемагати, вигравати
wind [waind]	wound [waund]	wound [waund]	заводити
write [rait]	wrote [rout]	written ['ritn]	писати

GLOSSARY

abiotic Nonliving; referring to the physical and chemical properties of an environment.
acid A substance that increases the hydrogen ion concentration of a solution.
activation energy The amount of energy that reactants must absorb before a chemical reaction will start; also called free energy of activation.
activator A protein that binds to DNA and stimulates gene transcription. In prokaryotes, activators bind in or near the promoter; in eukaryotes, activators generally bind to control elements in enhancers.
active site The specific region of an enzyme that binds the substrate and that forms the pocket in which catalysis occurs.
active transport The movement of a substance across a cell membrane against its concentration or electrochemical gradient, mediated by specific transport proteins and requiring an expenditure of energy.
adhesion The clinging of one substance to another, such as water to plant cell walls by means of hydrogen bonds.
aerobic respiration A catabolic pathway for organic molecules, using oxygen (O2) as the final electron acceptor in an electron transport chain and ultimately producing ATP. This is the most efficient catabolic pathway and is carried out in most eukaryotic cells and many prokaryotic organisms.
AIDS (acquired immunodeficiency syndrome) The symptoms and signs present during the late stages of HIV infection, defined by a specified reduction in the number of T cells and the appearance of characteristic secondary infections.
algae A diverse grade of photosynthetic protists, including unicellular and multicellular forms. Algal species are included in three of the five eukaryote supergroups (Chromalveolata, Rhizaria, and Archaeplastida).
allele Any of the alternative versions of a gene that may produce distinguishable phenotypic effects.
allopatric speciation The formation of new species in populations that are geographically isolated from one another.
allopolyploid A fertile individual that has more than two chromosome sets as a result of two different species interbreeding and combining their chromosomes.
allosteric regulation The binding of a regulatory molecule to a protein at one site that affects the function of the protein at a different site.
alternation of generations A life cycle in which there is both a multicellular diploid form, the sporophyte, and a multicellular haploid form, the gametophyte; characteristic of plants and some algae.
alternative RNA splicing A type of eukaryotic gene regulation at the RNA-processing level in which different mRNA molecules are produced from the same primary transcript, depending on which RNA segments are treated as exons and which as introns.
amino acid An organic molecule possessing both a carboxyl and an amino group. Amino acids serve as the monomers of polypeptides.

amino group A chemical group consisting of a nitrogen atom bonded to two hydrogen atoms; can act as a base in solution, accepting a hydrogen ion and acquiring a charge of 1_.
amoeba A protist grade characterized by the presence of pseudopodia.
amphipathic Having both a hydrophilic region and a hydrophobic region.
amylase An enzyme that hydrolyzes starch (a glucose polymer from plants) and glycogen (a glucose polymer from animals) into smaller polysaccharides and the disaccharide maltose.
anabolic pathway A metabolic pathway that consumes energy to synthesize a complex molecule from simpler molecules.
anaerobic respiration A catabolic pathway in which inorganic molecules other than oxygen accept electrons at the "downhill" end of electron transport chains.
anaphase The fourth stage of mitosis, in which the chromatids of each chromosome have separated and the daughter chromosomes are moving to the poles of the cell.
aneuploidy A chromosomal aberration in which one or more chromosomes are present in extra copies or are deficient in number.
antheridium (plural, **antheridia**) In plants, the male gametangium, a moist chamber in which gametes develop.
antibody A protein secreted by plasma cells (differentiated B cells) that binds to a particular antigen; also called immunoglobulin. All antibodies have the same Y-shaped structure and in their monomer form consist of two identical heavy chains and two identical light chains.
antigen A substance that elicits an immune response by binding to receptors of B cells, antibodies, or of T cells.
apomixis The ability of some plant species to reproduce asexually through seeds without fertilization by a male gamete.
apoptosis A type of programmed cell death, which is brought about by activation of enzymes that break down many chemical components in the cell.
aquaporin A channel protein in the plasma membrane of a plant, animal, or microorganism cell that specifically facilitates osmosis, the diffusion of free water across the membrane.
aqueous solution A solution in which water is the solvent.
Archaea One of two prokaryotic domains, the other being Bacteria.
Archaeplastida One of five supergroups of eukaryotes proposed in a current hypothesis of the evolutionary history of eukaryotes. This monophyletic group, which includes red algae, green algae, and land plants, descended from an ancient protist ancestor that engulfed a cyanobacterium. *See also* Excavata, Chromalveolata, Rhizaria, and Unikonta.
archegonium (plural, **archegonia**) In plants, the female gametangium, a moist chamber in which gametes develop.
artificial selection The selective breeding of domesticated plants and animals to encourage the occurrence of desirable traits.
asexual reproduction The generation of offspring from a single parent that occurs without the fusion of gametes (by budding, division of a single cell, or division of

the entire organism into two or more parts). In most cases, the offspring are genetically identical to the parent.
atom The smallest unit of matter that retains the properties of an element.
atomic nucleus An atom's dense central core, containing protons and neutrons.
ATP (adenosine triphosphate) An adenine-containing nucleoside triphosphate that releases free energy when its phosphate bonds are hydrolyzed. This energy is used to drive endergonic reactions in cells.
ATP synthase A complex of several membrane proteins that functions in chemiosmosis with adjacent electron transport chains, using the energy of a hydrogen ion (proton) concentration gradient to make ATP. ATP synthases are found in the inner mitochondrial membranes of eukaryotic cells and in the plasma membranes of prokaryotes.
autopolyploid An individual that has more than two chromosome sets that are all derived from a single species.
autosome A chromosome that is not directly involved in determining sex; not a sex chromosome.
autotroph An organism that obtains organic food molecules without eating other organisms or substances derived from other organisms. Autotrophs use energy from the sun or from oxidation of inorganic substances to make organic molecules from inorganic ones.
Bacteria One of two prokaryotic domains, the other being Archaea.
bacterial artificial chromosome (BAC) A large plasmid that acts as a bacterial chromosome and can carry inserts of 100,000 to 300,000 base pairs (100–300 kb).
balancing selection Natural selection that maintains two or more phenotypic forms in a population.
base A substance that reduces the hydrogen ion concentration of a solution.
behavioral ecology The study of the evolution of and ecological basis for animal behavior.
benign tumor A mass of abnormal cells with specific genetic and cellular changes such that the cells are not capable of surviving at a new site and generally remain at the site of the tumor's origin.
bicoid A maternal effect gene that codes for a protein responsible for specifying the anterior end in *Drosophila melanogaster*.
binary fission A method of asexual reproduction by "division in half." In prokaryotes, binary fission does not involve mitosis, but in single-celled eukaryotes that undergo binary fission, mitosis is part of the process.
biodiversity hot spot A relatively small area with numerous endemic species and a large number of endangered and threatened species.
bioenergetics (1) The overall flow and transformation of energy in an organism. (2) The study of how energy flows through organisms.
biofilm A surface-coating colony of one or more species of prokaryotes that engage in metabolic cooperation.
biofuel A fuel produced from dry organic matter or combustible oils produced by plants.
biogenic amine A neurotransmitter derived from an amino acid.

biogeochemical cycle Any of the various chemical cycles, which involve both biotic and abiotic components of ecosystems.
biogeography The study of the past and present geographic distribution of species.
bioinformatics The use of computers, software, and mathematical models to process and integrate biological information from large data sets.
biological augmentation An approach to restoration ecology that uses organisms to add essential materials to a degraded ecosystem.
biological clock An internal timekeeper that controls an organism's biological rhythms. The biological clock marks time with or without environmental cues but often requires signals from the environment to remain tuned to an appropriate period.
biological magnification A process in which retained substances become more concentrated at each higher trophic level in a food chain.
biological species concept Definition of a species as a group of populations whose members have the potential to interbreed in nature and produce viable, fertile offspring, but do not produce viable, fertile offspring with members of other such groups.
biology A natural science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy.
biomass The total mass of organic matter comprising a group of organisms in a particular habitat.
biosphere The entire portion of Earth inhabited by life; the sum of all the planet's ecosystems.
biotechnology The manipulation of organisms or their components to produce useful products.
biotic Pertaining to the living factors – the organisms – in an environment.
blastocoel The fluid-filled cavity that forms in the center of a blastula.
blastocyst The blastula stage of mammalian embryonic development, consisting of an inner cell mass, a cavity, and an outer layer, the trophoblast. In humans, the blastocyst forms 1 week after fertilization.
blastula A hollow ball of cells that marks the end of the cleavage stage during early embryonic development in animals.
blood A connective tissue with a fluid matrix called plasma in which red blood cells, white blood cells, and cell fragments called platelets are suspended.
bottleneck effect Genetic drift that occurs when the size of a population is reduced, as by a natural disaster or human actions. Typically, the surviving population is no longer genetically representative of the original population.
bottom-up model A model of community organization in which mineral nutrients influence community organization by controlling plant or phytoplankton numbers, which in turn control herbivore numbers, which in turn control predator numbers.
brainstem A collection of structures in the vertebrate brain, including the midbrain, the pons, and the medulla oblongata; functions in homeostasis, coordination of movement, and conduction of information to higher brain centers.
breathing Ventilation of the lungs through alternating inhalation and exhalation.

brown alga A multicellular, photosynthetic protest with a characteristic brown or olive color that results from carotenoids in its plastids. Most brown algae are marine, and some have a plantlike body (thallus).
Calvin cycle The second of two major stages in photosynthesis (following the light reactions), involving fixation of atmospheric CO2 and reduction of the fixed carbon into carbohydrate.
capsule (1) In many prokaryotes, a dense and well-defined layer of polysaccharide or protein that surrounds the cell wall and is sticky, protecting the cell and enabling it to adhere to substrates or other cells. (2) The sporangium of a bryophyte (moss, liverwort, or hornwort).
carbohydrate A sugar (monosaccharide) or one of its dimers (disaccharides) or polymers (polysaccharides).
carbon fixation The initial incorporation of carbon from CO2 into an organic compound by an autotrophic organism (a plant, another photosynthetic organism, or a chemoautotrophic prokaryote).
catabolic pathway A metabolic pathway that releases energy by breaking down complex molecules to simpler molecules.
catalyst A chemical agent that selectively increases the rate of a reaction without being consumed by the reaction.
cDNA library A gene library containing clones that carry complementary DNA (cDNA) inserts. The library includes only the genes that were transcribed in the cells whose mRNA was isolated to make the cDNA.
cell body The part of a neuron that houses the nucleus and most other organelles.
cell cycle An ordered sequence of events in the life of a cell, from its origin in the division of a parent cell until its own division into two. The eukaryotic cell cycle is composed of interphase (including G1, S, and G2 subphases) and M phase (including mitosis and cytokinesis).
cell cycle control system A cyclically operating set of molecules in the eukaryotic cell that both triggers and coordinates key events in the cell cycle.
cell division The reproduction of cells.
cell fractionation The disruption of a cell and separation of its parts by centrifugation at successively higher speeds.
cell plate A membrane-bounded, flattened sac located at the midline of a dividing plant cell, inside which the new cell wall forms during cytokinesis.
cell wall A protective layer external to the plasma membrane in the cells of plants, prokaryotes, fungi, and some protists. Polysaccharides such as cellulose (in plants and some protists), chitin (in fungi), and peptidoglycan (in bacteria) are important structural components of cell walls.
cell-mediated immune response The branch of adaptive immunity that involves the activation of cytotoxic T cells, which defend against infected cells.
cellular respiration The catabolic pathways of aerobic and anaerobic respiration, which break down organic molecules and use an electron transport chain for the production of ATP.
cellular slime mold A type of protist characterized by unicellular amoeboid cells and aggregated reproductive bodies in its life cycle.

central nervous system (CNS) The portion of the nervous system where signal integration occurs; in vertebrate animals, the brain and spinal cord.
central vacuole In a mature plant cell, a large membranous sac with diverse roles in growth, storage, and sequestration of toxic substances.
centromere In a duplicated chromosome, the region on each sister chromatid where they are most closely attached to each other by proteins that bind to specific DNA sequences; this close attachment causes a constriction in the condensed chromosome. (An uncondensed, unduplicated chromosome has a single centromere, identified by its DNA sequence.)
centrosome A structure present in the cytoplasm of animal cells that functions as a microtubule-organizing center and is important during cell division. A centrosome has two centrioles.
chemical bond An attraction between two atoms, resulting from a sharing of outer-shell electrons or the presence of opposite charges on the atoms. The bonded atoms gain complete outer electron shells.
chemical energy Energy available in molecules for release in a chemical reaction; a form of potential energy.
chemical equilibrium In a chemical reaction, the state in which the rate of the forward reaction equals the rate of the reverse reaction, so that the relative concentrations of the reactants and products do not change with time.
chemical reaction The making and breaking of chemical bonds, leading to changes in the composition of matter.
chemoautotroph An organism that obtains energy by oxidizing inorganic substances and needs only carbon dioxide as a carbon source.
chemoheterotroph An organism that requires organic molecules for both energy and carbon.
chemoreceptor A sensory receptor that responds to a chemical stimulus, such as a solute or an odorant.
chitin A structural polysaccharide, consisting of amino sugar monomers, found in many fungal cell walls and in the exoskeletons of all arthropods.
chlorophyll A green pigment located in membranes within the chloroplasts of plants and algae and in the membranes of certain prokaryotes. Chlorophyll *a* participates directly in the light reactions, which convert solar energy to chemical energy.
chloroplast An organelle found in plants and photosynthetic protists that absorbs sunlight and uses it to drive the synthesis of organic compounds from carbon dioxide and water.
choanocyte A flagellated feeding cell found in sponges. Also called a collar cell, it has a collar-like ring that traps food particles around the base of its flagellum.
cholesterol A steroid that forms an essential component of animal cell membranes and acts as a precursor molecule for the synthesis of other biologically important steroids, such as many hormones.
Chromalveolata One of five supergroups of eukaryotes proposed in a current hypothesis of the evolutionary history of eukaryotes. Chromalveolates may have originated by secondary endosymbiosis and include two large protist clades, the

alveolates and the stramenopiles. *See also* Excavata, Rhizaria, Archaeplastida, and Unikonta.

chromatin The complex of DNA and proteins that makes up eukaryotic chromosomes. When the cell is not dividing, chromatin exists in its dispersed form, as a mass of very long, thin fibers that are not visible with a light microscope.

chromosome A cellular structure carrying genetic material, found in the nucleus of eukaryotic cells. Each chromosome consists of one very long DNA molecule and associated proteins. (A bacterial chromosome usually consists of a single circular DNA molecule and associated proteins. It is found in the nucleoid region, which is not membrane bounded.) *See also* chromatin.

chromosome theory of inheritance A basic principle in biology stating that genes are located at specific positions (loci) on chromosomes and that the behavior of chromosomes during meiosis accounts for inheritance patterns.

chylomicron A lipid transport globule composed of fats mixed with cholesterol and coated with proteins.

circadian rhythm A physiological cycle of about 24 hours that persists even in the absence of external cues.

cleavage (1) The process of cytokinesis in animal cells, characterized by pinching of the plasma membrane. (2) The succession of rapid cell divisions without significant growth during early embryonic development that converts the zygote to a ball of cells.

clonal selection The process by which an antigen selectively binds to and activates only those lymphocytes bearing receptors specific for the antigen. The selected lymphocytes proliferate and differentiate into a clone of effector cells and a clone of memory cells specific for the stimulating antigen.

clone (1) A lineage of genetically identical individuals or cells. (2) In popular usage, an individual that is genetically identical to another individual. (3) As a verb, to make one or more genetic replicas of an individual or cell. *See also* gene cloning.

cloning vector In genetic engineering, a DNA molecule that can carry foreign DNA into a host cell and replicate there. Cloning vectors include plasmids and bacterial artificial chromosomes (BACs), which move recombinant DNA from a test tube back into a cell, and viruses that transfer recombinant DNA by infection.

codominance The situation in which the phenotypes of both alleles are exhibited in the heterozygote because both alleles affect the phenotype in separate, distinguishable ways.

codon A three-nucleotide sequence of DNA or mRNA that specifies a particular amino acid or termination signal; the basic unit of the genetic code.

coenocytic fungus A fungus that lacks septa and hence whose body is made up of a continuous cytoplasmic mass that may contain hundreds or thousands of nuclei.

coenzyme An organic molecule serving as a cofactor. Most vitamins function as coenzymes in metabolic reactions.

coevolution The joint evolution of two interacting species, each in response to selection imposed by the other.

cofactor Any nonprotein molecule or ion that is required for the proper functioning of an enzyme. Cofactors can be permanently bound to the active site or may bind loosely and reversibly, along with the substrate, during catalysis.
cohesion The linking together of like molecules, often by hydrogen bonds.
cohesion-tension hypothesis The leading explanation of the ascent of xylem sap. It states that transpiration exerts pull on xylem sap, putting the sap under negative pressure or tension, and that the cohesion of water molecules transmits this pull along the entire length of the xylem from shoots to roots.
collagen A glycoprotein in the extracellular matrix of animal cells that forms strong fibers, found extensively in connective tissue and bone; the most abundant protein in the animal kingdom.
colloid A mixture made up of a liquid and particles that (because of their large size) remain suspended rather than dissolved in that liquid.
community All the organisms that inhabit a particular area; an assemblage of populations of different species living close enough together for potential interaction.
community ecology The study of how interactions between species affect community structure and organization.
competitive exclusion The concept that when populations of two similar species compete for the same limited resources, one population will use the resources more efficiently and have a reproductive advantage that will eventually lead to the elimination of the other population.
competitive inhibitor A substance that reduces the activity of an enzyme by entering the active site in place of the substrate, whose structure it mimics.
complement system A group of about 30 blood proteins that may amplify the inflammatory response, enhance phagocytosis, or directly lyse extracellular pathogens.
complementary DNA (cDNA) A doublestranded DNA molecule made *in vitro* using mRNA as a template and the enzymes reverse transcriptase and DNA polymerase. A cDNA molecule corresponds to the exons of a gene.
compound A substance consisting of two or more different elements combined in a fixed ratio.
conduction The direct transfer of thermal motion (heat) between molecules of objects in direct contact with each other.
conjugation (1) In prokaryotes, the direct transfer of DNA between two cells that are temporarily joined. When the two cells are members of different species, conjugation results in horizontal gene transfer. (2) In ciliates, a sexual process in which two cells exchange haploid micronuclei but do not reproduce.
connective tissue Animal tissue that functions mainly to bind and support other tissues, having a sparse population of cells scattered through an extracellular matrix.
conservation biology The integrated study of ecology, evolutionary biology, physiology, molecular biology, and genetics to sustain biological diversity at all levels.

contractile vacuole A membranous sac that helps move excess water out of certain freshwater protists.
control element A segment of noncoding DNA that helps regulate transcription of a gene by serving as a binding site for a transcription factor. Multiple control elements are present in a eukaryotic gene's enhancer.
controlled experiment An experiment in which an experimental group is compared with a control group that varies only in the factor being tested.
convection The mass movement of warmed air or liquid to or from the surface of a body or object.
convergent evolution The evolution of similar features in independent evolutionary lineages.
convergent extension A process in which the cells of a tissue layer rearrange themselves in such a way that the sheet of cells becomes narrower (converges) and longer (extends).
cooperativity A kind of allosteric regulation whereby a shape change in one subunit of a protein caused by substrate binding is transmitted to all the other subunits, facilitating binding of additional substrate molecules to those subunits.
corepressor A small molecule that binds to a bacterial repressor protein and changes the protein's shape, allowing it to bind to the operator and switch an operon off.
cortex (1) The outer region of cytoplasm in a eukaryotic cell, lying just under the plasma membrane, that has a more gel-like consistency than the inner regions due to the presence of multiple microfilaments. (2) In plants, ground tissue that is between the vascular tissue and dermal tissue in a root or eudicot stem.
cortical nephron In mammals and birds, a nephron with a loop of Henle located almost entirely in the renal cortex.
countercurrent exchange The exchange of a substance or heat between two fluids flowing in opposite directions. For example, blood in a fish gill flows in the opposite direction of water passing over the gill, maximizing diffusion of oxygen into and carbon dioxide out of the blood.
countercurrent multiplier system A countercurrent system in which energy is expended in active transport to facilitate exchange of materials and generate concentration gradients.
covalent bond A type of strong chemical bond in which two atoms share one or more pairs of valence electrons.
crassulacean acid metabolism (CAM) An adaptation for photosynthesis in arid conditions, first discovered in the family Crassulaceae. In this process, a plant takes up CO2 and incorporates it into a variety of organic acids at night; during the day, CO2 is released from organic acids for use in the Calvin cycle.
crista (plural, **cristae**) An infolding of the inner membrane of a mitochondrion. The inner membrane houses electron transport chains and molecules of the enzyme catalyzing the synthesis of ATP (ATP synthase).
crossing over The reciprocal exchange of genetic material between nonsister chromatids during prophase I of meiosis.

cross-pollination In angiosperms, the transfer of pollen from an anther of a flower on one plant to the stigma of a flower on another plant of the same species.
cuticle (1) A waxy covering on the surface of stems and leaves that prevents desiccation in terrestrial plants. (2) The exoskeleton of an arthropod, consisting of layers of protein and chitin that are variously modified for different functions. (3) A tough coat that covers the body of a nematode.
cyclic AMP (cAMP) Cyclic adenosine monophosphate, a ring-shaped molecule made from ATP that is a common intracellular signaling molecule (second messenger) in eukaryotic cells. It is also a regulator of some bacterial operons.
cyclin A cellular protein that occurs in a cyclically fluctuating concentration and that plays an important role in regulating the cell cycle.
cyclin-dependent kinase (Cdk) A protein kinase that is active only when attached to a particular cyclin.
cytochrome An iron-containing protein that is a component of electron transport chains in the mitochondria and chloroplasts of eukaryotic cells and the plasma membranes of prokaryotic cells.
cytogenetic map A map of a chromosome that locates genes with respect to chromosomal features distinguishable in a microscope.
cytokine Any of a group of small proteins secreted by a number of cell types, including macrophages and helper T cells, that regulate the function of other cells.
cytokinesis The division of the cytoplasm to form two separate daughter cells immediately after mitosis, meiosis I, or meiosis II.
cytoplasm The contents of the cell bounded by the plasma membrane; in eukaryotes, the portion exclusive of the nucleus.
cytoplasmic determinant A maternal substance, such as a protein or RNA, that when placed into an egg influences the course of early development by regulating the expression of genes that affect the developmental fate of cells.
cytoplasmic streaming A circular flow of cytoplasm, involving interactions of myosin and actin filaments, that speeds the distribution of materials within cells.
cytosol The semifluid portion of the cytoplasm.
cytotoxic T cell A type of lymphocyte that, when activated, kills infected cells as well as certain cancer cells and transplanted cells.
decomposer An organism that absorbs nutrients from nonliving organic material such as corpses, fallen plant material, and the wastes of living organisms and converts them to inorganic forms; a detritivore.
dehydration reaction A chemical reaction in which two molecules become covalently bonded to each other with the removal of a water molecule.
deletion (1) A deficiency in a chromosome resulting from the loss of a fragment through breakage. (2) A mutational loss of one or more nucleotide pairs from a gene.
denaturation In proteins, a process in which a protein loses its native shape due to the disruption of weak chemical bonds and interactions, thereby becoming biologically inactive; in DNA, the separation of the two strands of the double helix. Denaturation occurs under extreme (noncellular) conditions of pH, salt concentration, or temperature.

dendritic cell An antigen-presenting cell, located mainly in lymphatic tissues and skin, that is particularly efficient in presenting anti-gens to helper T cells, thereby initiating a primary immune response.
density-dependent inhibition The phenomenon observed in normal animal cells that causes them to stop dividing when they come into contact with one another.
deoxyribonucleic acid (DNA) A nucleic acid molecule, usually a double-stranded helix, in which each polynucleotide strand consists of nucleotide monomers with a deoxyribose sugar and the nitrogenous bases adenine (A), cytosine (C), guanine (G), and thymine (T); capable of being replicated and determining the inherited structure of a cell's proteins.
deoxyribose The sugar component of DNA nucleotides, having one fewer hydroxyl group than ribose, the sugar component of RNA nucleotides.
depolarization A change in a cell's membrane potential such that the inside of the membrane is made less negative relative to the outside.
desmosome A type of intercellular junction in animal cells that functions as a rivet, fastening cells together.
determinate cleavage A type of embryonic development in protostomes that rigidly casts the developmental fate of each embryonic cell very early.
determinate growth A type of growth characteristic of most animals and some plant organs, in which growth stops after a certain size is reached.
determination The progressive restriction of developmental potential in which the possible fate of each cell becomes more limited as an embryo develops. At the end of determination, a cell is committed to its fate.
detritivore A consumer that derives its energy and nutrients from nonliving organic material such as corpses, fallen plant material, and the wastes of living organisms; a decomposer.
detritus Dead organic matter.
diacylglycerol (DAG) A second messenger produced by the cleavage of the phospholipid PIP2 in the plasma membrane.
differential gene expression The expression of different sets of genes by cells with the same genome.
differentiation The process by which a cell or group of cells become specialized in structure and function.
diffusion The spontaneous movement of a substance down its concentration or electrochemical gradient, from a region where it is more concentrated to a region where it is less concentrated.
digestion The second stage of food processing in animals: the breaking down of food into molecules small enough for the body to absorb.
dihybrid An organism that is heterozygous with respect to two genes of interest. All the offspring from a cross between parents doubly homozygous for different alleles are dihybrids. For example, parents of genotypes *AABB* and *aabb* produce a dihybrid of genotype *AaBb*.
dihybrid cross A cross between two organisms that are each heterozygous for both of the characters being followed (or the self-pollination of a plant that is heterozygous for both characters).

diploid cell A cell containing two sets of chromosomes (2*n*), one set inherited from each parent.
directional selection Natural selection in which individuals at one end of the phenotypic range survive or reproduce more successfully than do other individuals.
disaccharide A double sugar, consisting of two monosaccharides joined by a glycosidic linkage formed by a dehydration reaction.
disruptive selection Natural selection in which individuals on both extremes of a phenotypic range survive or reproduce more successfully than do individuals with intermediate phenotypes.
DNA (deoxyribonucleic acid) A double-stranded, helical nucleic acid molecule, consisting of nucleotide monomers with a deoxyribose sugar and the nitrogenous bases adenine (A), cytosine (C), guanine (G), and thymine (T); capable of being replicated and determining the inherited structure of a cell's proteins.
DNA microarray assay A method to detect and measure the expression of thousands of genes at one time. Tiny amounts of a large number of single-stranded DNA fragments representing different genes are fixed to a glass slide and tested for hybridization with samples of labeled cDNA.
DNA polymerase An enzyme that catalyzes the elongation of new DNA (for example, at a replication fork) by the addition of nucleotides to the 3_ end of an existing chain. There are several different DNA polymerases; DNA polymerase III and DNA polymerase I play major roles in DNA replication in *E. coli*.
DNA replication The process by which a DNA molecule is copied; also called DNA synthesis.
domain (1) A taxonomic category above the kingdom level. The three domains are Archaea, Bacteria, and Eukarya. (2) A discrete structural and functional region of a protein.
dominant allele An allele that is fully expressed in the phenotype of a heterozygote.
dominant species A species with substantially higher abundance or biomass than other species in a community. Dominant species exert a powerful control over the occurrence and distribution of other species.
double bond A double covalent bond; the sharing of two pairs of valence electrons by two atoms.
double fertilization A mechanism of fertilization in angiosperms in which two sperm cells unite with two cells in the female gametophyte (embryo sac) to form the zygote and endosperm.
double helix The form of native DNA, referring to its two adjacent antiparallel polynucleotide strands wound around an imaginary axis into a spiral shape.
duplication An aberration in chromosome structure due to fusion with a fragment from a homologous chromosome, such that a portion of a chromosome is duplicated.
dynamic stability hypothesis The concept that long food chains are less stable than short chains.
E site One of a ribosome's three binding sites for tRNA during translation. The E site is the place where discharged tRNAs leave the ribosome. (E stands for exit.)

ecological footprint The aggregate land and water area required by a person, city, or nation to produce all of the resources it consumes and to absorb all of the wastes it generates.
ecological niche (nich) The sum of a species' use of the biotic and abiotic resources in its environment.
ecological species concept A definition of species in terms of ecological niche, the sum of how members of the species interact with the nonliving and living parts of their environment.
ecological succession Transition in the species composition of a community following a disturbance; establishment of a community in an area virtually barren of life.
ecology The study of how organisms interact with each other and their environment.
ecosystem All the organisms in a given area as well as the abiotic factors with which they interact; one or more communities and the physical environment around them.
ecosystem ecology The study of energy flow and the cycling of chemicals among the various biotic and abiotic components in an ecosystem.
ecosystem engineer An organism that influences community structure by causing physical changes in the environment.
ecosystem service A function performed by an ecosystem that directly or indirectly benefits humans.
ecotone The transition from one type of habitat or ecosystem to another, such as the transition from a forest to a grassland.
ectoparasite A parasite that feeds on the external surface of a host.
ectopic Occurring in an abnormal location.
Ediacaran biota An early group of soft-bodied, multicellular eukaryotes known from fossils that range in age from 565 million to 550 million years old.
egg The female gamete.
egg-polarity gene A gene that helps control the orientation (polarity) of the egg; also called a maternal effect gene.
electron microscope (EM) A microscope that uses magnets to focus an electron beam on or through a specimen, resulting in a practical resolution of a hundredfold greater than that of a light microscope using standard techniques. A transmission electron microscope (TEM) is used to study the internal structure of thin sections of cells. A scanning electron microscope (SEM) is used to study the fine details of cell surfaces.
electron transport chain A sequence of electron carrier molecules (membrane proteins) that shuttle electrons down a series of redox reactions that release energy used to make ATP.
electronegativity The attraction of a given atom for the electrons of a covalent bond.
electroporation A technique to introduce recombinant DNA into cells by applying a brief electrical pulse to a solution containing the cells. The pulse creates temporary holes in the cells' plasma membranes, through which DNA can enter.

elimination The fourth and final stage of food processing in animals: the passing of undigested material out of the body.
embryo sac The female gametophyte of angiosperms, formed from the growth and division of the megaspore into a multicellular structure that typically has eight haploid nuclei.
endangered species A species that is in danger of extinction throughout all or a significant portion of its range.
endergonic reaction A nonspontaneous chemical reaction, in which free energy is absorbed from the surroundings.
endomembrane system The collection of membranes inside and surrounding a eukaryotic cell, related either through direct physical contact or by the transfer of membranous vesicles; includes the plasma membrane, the nuclear envelope, the smooth and rough endoplasmic reticulum, the Golgi apparatus, lysosomes, vesicles, and vacuoles.
endoparasite A parasite that lives within a host.
endophyte A fungus that lives inside a leaf or other plant part without causing harm to the plant.
endoplasmic reticulum (ER) An extensive membranous network in eukaryotic cells, continuous with the outer nuclear membrane and composed of ribosome-studded (rough) and ribosome-free (smooth) regions.
endosymbiont theory The theory that mitochondria and plastids, including chloroplasts, originated as prokaryotic cells engulfed by an ancestral eukaryotic cell. The engulfed cell and its host cell then evolved into a single organism.
endosymbiosis A process in which a unicellular organism (the "host") engulfs another cell, which lives within the host cell and ultimately becomes an organelle in the host cell. *See also* endosymbiont theory.
energetic hypothesis The concept that the length of a food chain is limited by the inefficiency of energy transfer along the chain.
energy coupling In cellular metabolism, the use of energy released from an exergonic reaction to drive an endergonic reaction.
enhancer A segment of eukaryotic DNA containing multiple control elements, usually located far from the gene whose transcription it regulates.
enteric division One of three divisions of the autonomic nervous system; consists of networks of neurons in the digestive tract, pancreas, and gallbladder; normally regulated by the sympathetic and parasympathetic divisions of the autonomic nervous system.
entropy A measure of disorder, or randomness.
enzymatic hydrolysis The process in digestion that splits macromolecules from food by the enzymatic addition of water.
enzyme A macromolecule serving as a catalyst, a chemical agent that increases the rate of a reaction without being consumed by the reaction. Most enzymes are proteins.
enzyme-substrate complex A temporary complex formed when an enzyme binds to its substrate molecule(s).

epigenetic inheritance Inheritance of traits transmitted by mechanisms not directly involving the nucleotide sequence of a genome.
epistasis A type of gene interaction in which the phenotypic expression of one gene alters that of another independently inherited gene.
epitope A small, accessible region of an antigen to which an antigen receptor or antibody binds; also called an antigenic determinant.
erythrocyte A blood cell that contains hemoglobin, which transports oxygen; also called a red blood cell.
erythropoietin (EPO) A hormone that stimulates the production of erythrocytes. It is secreted by the kidney when body tissues do not receive enough oxygen.
essential amino acid An amino acid that an animal cannot synthesize itself and must be obtained from food in prefabricated form.
essential element A chemical element required for an organism to survive, grow, and reproduce.
essential fatty acid An unsaturated fatty acid that an animal needs but cannot make.
essential nutrient A substance that an organism cannot synthesize from any other material and therefore must absorb in preassembled form.
estrous cycle A reproductive cycle characteristic of female mammals except humans and certain other primates, in which the nonpregnant endometrium is reabsorbed rather than shed, and sexual response occurs only during mid-cycle at estrus.
etiolation Plant morphological adaptations for growing in darkness.
euchromatin The less condensed form of eukaryotic chromatin that is available for transcription.
Eukarya The domain that includes all eukaryotic organisms.
eukaryotic cell A type of cell with a membrane-enclosed nucleus and membrane-enclosed organelles. Organisms with eukaryotic cells (protists, plants, fungi, and animals) are called eukaryotes.
eutrophication A process by which nutrients, particularly phosphorus and nitrogen, become highly concentrated in a body of water, leading to increased growth of organisms such as algae or cyanobacteria.
evaporation The process by which a liquid changes to a gas.
evaporative cooling The process in which the surface of an object becomes cooler during evaporation, a result of the molecules with the greatest kinetic energy changing from the liquid to the gaseous state.
evapotranspiration The total evaporation of water from an ecosystem, including water transpired by plants and evaporated from a landscape, usually measured in millimeters and estimated for a year.
evo-devo Evolutionary developmental biology; a field of biology that compares developmental processes of different multicellular organisms to understand how these processes have evolved and how changes can modify existing organismal features or lead to new ones.
evolution Descent with modification; the idea that living species are descendants of ancestral species that were different from the presentday ones; also defined

more narrowly as the change in the genetic composition of a population from generation to generation.

Excavata One of five supergroups of eukaryotes proposed in a current hypothesis of the evolutionary history of eukaryotes. Excavates have unique cytoskeletal features, and some species have an "excavated" feeding groove on one side of the cell body. *See also* Chromalveolata, Rhizaria, Archaeplastida, and Unikonta.

excitatory postsynaptic potential (EPSP) An electrical change (depolarization) in the membrane of a postsynaptic cell caused by the binding of an excitatory neurotransmitter from a presynaptic cell to a postsynaptic receptor; makes it more likely for a postsynaptic cell to generate an action potential.

excretion The disposal of nitrogen-containing metabolites and other waste products.

exergonic reaction A spontaneous chemical reaction, in which there is a net release of free energy.

exocytosis The cellular secretion of biological molecules by the fusion of vesicles containing them with the plasma membrane.

exon A sequence within a primary transcript that remains in the RNA after RNA processing; also refers to the region of DNA from which this sequence was transcribed.

exotoxin A toxic protein that is secreted by a prokaryote or other pathogen and that produces specific symptoms, even if the pathogen is no longer present.

expression vector A cloning vector that contains a highly active bacterial promoter just upstream of a restriction site where a eukaryotic gene can be inserted, allowing the gene to be expressed in a bacterial cell. Expression vectors are also available that have been genetically engineered for use in specific types of eukaryotic cells.

external fertilization The fusion of gametes that parents have discharged into the environment.

extracellular digestion The breakdown of food in compartments that are continuous with the outside of an animal's body.

extracellular matrix (ECM) The meshwork surrounding animal cells, consisting of glycoproteins, polysaccharides, and proteoglycans synthesized and secreted by the cells.

F factor In bacteria, the DNA segment that confers the ability to form pili for conjugation and associated functions required for the transfer of DNA from donor to recipient. The F factor may exist as a plasmid or be integrated into the bacterial chromosome.

facilitation An interaction in which one species has a positive effect on the survival and reproduction of another species without the intimate association of a symbiosis.

facultative anaerobe An organism that makes ATP by aerobic respiration if oxygen is present but that switches to anaerobic respiration or fermentation if oxygen is not present.

family In Linnaean classification, the taxonomic category above genus.

fat A lipid consisting of three fatty acids linked to one glycerol molecule; also called a triacylglycerol or triglyceride.
fatty acid A carboxylic acid with a long carbon chain. Fatty acids vary in length and in the number and location of double bonds; three fatty acids linked to a glycerol molecule form a fat molecule, also known as a triacylglycerol or triglyceride.
feedback inhibition A method of metabolic control in which the end product of a metabolic pathway acts as an inhibitor of an enzyme within that pathway.
fermentation A catabolic process that makes a limited amount of ATP from glucose (or other organic molecules) without an electron transport chain and that produces a characteristic end product, such as ethyl alcohol or lactic acid.
fertilization (1) The union of haploid gametes to produce a diploid zygote. (2) The addition of mineral nutrients to the soil.
fiber A lignified cell type that reinforces the xylem of angiosperms and functions in mechanical support; a slender, tapered sclerenchyma cell that usually occurs in bundles.
fibroblast A type of cell in loose connective tissue that secretes the protein ingredients of the extracellular fibers.
fibronectin An extracellular glycoprotein secreted by animal cells that helps them attach to the extracellular matrix.
filtration In excretory systems, the extraction of water and small solutes, including metabolic wastes, from the body fluid.
fimbria (plural, **fimbriae**) A short, hairlike appendage of a prokaryotic cell that helps it adhere to the substrate or to other cells.
fission The separation of an organism into two or more individuals of approximately equal size.
food chain The pathway along which food energy is transferred from trophic level to trophic level, beginning with producers.
food vacuole A membranous sac formed by phagocytosis of microorganisms or particles to be used as food by the cell.
food web The interconnected feeding relationships in an ecosystem.
foot (1) The portion of a bryophyte sporophyte that gathers sugars, amino acids, water, and minerals from the parent gametophyte via transfer cells. (2) One of the three main parts of a mollusc; a muscular structure usually used for movement.
foraging The seeking and obtaining of food.
fossil A preserved remnant or impression of an organism that lived in the past.
founder effect Genetic drift that occurs when a few individuals become isolated from a larger population and form a new population whose gene pool composition is not reflective of that of the original population.
fragmentation A means of asexual reproduction whereby a single parent breaks into parts that regenerate into whole new individuals.
frameshift mutation A mutation occurring when nucleotides are inserted in or deleted from a gene and the number inserted or deleted is not a multiple of three, resulting in the improper grouping of the subsequent nucleotides into codons.

frequency-dependent selection Selection in which the fitness of a phenotype depends on how common the phenotype is in a population.
G protein A GTP-binding protein that relays signals from a plasma membrane signal receptor, known as a G protein-coupled receptor, to other signal transduction proteins inside the cell.
G protein-coupled receptor (GPCR) A signal receptor protein in the plasma membrane that responds to the binding of a signaling molecule by activating a G protein. Also called a G protein-linked receptor.
G0 phase A nondividing state occupied by cells that have left the cell cycle, sometimes reversibly.
G1 phase The first gap, or growth phase, of the cell cycle, consisting of the portion of interphase before DNA synthesis begins.
G2 phase The second gap, or growth phase, of the cell cycle, consisting of the portion of interphase after DNA synthesis occurs.
gametangium (plural, **gametangia**) Multicellular plant structure in which gametes are formed. Female gametangia are called archegonia, and male gametangia are called antheridia.
gamete A haploid reproductive cell, such as an egg or sperm. Gametes unite during sexual reproduction to produce a diploid zygote.
gametogenesis The process by which gametes are produced.
gametophore The mature gamete-producing structure of a moss gametophyte.
gametophyte In organisms (plants and some algae) that have alternation of generations, the multicellular haploid form that produces haploid gametes by mitosis. The haploid gametes unite and develop into sporophytes.
gamma-aminobutyric acid (GABA) An amino acid that functions as a CNS neurotransmitter in the central nervous system of vertebrates.
gap junction A type of intercellular junction in animal cells, consisting of proteins surrounding a pore that allows the passage of materials between cells.
gas exchange The uptake of molecular oxygen from the environment and the discharge of carbon dioxide to the environment.
gastrula An embryonic stage in animal development encompassing the formation of three layers: ectoderm, mesoderm, and endoderm.
gastrulation In animal development, a series of cell and tissue movements in which the blastula-stage embryo folds inward, producing a three-layered embryo, the gastrula.
gated channel A transmembrane protein channel that opens or closes in response to a particular stimulus.
gel electrophoresis A technique for separating nucleic acids or proteins on the basis of their size and electrical charge, both of which affect their rate of movement through an electric field in a gel made of agarose or another polymer.
gene A discrete unit of hereditary information consisting of a specific nucleotide sequence in DNA (or RNA, in some viruses).
gene annotation Analysis of genomic sequences to identify protein-coding genes and determine the function of their products.
gene cloning The production of multiple copies of a gene.

gene expression The process by which information encoded in DNA directs the synthesis of proteins or, in some cases, RNAs that are not translated into proteins and instead function as RNAs.
gene flow The transfer of alleles from one population to another, resulting from the movement of fertile individuals or their gametes.
gene pool The aggregate of all copies of every type of allele at all loci in every individual in a population. The term is also used in a more restricted sense as the aggregate of alleles for just one or a few loci in a population.
gene therapy The introduction of genes into an afflicted individual for therapeutic purposes.
gene-for-gene recognition A widespread form of plant disease resistance involving recognition of pathogen-derived molecules by the protein products of specific plant disease resistance genes.
genetic drift A process in which chance events cause unpredictable fluctuations in allele frequencies from one generation to the next. Effects of genetic drift are most pronounced in small populations.
genetic engineering The direct manipulation of genes for practical purposes.
genetic map An ordered list of genetic loci (genes or other genetic markers) along a chromosome.
genetic profile An individual's unique set of genetic markers, detected most often today by PCR or, previously, by electrophoresis and nucleic acid probes.
genetic recombination General term for the production of offspring with combinations of traits that differ from those found in either parent.
genetic variation Differences among individuals in the composition of their genes or other DNA segments.
genetically modified (GM) organism An organism that has acquired one or more genes by artificial means; also known as a transgenic organism.
genetics The scientific study of heredity and hereditary variation.
genome The genetic material of an organism or virus; the complete complement of an organism's or virus's genes along with its noncoding nucleic acid sequences.
genome-wide association study A large-scale analysis of the genomes of many people having a certain phenotype or disease, with the aim of finding genetic markers that correlate with that phenotype or disease.
genomic imprinting A phenomenon in which expression of an allele in offspring depends on whether the allele is inherited from the male or female parent.
genomic library A set of cell clones containing all the DNA segments from a genome, each within a plasmid, BAC, or other cloning vector.
genomics The study of whole sets of genes and their interactions within a species, as well as genome comparisons between species.
genotype The genetic makeup, or set of alleles, of an organism.
genus (plural, **genera**) A taxonomic category above the species level, designated by the first word of a species' two-part scientific name.
geologic record The division of Earth's history into time periods, grouped into three eons – Archaean, Proterozoic, and Phanerozoic—and further subdivided into eras, periods, and epochs.

germ layer One of the three main layers in a gastrula that will form the various tissues and organs of an animal body.
gestation Pregnancy; the state of carrying developing young within the female reproductive tract.
global climate change Increase in temperature and change in weather patterns all around the planet, due mostly to increasing atmospheric CO2 levels from the burning of fossil fuels. The increase in temperature, called global warming, is a major aspect of global climate change.
global ecology The study of the functioning and distribution of organisms across the biosphere and how the regional exchange of energy and materials affects them.
glutamate An amino acid that functions as a neurotransmitter in the central nervous system.
glyceraldehyde 3-phosphate (G3P) A three-carbon carbohydrate that is the direct product of the Calvin cycle; it is also an intermediate in glycolysis.
glycogen An extensively branched glucose storage polysaccharide found in the liver and muscle of animals; the animal equivalent of starch.
glycolipid A lipid with one or more covalently attached carbohydrates.
glycolysis A series of reactions that ultimately splits glucose into pyruvate. Glycolysis occurs in almost all living cells, serving as the starting point for fermentation or cellular respiration.
glycoprotein A protein with one or more covalently attached carbohydrates.
glycosidic linkage A covalent bond formed between two monosaccharides by a dehydration reaction.
golden alga A biflagellated, photosynthetic protist named for its color, which results from its yellow and brown carotenoids.
Golgi apparatus An organelle in eukaryotic cells consisting of stacks of flat membranous sacs that modify, store, and route products of the endoplasmic reticulum and synthesize some products, notably noncellulose carbohydrates.
grade A group of organisms that share the same level of organizational complexity or share a key adaptation.
Gram stain A staining method that distinguishes between two different kinds of bacterial cell walls; may be used to help determine medical response to an infection.
gram-negative Describing the group of bacteria that have a cell wall that is structurally more complex and contains less peptidoglycan than the cell wall of gram-positive bacteria. Gramnegative bacteria are often more toxic than gram-positive bacteria.
gram-positive Describing the group of bacteria that have a cell wall that is structurally less complex and contains more peptidoglycan than the cell wall of gram-negative bacteria. Gram-positive bacteria are usually less toxic than gram-negative bacteria.
granum (plural, **grana**) A stack of membrane-bounded thylakoids in the chloroplast. Grana function in the light reactions of photosynthesis.
green alga A photosynthetic protist, named for green chloroplasts that are similar in structure and pigment composition to those of land plants. Green algae are a

paraphyletic group, some of whose members are more closely related to land plants than they are to other green algae.
greenhouse effect The warming of Earth due to the atmospheric accumulation of carbon dioxide and certain other gases, which absorb reflected infrared radiation and reradiate some of it back toward Earth.
gross primary production (GPP) The total primary production of an ecosystem.
growth factor (1) A protein that must be present in the extracellular environment (culture medium or animal body) for the growth and normal development of certain types of cells. (2) A local regulator that acts on nearby cells to stimulate cell proliferation and differentiation.
guard cells The two cells that flank the stomatal pore and regulate the opening and closing of the pore.
gustation The sense of taste.
hair cell A mechanosensory cell that alters output to the nervous system when hairlike projections on the cell surface are displaced.
Hamilton's rule The principle that for natural selection to favor an altruistic act, the benefit to the recipient, devalued by the coefficient of relatedness, must exceed the cost to the altruist.
haploid cell A cell containing only one set of chromosomes (*n*).
Hardy-Weinberg principle The principle that frequencies of alleles and genotypes in a population remain constant from generation to generation, provided that only Mendelian segregation and recombination of alleles are at work.
heavy chain One of the two types of polypeptide chains that make up an antibody molecule and B cell receptor; consists of a variable region, which contributes to the antigenbinding site, and a constant region.
helicase An enzyme that untwists the double helix of DNA at replication forks, separating the two strands and making them available as template strands.
helper T cell A type of T cell that, when activated, secretes cytokines that promote the response of B cells (humoral response) and cytotoxic T cells (cell-mediated response) to antigens.
hemoglobin An iron-containing protein in red blood cells that reversibly binds oxygen.
heredity The transmission of traits from one generation to the next.
hermaphrodite An individual that functions as both male and female in sexual reproduction by producing both sperm and eggs.
hermaphroditism A condition in which an individual has both female and male gonads and functions as both a male and female in sexual reproduction by producing both sperm and eggs.
heterochromatin Eukaryotic chromatin that remains highly compacted during interphase and is generally not transcribed.
heterocyst A specialized cell that engages in nitrogen fixation in some filamentous cyanobacteria; also called a *heterocyte*.
heteromorphic Referring to a condition in the life cycle of plants and certain algae in which the sporophyte and gametophyte generations differ in morphology.

heterosporous Referring to a plant species that has two kinds of spores: microspores, which develop into male gametophytes, and megaspores, which develop into female gametophytes.
heterotroph An organism that obtains organic food molecules by eating other organisms or substances derived from them.
heterozygote advantage Greater reproductive success of heterozygous individuals compared with homozygotes; tends to preserve variation in a gene pool.
heterozygous Having two different alleles for a given gene.
high-density lipoprotein (HDL) A particle in the blood made up of thousands of cholesterol molecules and other lipids bound to a protein. HDL scavenges excess cholesterol.
histone A small protein with a high proportion of positively charged amino acids that binds to the negatively charged DNA and plays a key role in chromatin structure.
histone acetylation The attachment of acetyl groups to certain amino acids of histone proteins.
HIV (human immunodeficiency virus) The infectious agent that causes AIDS. HIV is a retrovirus.
holoblastic Referring to a type of cleavage in which there is complete division of the egg; occurs in eggs that have little yolk (such as those of the sea urchin) or a moderate amount of yolk (such as those of the frog).
homeobox A 180-nucleotide sequence within homeotic genes and some other developmental genes that is widely conserved in animals. Related sequences occur in plants and yeasts.
homeotic gene Any of the master regulatory genes that control placement and spatial organization of body parts in animals, plants, and fungi by controlling the developmental fate of groups of cells.
hominin A member of the human branch of the evolutionary tree. Hominins include *Homo sapiens* and our ancestors, a group of extinct species that are more closely related to us than to chimpanzees.
homologous chromosomes A pair of chromosomes of the same length, centromere position, and staining pattern that possess genes for the same characters at corresponding loci. One homologous chromosome is inherited from the organism's father, the other from the mother. Also called homologs, or a homologous pair.
homologous structures Structures in different species that are similar because of common ancestry.
homology Similarity in characteristics resulting from a shared ancestry.
homoplasy A similar (analogous) structure or molecular sequence that has evolved independently in two species.
homozygous Having two identical alleles for a given gene.
hormone In multicellular organisms, one of many types of secreted chemicals that are formed in specialized cells, travel in body fluids, and act on specific target cells in other parts of the body, changing the target cells' functioning. Hormones are thus important in long-distance signaling.

Human Genome Project An international collaborative effort to map and sequence the DNA of the entire human genome.
hybrid Offspring that results from the mating of individuals from two different species or from two true-breeding varieties of the same species.
hybridization In genetics, the mating, or crossing, of two true-breeding varieties.
hydrocarbon An organic molecule consisting only of carbon and hydrogen.
hydrogen bond A type of weak chemical bond that is formed when the slightly positive hydrogen atom of a polar covalent bond in one molecule is attracted to the slightly negative atom of a polar covalent bond in another molecule or in another region of the same molecule.
hydrolysis A chemical reaction that breaks bonds between two molecules by the addition of water; functions in disassembly of polymers to monomers.
hydrophilic Having an affinity for water.
hydrophobic Having no affinity for water; tending to coalesce and form droplets in water.
hydrophobic interaction A type of weak chemical interaction caused when molecules that do not mix with water coalesce to exclude water.
hydroponic culture A method in which plants are grown in mineral solutions rather than in soil.
hydroxyl group A chemical group consisting of an oxygen atom joined to a hydrogen atom. Molecules possessing this group are soluble in water and are called alcohols.
hypotonic Referring to a solution that, when surrounding a cell, will cause the cell to take up water.
imbibition The physical adsorption of water onto the internal surfaces of structures.
immunization The process of generating a state of immunity by artificial means. In active immunization, also called vaccination, an inactive or weakened form of a pathogen is administered, inducing B and T cell responses and immunological memory. In passive immunization, antibodies specific for a particular microbe are administered, conferring immediate but temporary protection.
immunodeficiency A disorder in which the ability of an immune system to protect against pathogens is defective or absent.
immunoglobulin (Ig) Any of the class of proteins that function as antibodies. Immunoglobulins are divided into five major classes that differ in their distribution in the body and antigen disposal activities.
imprinting In animal behavior, the formation at a specific stage in life of a long-lasting behavioral response to a specific individual or object.
***in situ* hybridization** A technique using nucleic acid hybridization with a labeled probe to detect the location of a specific mRNA in an intact organism.
***in vitro* fertilization (IVF)** Fertilization of oocytes in laboratory containers followed by artificial implantation of the early embryo in the mother's uterus.
***in vitro* mutagenesis** A technique used to discover the function of a gene by cloning it, introducing specific changes into the cloned gene's sequence, reinserting the mutated gene into a cell, and studying the phenotype of the mutant.

incomplete dominance The situation in which the phenotype of heterozygotes is intermediate between the phenotypes of individuals homozygous for either allele.
inducer A specific small molecule that binds to a bacterial repressor protein and changes the repressor's shape so that it cannot bind to an operator, thus switching an operon on.
induction The process in which one group of embryonic cells influences the development of another, usually by causing changes in gene expression.
inflammatory response An innate immune defense triggered by physical injury or infection of tissue involving the release of substances that promote swelling, enhance the infiltration of white blood cells, and aid in tissue repair and destruction of invading pathogens.
ingestion The first stage of food processing in animals: the act of eating.
inhibitory postsynaptic potential (IPSP) An electrical change (usually hyperpolarization) in the membrane of a postsynaptic neuron caused by the binding of an inhibitory neurotransmitter from a presynaptic cell to a postsynaptic receptor; makes it more difficult for a postsynaptic neuron to generate an action potential.
innate behavior Animal behavior that is developmentally fixed and under strong genetic control. Innate behavior is exhibited in virtually the same form by all individuals in a population despite internal and external environmental differences during development and throughout their lifetimes.
innate immunity A form of defense common to all animals that is active immediately upon exposure to pathogens and that is the same whether or not the pathogen has been encountered previously.
inner cell mass An inner cluster of cells at one end of a mammalian blastocyst that subsequently develops into the embryo proper and some of the extraembryonic membranes.
inositol trisphosphate (IP3) A second messenger that functions as an intermediate between certain signaling molecules and a subsequent second messenger, Ca2_, by causing a rise in cytoplasmic Ca2_ concentration.
insertion A mutation involving the addition of one or more nucleotide pairs to a gene.
integral protein A transmembrane protein with hydrophobic regions that extend into and often completely span the hydrophobic interior of the membrane and with hydrophilic regions in contact with the aqueous solution on one or both sides of the membrane (or lining the channel in the case of a channel protein).
integrin In animal cells, a transmembrane receptor protein with two subunits that interconnects the extracellular matrix and the cytoskeleton.
intermediate disturbance hypothesis The concept that moderate levels of disturbance can foster greater species diversity than low or high levels of disturbance.
internal fertilization The fusion of eggs and sperm within the female reproductive tract. The sperm are typically deposited in or near the tract.
interphase The period in the cell cycle when the cell is not dividing. During interphase, cellular metabolic activity is high, chromosomes and organelles are

duplicated, and cell size may increase. Interphase often accounts for about 90% of the cell cycle.
intersexual selection Selection whereby individuals of one sex (usually females) are choosy in selecting their mates from individuals of the other sex; also called mate choice.
interspecific competition Competition for resources between individuals of two or more species when resources are in short supply.
interspecific interaction A relationship between individuals of two or more species in a community.
interstitial fluid The fluid filling the spaces between cells in most animals.
intrasexual selection Selection in which there is direct competition among individuals of one sex for mates of the opposite sex.
introduced species A species moved by humans, either intentionally or accidentally, from its native location to a new geographic region; also called non-native or exotic species.
intron A noncoding, intervening sequence within a primary transcript that is removed from the transcript during RNA processing; also refers to the region of DNA from which this sequence was transcribed.
invasive species A species, often introduced by humans, that takes hold outside its native range.
inversion An aberration in chromosome structure resulting from reattachment of a chromosomal fragment in a reverse orientation to the chromosome from which it originated.
invertebrate An animal without a backbone. Invertebrates make up 95% of animal species.
ionic bond A chemical bond resulting from the attraction between oppositely charged ions.
ionic compound A compound resulting from the formation of an ionic bond; also called a salt.
isomer One of several compounds with the same molecular formula but different structures and therefore different properties. The three types of isomers are structural isomers, *cis-trans* isomers, and enantiomers.
isomorphic Referring to alternating generations in plants and certain algae in which the sporophytes and gametophytes look alike, although they differ in chromosome number.
isopod A member of one of the largest groups of crustaceans, which includes terrestrial, freshwater, and marine species. Among the terrestrial isopods are the pill bugs, or wood lice.
isotonic Referring to a solution that, when surrounding a cell, causes no net movement of water into or out of the cell.
karyotype A display of the chromosome pairs of a cell arranged by size and shape.
keystone species A species that is not necessarily abundant in a community yet exerts strong control on community structure by the nature of its ecological role or niche.

kin selection Natural selection that favors altruistic behavior by enhancing the reproductive success of relatives.
kinetochore A structure of proteins attached to the centromere that links each sister chromatid to the mitotic spindle.
kinetoplastid A protist, such as a trypanosome, that has a single large mitochondrion that houses an organized mass of DNA.
kingdom A taxonomic category, the second broadest after domain.
***K*-selection** Selection for life history traits that are sensitive to population density; also called density-dependent selection.
landscape ecology The study of how the spatial arrangement of habitat types affects the distribution and abundance of organisms and ecosystem processes.
larva (plural, **larvae**) A free-living, sexually immature form in some animal life cycles that may differ from the adult animal in morphology, nutrition, and habitat.
lateral inhibition A process that sharpens the edges and enhances the contrast of a perceived image by inhibiting receptors lateral to those that have responded to light.
law of independent assortment Mendel's second law, stating that each pair of alleles segregates, or assorts, independently of each other pair during gamete formation; applies when genes for two characters are located on different pairs of homologous chromosomes or when they are far enough apart on the same chromosome to behave as though they are on different chromosomes.
law of segregation Mendel's first law, stating that the two alleles in a pair segregate (separate from each other) into different gametes during gamete formation.
leaf The main photosynthetic organ of vascular plants.
leukocyte A blood cell that functions in fighting infections; also called a white blood cell.
lichen The mutualistic association between a fungus and a photosynthetic alga or cyanobacterium.
life cycle The generation-to-generation sequence of stages in the reproductive history of an organism.
ligand A molecule that binds specifically to another molecule, usually a larger one.
ligand-gated ion channel A transmembrane protein containing a pore that opens or closes as it changes shape in response to a signaling molecule (ligand), allowing or blocking the flow of specific ions; also called an ionotropic receptor.
light chain One of the two types of polypeptide chains that make up an antibody molecule and B cell receptor; consists of a variable region, which contributes to the antigen-binding site, and a constant region.
light microscope (LM) An optical instrument with lenses that refract (bend) visible light to magnify images of specimens.
light reactions The first of two major stages in photosynthesis (preceding the Calvin cycle). These reactions, which occur on the thylakoid membranes of the chloroplast or on membranes of certain prokaryotes, convert solar energy to the chemical energy of ATP and NADPH, releasing oxygen in the process.

light-harvesting complex A complex of proteins associated with pigment molecules (including chlorophyll *a*, chlorophyll *b*, and carotenoids) that captures light energy and transfers it to reaction-center pigments in a photosystem.
linkage map A genetic map based on the frequencies of recombination between markers during crossing over of homologous chromosomes.
linked genes Genes located close enough together on a chromosome that they tend to be inherited together.
lipid Any of a group of large biological molecules, including fats, phospholipids, and steroids, that mix poorly, if at all, with water.
local regulator A secreted molecule that influences cells near where it is secreted.
locus (plural, **loci**) A specific place along the length of a chromosome where a given gene is located.
low-density lipoprotein (LDL) A particle in the blood made up of thousands of cholesterol molecules and other lipids bound to a protein. LDL transports cholesterol from the liver for incorporation into cell membranes.
lymphocyte A type of white blood cell that mediates immune responses. The two main classes are B cells and T cells.
lysogenic cycle A type of phage replicative cycle in which the viral genome becomes incorporated into the bacterial host chromosome as a prophage, is replicated along with the chromosome, and does not kill the host.
lysosome A membrane-enclosed sac of hydrolytic enzymes found in the cytoplasm of animal cells and some protists.
lysozyme An enzyme that destroys bacterial cell walls; in mammals, found in sweat, tears, and saliva.
lytic cycle A type of phage replicative cycle resulting in the release of new phages by lysis (and death) of the host cell.
macromolecule A giant molecule formed by the joining of smaller molecules, usually by a dehydration reaction. Polysaccharides, proteins, and nucleic acids are macromolecules.
macronutrient An essential element that an organism must obtain in relatively large amounts. *See also* micronutrient.
macrophage A phagocytic cell present in many tissues that functions in innate immunity by destroying microbes and in acquired immunity as an antigen-presenting cell.
major histocompatibility complex (MHC) molecule A host protein that functions in antigen presentation. Foreign MHC molecules on transplanted tissue can trigger T cell responses that may lead to rejection of the transplant.
malignant tumor A cancerous tumor containing cells that have significant genetic and cellular changes and are capable of invading and surviving in new sites. Malignant tumors can impair the functions of one or more organs.
mammal Member of the class Mammalia, amniotes that have hair and mammary glands (glands that produce milk).
map unit A unit of measurement of the distance between genes. One map unit is equivalent to a 1% recombination frequency.

mass extinction The elimination of a large number of species throughout Earth, the result of global environmental changes.
mast cell A vertebrate body cell that produces histamine and other molecules that trigger inflammation in response to infection and in allergic reactions.
maternal effect gene A gene that, when mutant in the mother, results in a mutant phenotype in the offspring, regardless of the offspring's genotype. Maternal effect genes, also called egg-polarity genes, were first identified in *Drosophila melanogaster*.
maximum likelihood As applied to molecular systematics, a principle that states that when considering multiple phylogenetic hypotheses, one should take into account the hypothesis that reflects the most likely sequence of evolutionary events, given certain rules about how DNA changes over time.
mechanoreceptor A sensory receptor that detects physical deformation in the body's environment associated with pressure, touch, stretch, motion, or sound.
megaphyll A leaf with a highly branched vascular system, characteristic of the vast majority of vascular plants. *See* microphyll.
megaspore A spore from a heterosporous plant species that develops into a female gametophyte.
meiosis A modified type of cell division in sexually reproducing organisms consisting of two rounds of cell division but only one round of DNA replication. It results in cells with half the number of chromosome sets as the original cell.
meiosis I The first division of a two-stage process of cell division in sexually reproducing organisms that results in cells with half the number of chromosome sets as the original cell.
meiosis II The second division of a two-stage process of cell division in sexually reproducing organisms that results in cells with half the number of chromosome sets as the original cell.
membrane potential The difference in electrical charge (voltage) across a cell's plasma membrane due to the differential distribution of ions. Membrane potential affects the activity of excitable cells and the transmembrane movement of all charged substances.
messenger RNA (mRNA) A type of RNA, synthesized using a DNA template, that attaches to ribosomes in the cytoplasm and specifies the primary structure of a protein. (In eukaryotes, the primary RNA transcript must undergo RNA processing to become mRNA.)
metabolic pathway A series of chemical reactions that either builds a complex molecule (anabolic pathway) or breaks down a complex molecule to simpler molecules (catabolic pathway).
metabolic rate The total amount of energy an animal uses in a unit of time.
metabolism The totality of an organism's chemical reactions, consisting of catabolic and anabolic pathways, which manage the material and energy resources of the organism.
metagenomics The collection and sequencing of DNA from a group of species, usually an environmental sample of microorganisms. Computer software sorts

partial sequences and assembles them into genome sequences of individual species making up the sample.
metaphase The third stage of mitosis, in which the spindle is complete and the chromosomes, attached to microtubules at their kinetochores, are all aligned at the metaphase plate.
metastasis The spread of cancer cells to locations distant from their original site.
methyl group A chemical group consisting of a carbon bonded to three hydrogen atoms. The methyl group may be attached to a carbon or to a different atom.
microfilament A cable composed of actin proteins in the cytoplasm of almost every eukaryotic cell, making up part of the cytoskeleton and acting alone or with myosin to cause cell contraction; also known as an actin filament.
micronutrient An essential element that an organism needs in very small amounts.
microRNA (miRNA) A small, single-stranded RNA molecule, generated from a hairpin structure on a precursor RNA transcribed from a particular gene. The miRNA associates with one or more proteins in a complex that can degrade or prevent translation of an mRNA with a complementary sequence.
microtubule A hollow rod composed of tubulin proteins that makes up part of the cytoskeleton in all eukaryotic cells and is found in cilia and flagella.
microvillus (plural, **microvilli**) One of many fine, finger-like projections of the epithelial cells in the lumen of the small intestine that increase its surface area.
mineral In nutrition, a simple nutrient that is inorganic and therefore cannot be synthesized in the body.
mismatch repair The cellular process that uses specific enzymes to remove and replace incorrectly paired nucleotides.
missense mutation A nucleotide-pair substitution that results in a codon that codes for a different amino acid.
mitochondrial matrix The compartment of the mitochondrion enclosed by the inner membrane and containing enzymes and substrates for the citric acid cycle, as well as ribosomes and DNA.
mitochondrion (plural, **mitochondria**) An organelle in eukaryotic cells that serves as the site of cellular respiration; uses oxygen to break down organic molecules and synthesize ATP.
mitosis A process of nuclear division in eukaryotic cells conventionally divided into five stages: prophase, prometaphase, metaphase, anaphase, and telophase. Mitosis conserves chromosome number by allocating replicated chromosomes equally to each of the daughter nuclei.
mitotic (M) phase The phase of the cell cycle that includes mitosis and cytokinesis.
mixotroph An organism that is capable of both photosynthesis and heterotrophy.
molecular systematics A scientific discipline that uses nucleic acids or other molecules to infer evolutionary relationships between different species.
molecule Two or more atoms held together by covalent bonds.
monohybrid An organism that is heterozygous with respect to a single gene of interest. All the offspring from a cross between parents homozygous for different

alleles are monohybrids. For example, parents of genotypes *AA* and *aa* produce a monohybrid of genotype *Aa*.

monohybrid cross A cross between two organisms that are heterozygous for the character being followed (or the self-pollination of a heterozygous plant).

monomer The subunit that serves as the building block of a polymer.

monosaccharide The simplest carbohydrate, active alone or serving as a monomer for disaccharides and polysaccharides. Also known as simple sugars, monosaccharides have molecular formulas that are generally some multiple of CH2O.

monosomic Referring to a diploid cell that has only one copy of a particular chromosome instead of the normal two.

morphogenesis The cellular and tissue-based processes by which an animal body takes shape.

morphological species concept A definition of species in terms of measurable anatomical criteria.

motor protein A protein that interacts with cytoskeletal elements and other cell components, producing movement of the whole cell or parts of the cell.

MPF Maturation-promoting factor (or M-phasepromoting factor); a protein complex required for a cell to progress from late interphase to mitosis. The active form consists of cyclin and a protein kinase.

multigene family A collection of genes with similar or identical sequences, presumably of common origin.

multiplication rule A rule of probability stating that the probability of two or more independent events occurring together can be determined by multiplying their individual probabilities.

mutagen A chemical or physical agent that interacts with DNA and can cause a mutation.

mutation A change in the nucleotide sequence of an organism's DNA or in the DNA or RNA of a virus.

myosin A type of motor protein that associates into filaments that interact with actin filaments to cause cell contraction.

natural killer cell A type of white blood cell that can kill tumor cells and virus-infected cells as part of innate immunity.

natural selection A process in which individuals that have certain inherited traits tend to survive and reproduce at higher rates than other individuals *because of* those traits.

neuropeptide A relatively short chain of amino acids that serves as a neurotransmitter.

neurotransmitter A molecule that is released from the synaptic terminal of a neuron at a chemical synapse, diffuses across the synaptic cleft, and binds to the postsynaptic cell, triggering a response.

neutral theory The hypothesis that much evolutionary change in genes and proteins has no effect on fitness and therefore is not influenced by natural selection.

neutral variation Genetic variation that does not provide a selective advantage or disadvantage.
nitrogen cycle The natural process by which nitrogen, either from the atmosphere or from decomposed organic material, is converted by soil bacteria to compounds assimilated by plants. This incorporated nitrogen is then taken in by other organisms and subsequently released, acted on by bacteria, and made available again to the nonliving environment.
nitrogen fixation The conversion of atmospheric nitrogen (N2) to ammonia (NH3). Biological nitrogen fixation is carried out by certain prokaryotes, some of which have mutualistic relationships with plants.
nondisjunction An error in meiosis or mitosis in which members of a pair of homologous chromosomes or a pair of sister chromatids fail to separate properly from each other.
nonequilibrium model A model that maintains that communities change constantly after being buffeted by disturbances.
nonpolar covalent bond A type of covalent bond in which electrons are shared equally between two atoms of similar electronegativity.
nonsense mutation A mutation that changes an amino acid codon to one of the three stop codons, resulting in a shorter and usually nonfunctional protein.
nuclear envelope In a eukaryotic cell, the double membrane that surrounds the nucleus, perforated with pores that regulate traffic with the cytoplasm. The outer membrane is continuous with the endoplasmic reticulum.
nuclear lamina A netlike array of protein filaments that lines the inner surface of the nuclear envelope and helps maintain the shape of the nucleus.
nuclease An enzyme that cuts DNA or RNA, either removing one or a few bases or hydrolyzing the DNA or RNA completely into its component nucleotides.
nucleic acid A polymer (polynucleotide) consisting of many nucleotide monomers; serves as a blueprint for proteins and, through the actions of proteins, for all cellular activities. The two types are DNA and RNA.
nucleic acid hybridization The process of base pairing between a gene and a complementary sequence on another nucleic acid molecule.
nucleic acid probe In DNA technology, a labeled single-stranded nucleic acid molecule used to locate a specific nucleotide sequence in a nucleic acid sample. Molecules of the probe hydrogen-bond to the complementary sequence wherever it occurs; radioactive, fluorescent, or other labeling of the probe allows its location to be detected.
nucleoid A non-membranebounded region in a prokaryotic cell where the DNA is concentrated.
nucleolus (plural, **nucleoli**) A specialized structure in the nucleus, consisting of chromosomal regions containing ribosomal RNA (rRNA) genes along with ribosomal proteins imported from the cytoplasm; site of rRNA synthesis and ribosomal subunit assembly. *See also* ribosome.
nucleosome The basic, beadlike unit of DNA packing in eukaryotes, consisting of a segment of DNA wound around a protein core composed of two copies of each of four types of histone.

nucleotide The building block of a nucleic acid, consisting of a five-carbon sugar covalently bonded to a nitrogenous base and one or more phosphate groups.
nucleotide excision repair A repair system that removes and then correctly replaces a damaged segment of DNA using the undamaged strand as a guide.
nucleotide-pair substitution A type of point mutation in which one nucleotide in a DNA strand and its partner in the complementary strand are replaced by another pair of nucleotides.
nucleus (1) An atom's central core, containing protons and neutrons. (2) The organelle of a eukaryotic cell that contains the genetic material in the form of chromosomes, made up of chromatin. (3) A cluster of neurons.
nutrition The process by which an organism takes in and makes use of food substances.
obligate aerobe An organism that requires oxygen for cellular respiration and cannot live without it.
obligate anaerobe An organism that only carries out fermentation or anaerobic respiration. Such organisms cannot use oxygen and in fact may be poisoned by it.
Okazaki fragment A short segment of DNA synthesized away from the replication fork on a template strand during DNA replication. Many such segments are joined together to make up the lagging strand of newly synthesized DNA.
olfaction The sense of smell.
oncogene A gene found in viral or cellular genomes that is involved in triggering molecular events that can lead to cancer.
oocyte A cell in the female reproductive system that differentiates to form an egg.
oogenesis The process in the ovary that results in the production of female gametes.
oogonium (plural, **oogonia**) A cell that divides mitotically to form oocytes.
operator In bacterial and phage DNA, a sequence of nucleotides near the start of an operon to which an active repressor can attach. The binding of the repressor prevents RNA polymerase from attaching to the promoter and transcribing the genes of the operon.
operon A unit of genetic function found in bacteria and phages, consisting of a promoter, an operator, and a coordinately regulated cluster of genes whose products function in a common pathway.
opsin A membrane protein bound to a lightabsorbing pigment molecule.
order In Linnaean classification, the taxonomic category above the level of family.
organelle Any of several membrane-enclosed structures with specialized functions, suspended in the cytosol of eukaryotic cells.
organic chemistry The study of carbon compounds (organic compounds).
organismal ecology The branch of ecology concerned with the morphological, physiological, and behavioral ways in which individual organisms meet the challenges posed by their biotic and abiotic environments.
origin of replication Site where the replication of a DNA molecule begins, consisting of a specific sequence of nucleotides.
osmoregulation Regulation of solute concentrations and water balance by a cell or organism.

osmoregulator An animal that controls its internal osmolarity independent of the external environment.
osmosis The diffusion of free water across a selectively permeable membrane.
osteichthyan Member of a vertebrate clade with jaws and mostly bony skeletons.
outgroup A species or group of species from an evolutionary lineage that is known to have diverged before the lineage that contains the group of species being studied. An outgroup is selected so that its members are closely related to the group of species being studied, but not as closely related as any study-group members are to each other.
oval window In the vertebrate ear, a membranecovered gap in the skull bone, through which sound waves pass from the middle ear to the inner ear.
ovarian cycle The cyclic recurrence of the follicular phase, ovulation, and the luteal phase in the mammalian ovary, regulated by hormones.
ovary (1) In flowers, the portion of a carpel in which the egg-containing ovules develop. (2) In animals, the structure that produces female gametes and reproductive hormones.
oviduct A tube passing from the ovary to the vagina in invertebrates or to the uterus in vertebrates, where it is also known as a fallopian tube.
oviparous Referring to a type of development in which young hatch from eggs laid outside the mother's body.
ovoviviparous Referring to a type of development in which young hatch from eggs that are retained in the mother's uterus.
ovulation The release of an egg from an ovary. In humans, an ovarian follicle releases an egg during each uterine (menstrual) cycle.
ovule A structure that develops within the ovary of a seed plant and contains the female gametophyte.
oxidation The complete or partial loss of electrons from a substance involved in a redox reaction.
oxidative phosphorylation The production of ATP using energy derived from the redox reactions of an electron transport chain; the third major stage of cellular respiration.
oxidizing agent The electron acceptor in a redox reaction.
oxytocin A hormone produced by the hypothalamus and released from the posterior pituitary. It induces contractions of the uterine muscles during labor and causes the mammary glands to eject milk during nursing.
P generation The true-breeding (homozygous) parent individuals from which F1 hybrid offspring are derived in studies of inheritance; P stands for "parental."
P site One of a ribosome's three binding sites for tRNA during translation. The P site holds the tRNA carrying the growing polypeptide chain. (P stands for peptidyl tRNA.)
***p53* gene** A tumor-suppressor gene that codes for a specific transcription factor that promotes the synthesis of proteins that inhibit the cell cycle.
paedomorphosis The retention in an adult organism of the juvenile features of its evolutionary ancestors.

pain receptor A sensory receptor that responds to noxious or painful stimuli; also called a nociceptor.
paleoanthropology The study of human origins and evolution.
paleontology The scientific study of fossils.
pancreas A gland with exocrine and endocrine tissues. The exocrine portion functions in digestion, secreting enzymes and an alkaline solution into the small intestine via a duct; the ductless endocrine portion functions in homeostasis, secreting the hormones insulin and glucagon into the blood.
pandemic A global epidemic.
Pangaea The supercontinent that formed near the end of the Paleozoic era, when plate movements brought all the landmasses of Earth together.
parabasalid A protist, such as a trichomonad, with modified mitochondria.
paracrine Referring to a secreted molecule that acts on a neighboring cell.
paralogous genes Homologous genes that are found in the same genome as a result of gene duplication.
paraphyletic Pertaining to a group of taxa that consists of a common ancestor and some, but not all, of its descendants.
parareptile A basal group of reptiles, consisting mostly of large, stocky quadrupedal herbivores. Parareptiles died out in the late Triassic period.
parasite An organism that feeds on the cell contents, tissues, or body fluids of another species (the host) while in or on the host organism. Parasites harm but usually do not kill their host.
parasitism A symbiotic relationship in which one organism, the parasite, benefits at the expense of another, the host, by living either within or on the host.
parasympathetic division One of three divisions of the autonomic nervous system; generally enhances body activities that gain and conserve energy, such as digestion and reduced heart rate.
parathyroid gland One of four small endocrine glands, embedded in the surface of the thyroid gland, that secrete parathyroid hormone.
parathyroid hormone (PTH) A hormone secreted by the parathyroid glands that raises blood calcium level by promoting calcium release from bone and calcium retention by the kidneys.
parenchyma cell A relatively unspecialized plant cell type that carries out most of the metabolism, synthesizes and stores organic products, and develops into a more differentiated cell type.
parental type An offspring with a phenotype that matches one of the true-breeding parental (P generation) phenotypes; also refers to the phenotype itself.
Parkinson's disease A progressive brain disease characterized by difficulty in initiating movements, slowness of movement, and rigidity.
parthenogenesis A form of asexual reproduction in which females produce offspring from unfertilized eggs.
partial pressure The pressure exerted by a particular gas in a mixture of gases (for instance, the pressure exerted by oxygen in air).
passive immunity Short-term immunity conferred by the transfer of antibodies, as occurs in the transfer of maternal antibodies to a fetus or nursing infant.

passive transport The diffusion of a substance across a biological membrane with no expenditure of energy.
pathogen An organism, virus, viroid, or prion that causes disease.
pattern formation The development of a multicellular organism's spatial organization, the arrangement of organs and tissues in their characteristic places in three-dimensional space.
peat Extensive deposits of partially decayed organic material often formed primarily from the wetland moss *Sphagnum*.
pedigree A diagram of a family tree with conventional symbols, showing the occurrence of heritable characters in parents and offspring over multiple generations.
pelagic zone The open-water component of aquatic biomes.
PEP carboxylase An enzyme that adds CO2 to phosphoenolpyruvate (PEP) to form oxaloacetate in mesophyll cells of C4 plants. It acts prior to photosynthesis.
pepsin An enzyme present in gastric juice that begins the hydrolysis of proteins.
pepsinogen The inactive form of pepsin secreted by chief cells located in gastric pits of the stomach.
peptide bond The covalent bond between the carboxyl group on one amino acid and the amino group on another, formed by a dehydration reaction.
peptidoglycan A type of polymer in bacterial cell walls consisting of modified sugars cross-linked by short polypeptides.
perception The interpretation of sensory system input by the brain.
pericycle The outermost layer in the vascular cylinder, from which lateral roots arise.
periderm The protective coat that replaces the epidermis in woody plants during secondary growth, formed of the cork and cork cambium.
peripheral nervous system (PNS) The sensory and motor neurons that connect to the central nervous system.
peripheral protein A protein loosely bound to the surface of a membrane or to part of an integral protein and not embedded in the lipid bilayer.
peristalsis (1) Alternating waves of contraction and relaxation in the smooth muscles lining the alimentary canal that push food along the canal. (2) A type of movement on land produced by rhythmic waves of muscle contractions passing from front to back, as in many annelids.
peristome A ring of interlocking, tooth-like structures on the upper part of a moss capsule (sporangium), often specialized for gradual spore discharge.
peritubular capillary One of the tiny blood vessels that form a network surrounding the proximal and distal tubules in the kidney.
permafrost A permanently frozen soil layer.
peroxisome An organelle containing enzymes that transfer hydrogen atoms from various substrates to oxygen (O2), producing and then degrading hydrogen peroxide (H2O2).
petal A modified leaf of a flowering plant. Petals are the often colorful parts of a flower that advertise it to insects and other pollinators.
petiole The stalk of a leaf, which joins the leaf to a node of the stem.

pH A measure of hydrogen ion concentration equal to –log [H_] and ranging in value from 0 to 14.
phage A virus that infects bacteria; also called a bacteriophage.
phagocytosis A type of endocytosis in which large particulate substances or small organisms are taken up by a cell. It is carried out by some protists and by certain immune cells of animals (in mammals, mainly macrophages, neutrophils, and dendritic cells).
pharyngeal cleft In chordate embryos, one of the grooves that separate a series of pouches along the sides of the pharynx and may develop into a pharyngeal slit.
pharyngeal slit In chordate embryos, one of the slits that form from the pharyngeal clefts and communicate to the outside, later developing into gill slits in many vertebrates.
pharynx (1) An area in the vertebrate throat where air and food passages cross. (2) In flatworms, the muscular tube that protrudes from the ventral side of the worm and ends in the mouth.
phase change A shift from one developmental phase to another.
phenotype The observable physical and physiological traits of an organism, which are determined by its genetic makeup.
pheromone (fa–r_-uh-mo–n) In animals and fungi, a small molecule released into the environment that functions in communication between members of the same species. In animals, it acts much like a hormone in influencing physiology and behavior.
phloem Vascular plant tissue consisting of living cells arranged into elongated tubes that transport sugar and other organic nutrients throughout the plant.
phloem sap The sugar-rich solution carried through a plant's sieve tubes.
phosphate group A chemical group consisting of a phosphorus atom bonded to four oxygen atoms; important in energy transfer.
phospholipid A lipid made up of glycerol joined to two fatty acids and a phosphate group. The hydrocarbon chains of the fatty acids act as nonpolar, hydrophobic tails, while the rest of the molecule acts as a polar, hydrophilic head. Phospholipids form bilayers that function as biological membranes.
phosphorylated intermediate A molecule (often a reactant) with a phosphate group covalently bound to it, making it more reactive (less stable) than the unphosphorylated molecule.
photic zone The narrow top layer of an ocean or lake, where light penetrates sufficiently for photosynthesis to occur.
photoautotroph An organism that harnesses light energy to drive the synthesis of organic compounds from carbon dioxide.
photoheterotroph An organism that uses light to generate ATP but must obtain carbon in organic form.
photomorphogenesis Effects of light on plant morphology.
photon A quantum, or discrete quantity, of light energy that behaves as if it were a particle.
photoperiodism A physiological response to photoperiod, the relative lengths of night and day. An example of photoperiodism is flowering.

photophosphorylation The process of generating ATP from ADP and phosphate by means of chemiosmosis, using a proton-motive force generated across the thylakoid membrane of the chloroplast or the membrane of certain prokaryotes during the light reactions of photosynthesis.
photoreceptor An electromagnetic receptor that detects the radiation known as visible light.
photorespiration A metabolic pathway that consumes oxygen and ATP, releases carbon dioxide, and decreases photosynthetic output. Photorespiration generally occurs on hot, dry, bright days, when stomata close and the O2/CO2 ratio in the leaf increases, favoring the binding of O2 rather than CO2 by rubisco.
photosynthesis The conversion of light energy to chemical energy that is stored in sugars or other organic compounds; occurs in plants, algae, and certain prokaryotes.
photosystem A light-capturing unit located in the thylakoid membrane of the chloroplast or in the membrane of some prokaryotes, consisting of a reaction-center complex surrounded by numerous light-harvesting complexes. There are two types of photosystems, I and II; they absorb light best at different wavelengths.
photosystem I (PS I) A light-capturing unit in a chloroplast's thylakoid membrane or in the membrane of some prokaryotes; it has two molecules of P700 chlorophyll *a* at its reaction center.
photosystem II (PS II) One of two lightcapturing units in a chloroplast's thylakoid membrane or in the membrane of some prokaryotes; it has two molecules of P680 chlorophyll *a* at its reaction center.
phototropism Growth of a plant shoot toward or away from light.
phragmoplast An alignment of cytoskeletal elements and Golgi-derived vesicles that forms across the midline of a dividing plant cell.
phyllotaxy The pattern of leaf attachment to the stem of a plant.
PhyloCode Proposed system of classification of organisms based on evolutionary relationships: Only groups that include a common ancestor and all of its descendants are named.
phylogenetic species concept A definition of species as the smallest group of individuals that share a common ancestor, forming one branch on the tree of life.
phylogenetic tree A branching diagram that represents a hypothesis about the evolutionary history of a group of organisms.
phylogeny The evolutionary history of a species or group of related species.
phylum (plural, **phyla**) In Linnaean classification, the taxonomic category above class.
physical map A genetic map in which the actual physical distances between genes or other genetic markers are expressed, usually as the number of base pairs along the DNA.
physiology The processes and functions of an organism.
phytochrome A type of light receptor in plants that mostly absorbs red light and regulates many plant responses, such as seed germination and shade avoidance.
phytoremediation An emerging technology that seeks to reclaim contaminated areas by taking advantage of some plant species' ability to extract heavy metals

and other pollutants from the soil and to concentrate them in easily harvested portions of the plant.
pilus (plural, **pili**) In bacteria, a structure that links one cell to another at the start of conjugation; also known as a sex pilus or conjugation pilus.
pineal gland A small gland on the dorsal surface of the vertebrate forebrain that secretes the hormone melatonin.
pinocytosis A type of endocytosis in which the cell ingests extracellular fluid and its dissolved solutes.
pistil A single carpel or a group of fused carpels.
pith Ground tissue that is internal to the vascular tissue in a stem; in many monocot roots, parenchyma cells that form the central core of the vascular cylinder.
pituitary gland An endocrine gland at the base of the hypothalamus; consists of a posterior lobe, which stores and releases two hormones produced by the hypothalamus, and an anterior lobe, which produces and secretes many hormones that regulate diverse body functions.
placenta A structure in the pregnant uterus for nourishing a viviparous fetus with the mother's blood supply; formed from the uterine lining and embryonic membranes.
placental transfer cell A plant cell that enhances the transfer of nutrients from parent to embryo.
placoderm A member of an extinct group of fishlike vertebrates that had jaws and were enclosed in a tough outer armor.
planarian A free-living flatworm found in ponds and streams.
plasma The liquid matrix of blood in which the blood cells are suspended.
plasma cell The antibody-secreting effector cell of humoral immunity. Plasma cells arise from antigen-stimulated B cells.
plasma membrane The membrane at the boundary of every cell that acts as a selective barrier, regulating the cell's chemical composition.
plasmid A small, circular, doublestranded DNA molecule that carries accessory genes separate from those of a bacterial chromosome; in DNA cloning, used as vectors carrying up to about 10,000 base pairs (10 kb) of DNA. Plasmids are also found in some eukaryotes, such as yeasts.
plasmodesma (plural, **plasmodesmata**) An open channel through the cell wall that connects the cytoplasm of adjacent plant cells, allowing water, small solutes, and some larger molecules to pass between the cells.
plasmodial slime mold A type of protist that has amoeboid cells, flagellated cells, and a plasmodial feeding stage in its life cycle.
plasmodium A single mass of cytoplasm containing many diploid nuclei that forms during the life cycle of some slime molds.
plasmogamy In fungi, the fusion of the cytoplasm of cells from two individuals; occurs as one stage of sexual reproduction, followed later by karyogamy.
plasmolysis A phenomenon in walled cells in which the cytoplasm shrivels and the plasma membrane pulls away from the cell wall; occurs when the cell loses water to a hypertonic environment.

plastid One of a family of closely related organelles that includes chloroplasts, chromoplasts, and amyloplasts. Plastids are found in cells of photosynthetic eukaryotes.
plate tectonics The theory that the continents are part of great plates of Earth's crust that float on the hot, underlying portion of the mantle. Movements in the mantle cause the continents to move slowly over time.
platelet A pinched-off cytoplasmic fragment of a specialized bone marrow cell. Platelets circulate in the blood and are important in blood clotting.
pleiotropy The ability of a single gene to have multiple effects.
pluripotent Describing a cell that can give rise to many, but not all, parts of an organism.
point mutation A change in a single nucleotide pair of a gene.
polar covalent bond A covalent bond between atoms that differ in electronegativity. The shared electrons are pulled closer to the more electronegative atom, making it slightly negative and the other atom slightly positive.
polar molecule A molecule (such as water) with an uneven distribution of charges in different regions of the molecule.
polarity A lack of symmetry; structural differences in opposite ends of an organism or structure, such as the root end and shoot end of a plant.
pollen grain In seed plants, a structure consisting of the male gametophyte enclosed within a pollen wall.
pollen tube A tube that forms after germination of the pollen grain and that functions in the delivery of sperm to the ovule.
pollination The transfer of pollen to the part of a seed plant containing the ovules, a process required for fertilization.
poly-A tail A sequence of 50–250 adenine nucleotides added onto the 3_ end of a pre-mRNA molecule.
polygamous Referring to a type of relationship in which an individual of one sex mates with several of the other.
polygenic inheritance An additive effect of two or more genes on a single phenotypic character.
polymer A long molecule consisting of many similar or identical monomers linked together by covalent bonds.
polymerase chain reaction (PCR) A technique for amplifying DNA *in vitro* by incubating it with specific primers, a heat-resistant DNA polymerase, and nucleotides.
polynucleotide A polymer consisting of many nucleotide monomers in a chain. The nucleotides can be those of DNA or RNA.
polyp The sessile variant of the cnidarian body plan. The alternate form is the medusa.
polypeptide A polymer of many amino acids linked together by peptide bonds.
polyphyletic Pertaining to a group of taxa derived from two or more different ancestors.

polyploidy A chromosomal alteration in which the organism possesses more than two complete chromosome sets. It is the result of an accident of cell division.
polyribosome (polysome) A group of several ribosomes attached to, and translating, the same messenger RNA molecule.
polysaccharide A polymer of many monosaccharides, formed by dehydration reactions.
polytomy In a phylogenetic tree, a branch point from which more than two descendant taxa emerge. A polytomy indicates that the evolutionary relationships between the descendant taxa are not yet clear.
pons A portion of the brain that participates in certain automatic, homeostatic functions, such as regulating the breathing centers in the medulla.
population A group of individuals of the same species that live in the same area and interbreed, producing fertile offspring.
population dynamics The study of how complex interactions between biotic and abiotic factors influence variations in population size.
population ecology The study of populations in relation to their environment, including environmental influences on population density and distribution, age structure, and variations in population size.
positional information Molecular cues that control pattern formation in an animal or plant embryonic structure by indicating a cell's location relative to the organism's body axes. These cues elicit a response by genes that regulate development.
positive feedback A form of regulation in which an end product of a process speeds up that process; in physiology, a control mechanism in which a change in a variable triggers a response that reinforces or amplifies the change.
positive pressure breathing A breathing system in which air is forced into the lungs.
posterior Pertaining to the rear, or tail end, of a bilaterally symmetrical animal.
posterior pituitary An extension of the hypothalamus composed of nervous tissue that secretes oxytocin and antidiuretic hormone made in the hypothalamus; a temporary storage site for these hormones.
postzygotic barrier A reproductive barrier that prevents hybrid zygotes produced by two different species from developing into viable, fertile adults.
potential energy The energy that matter possesses as a result of its location or spatial arrangement (structure).
predation An interaction between species in which one species, the predator, eats the other, the prey.
pregnancy The condition of carrying one or more embryos in the uterus.
prepuce A fold of skin covering the head of the clitoris or penis.
pressure potential (ΨP) A component of water potential that consists of the physical pressure on a solution, which can be positive, zero, or negative.
prezygotic barrier A reproductive barrier that impedes mating between species or hinders fertilization if interspecific mating is attempted.
primary cell wall In plants, a relatively thin and flexible layer that surrounds the plasma membrane of a young cell.

primary consumer An herbivore; an organism that eats plants or other autotrophs.
primary electron acceptor In the thylakoid membrane of a chloroplast or in the membrane of some prokaryotes, a specialized molecule that shares the reaction-center complex with a pair of chlorophyll *a* molecules and that accepts an electron from them.
primary growth Growth produced by apical meristems, lengthening stems and roots.
primary immune response The initial adaptive immune response to an antigen, which appears after a lag of about 10 to 17 days.
primary oocyte An oocyte prior to completion of meiosis I.
primary producer An autotroph, usually a photosynthetic organism. Collectively, autotrophs make up the trophic level of an ecosystem that ultimately supports all other levels.
primary production The amount of light energy converted to chemical energy (organic compounds) by the autotrophs in an ecosystem during a given time period.
primary structure The level of protein structure referring to the specific linear sequence of amino acids.
primary succession A type of ecological succession that occurs in an area where there were originally no organisms present and where soil has not yet formed.
primary transcript An initial RNA transcript from any gene; also called pre-mRNA when transcribed from a protein-coding gene.
primary visual cortex The destination in the occipital lobe of the cerebrum for most of the axons from the lateral geniculate nuclei.
primase An enzyme that joins RNA nucleotides to make a primer during DNA replication, using the parental DNA strand as a template.
primer A short stretch of RNA with a free 3_ end, bound by complementary base pairing to the template strand and elongated with DNA nucleotides during DNA replication.
primitive streak A thickening along the future anterior-posterior axis on the surface of an early avian or mammalian embryo, caused by a piling up of cells as they congregate at the midline before moving into the embryo.
prion An infectious agent that is a misfolded version of a normal cellular protein. Prions appear to increase in number by converting correctly folded versions of the protein to more prions.
problem solving The cognitive activity of devising a method to proceed from one state to another in the face of real or apparent obstacles.
producer An organism that produces organic compounds from CO2 by harnessing light energy (in photosynthesis) or by oxidizing inorganic chemicals (in chemosynthetic reactions carried out by some prokaryotes).
product A material resulting from a chemical reaction.
production efficiency The percentage of energy stored in assimilated food that is not used for respiration or eliminated as waste.
progesterone A steroid hormone that prepares the uterus for pregnancy; the major progestin in mammals.

progestin Any steroid hormone with progesteronelike activity.
progymnosperm An extinct seedless vascular plant that may be ancestral to seed plants.
prokaryotic cell A type of cell lacking a membrane-enclosed nucleus and membrane-enclosed organelles. Organisms with prokaryotic cells (bacteria and archaea) are called prokaryotes.
prolactin A hormone produced and secreted by the anterior pituitary with a great diversity of effects in different vertebrate species. In mammals, it stimulates growth of and milk production by the mammary glands.
proliferative phase That portion of the uterine (menstrual) cycle when the endometrium regenerates and thickens.
prometaphase The second stage of mitosis, in which the nuclear envelope fragments and the spindle microtubules attach to the kinetochores of the chromosomes.
promiscuous Referring to a type of relationship in which mating occurs with no strong pairbonds or lasting relationships.
promoter A specific nucleotide sequence in the DNA of a gene that binds RNA polymerase, positioning it to start transcribing RNA at the appropriate place.
prophage A phage genome that has been inserted into a specific site on a bacterial chromosome.
prophase The first stage of mitosis, in which the chromatin condenses into discrete chromosomes visible with a light microscope, the mitotic spindle begins to form, and the nucleolus disappears but the nucleus remains intact.
prostaglandin One of a group of modified fatty acids secreted by virtually all tissues and performing a wide variety of functions as local regulators.
prostate gland A gland in human males that secretes an acid-neutralizing component of semen.
protease An enzyme that digests proteins by hydrolysis.
proteasome A giant protein complex that recognizes and destroys proteins tagged for elimination by the small protein ubiquitin.
protein A biologically functional molecule consisting of one or more polypeptides folded and coiled into a specific three-dimensional structure.
protein kinase An enzyme that transfers phosphate groups from ATP to a protein, thus phosphorylating the protein.
protein phosphatase An enzyme that removes phosphate groups from (dephosphorylates) proteins, often functioning to reverse the effect of a protein kinase.
proteoglycan A large molecule consisting of a small core protein with many carbohydrate chains attached, found in the extracellular matrix of animal cells. A proteoglycan may consist of up to 95% carbohydrate.
proteomics The systematic study of the full protein sets (proteomes) encoded by genomes.
protist An informal term applied to any eukaryote that is not a plant, animal, or fungus. Most protists are unicellular, though some are colonial or multicellular.

protocell An abiotic precursor of a living cell that had a membrane-like structure and that maintained an internal chemistry different from that of its surroundings.
proton pump An active transport protein in a cell membrane that uses ATP to transport hydrogen ions out of a cell against their concentration gradient, generating a membrane potential in the process.
protonema (plural, **protonemata**) A mass of green, branched, one-cell-thick filaments produced by germinating moss spores.
Protonephridium (plural, **protonephridia**) An excretory system, such as the flame bulb system of flatworms, consisting of a network of tubules lacking internal openings.
proton-motive force The potential energy stored in the form of a proton electrochemical gradient, generated by the pumping of hydrogen ions (H_) across a biological membrane during chemiosmosis.
proto-oncogene A normal cellular gene that has the potential to become an oncogene.
protoplast The living part of a plant cell, which also includes the plasma membrane.
protoplast fusion The fusing of two protoplasts from different plant species that would otherwise be reproductively incompatible.
protostome development In animals, a developmental mode distinguished by the development of the mouth from the blastopore; often also characterized by spiral cleavage and by the body cavity forming when solid masses of mesoderm split.
provirus A viral genome that is permanently inserted into a host genome.
proximal tubule In the vertebrate kidney, the portion of a nephron immediately downstream from Bowman's capsule that conveys and helps refine filtrate.
pseudocoelomate An animal whose body cavity is lined by tissue derived from mesoderm and endoderm.
pseudogene A DNA segment very similar to a real gene but which does not yield a functional product; a DNA segment that formerly functioned as a gene but has become inactivated in a particular species because of mutation.
pseudopodium (plural, **pseudopodia**) A cellular extension of amoeboid cells used in moving and feeding.
pterophyte An informal name for a member of the phylum Pterophyta, which includes ferns, horsetails, and whisk ferns and their relatives.
pterosaur Winged reptile that lived during the Mesozoic era.
pulmocutaneous circuit A branch of the circulatory system in many amphibians that supplies the lungs and skin.
pulmonary circuit The branch of the circulatory system that supplies the lungs.
pulse The rhythmic bulging of the artery walls with each heartbeat.
punctuated equilibria In the fossil record, long periods of apparent stasis, in which a species undergoes little or no morphological change, interrupted by relatively brief periods of sudden change.
Punnett square A diagram used in the study of inheritance to show the predicted genotypic results of random fertilization in genetic crosses between individuals of known genotype.

pupil The opening in the iris, which admits light into the interior of the vertebrate eye. Muscles in the iris regulate its size.
purine One of two types of nitrogenous bases found in nucleotides, characterized by a six-membered ring fused to a fivemembered ring. Adenine (A) and guanine (G) are purines.
pyrimidine One of two types of nitrogenous bases found in nucleotides, characterized by a six-membered ring. Cytosine (C), thymine (T), and uracil (U) are pyrimidines.
quantitative character A heritable feature that varies continuously over a range rather than in an either-or fashion.
quaternary structure The particular shape of a complex, aggregate protein, defined by the characteristic three-dimensional arrangement of its constituent subunits, each a polypeptide.
R plasmid A bacterial plasmid carrying genes that confer resistance to certain antibiotics.
radial cleavage A type of embryonic development in deuterostomes in which the planes of cell division that transform the zygote into a ball of cells are either parallel or perpendicular to the vertical axis of the embryo, thereby aligning tiers of cells one above the other.
radial symmetry Symmetry in which the body is shaped like a pie or barrel (lacking a left side and a right side) and can be divided into mirror-imaged halves by any plane through its central axis.
radiation The emission of electromagnetic waves by all objects warmer than absolute zero.
radicle An embryonic root of a plant.
radioactive isotope An isotope (an atomic form of a chemical element) that is unstable; the nucleus decays spontaneously, giving off detectable particles and energy.
radiolarian A protist, usually marine, with a shell generally made of silica and pseudopodia that radiate from the central body.
radiometric dating A method for determining the absolute age of rocks and fossils, based on the half-life of radioactive isotopes.
radula A straplike scraping organ used by many molluscs during feeding.
***ras* gene** A gene that codes for Ras, a G protein that relays a growth signal from a growth factor receptor on the plasma membrane to a cascade of protein kinases, ultimately resulting in stimulation of the cell cycle.
ratite Member of the group of flightless birds.
ray-finned fish Member of the class Actinopterygii, aquatic osteichthyans with fins supported by long, flexible rays, including tuna, bass, and herring.
reabsorption In excretory systems, the recovery of solutes and water from filtrate.
reactant A starting material in a chemical reaction.
reaction-center complex A complex of proteins associated with a special pair of chlorophyll *a* molecules and a primary electron acceptor. Located centrally in a photosystem, this complex triggers the light reactions of photosynthesis. Excited

by light energy, the pair of chlorophylls donates an electron to the primary electron acceptor, which passes an electron to an electron transport chain.
reading frame On an mRNA, the triplet grouping of ribonucleotides used by the translation machinery during polypeptide synthesis.
receptacle The base of a flower; the part of the stem that is the site of attachment of the floral organs.
receptor potential An initial response of a receptor cell to a stimulus, consisting of a change in voltage across the receptor membrane proportional to the stimulus strength.
receptor tyrosine kinase (RTK) A receptor protein spanning the plasma membrane, the cytoplasmic (intracellular) part of which can catalyze the transfer of a phosphate group from ATP to a tyrosine on another protein. Receptor tyrosine kinases often respond to the binding of a signaling molecule by dimerizing and then phosphorylating a tyrosine on the cytoplasmic portion of the other receptor in the dimer. The phosphorylated tyrosines on the receptors then activate other signal transduction proteins within the cell.
receptor-mediated endocytosis The movement of specific molecules into a cell by the inward budding of vesicles containing proteins with receptor sites specific to the molecules being taken in; enables a cell to acquire bulk quantities of specific substances.
recessive allele An allele whose phenotypic effect is not observed in a heterozygote.
reciprocal altruism Altruistic behavior between unrelated individuals, whereby the altruistic individual benefits in the future when the beneficiary reciprocates.
recombinant chromosome A chromosome created when crossing over combines DNA from two parents into a single chromosome.
recombinant DNA A DNA molecule made *in vitro* with segments from different sources.
recombinant type (recombinant) An offspring whose phenotype differs from that of the true-breeding P generation parents; also refers to the phenotype itself.
rectum The terminal portion of the large intestine, where the feces are stored prior to elimination.
red alga A photosynthetic protist, named for its color, which results from a red pigment that masks the green of chlorophyll. Most red algae are multicellular and marine.
redox reaction A chemical reaction involving the complete or partial transfer of one or more electrons from one reactant to another; short for **red**uction-**ox**idation reaction.
reducing agent The electron donor in a redox reaction.
reduction The complete or partial addition of electrons to a substance involved in a redox reaction.
reflex An automatic reaction to a stimulus, mediated by the spinal cord or lower brain.

refractory period The short time immediately after an action potential in which the neuron cannot respond to another stimulus, owing to the inactivation of voltage-gated sodium channels.
regulator An animal for which mechanisms of homeostasis moderate internal changes in a particular variable in the face of external fluctuation of that variable.
regulatory gene A gene that codes for a protein, such as a repressor, that controls the transcription of another gene or group of genes.
reinforcement In evolutionary biology, a process in which a process in which natural selection strengthens prezygotic barriers to reproduction, thus reducing the chances of hybrid formation. Such a process is likely to occur only if hybrid offspring are less fit than members of the parent species.
relative abundance The proportional abundance of different species in a community.
relative fitness The contribution an individual makes to the gene pool of the next generation, relative to the contributions of other individuals in the population.
renal cortex The outer portion of the vertebrate kidney.
renal medulla The inner portion of the vertebrate kidney, beneath the renal cortex.
renal pelvis The funnel-shaped chamber that receives processed filtrate from the vertebrate kidney's collecting ducts and is drained by the ureter.
renin-angiotensin-aldosterone system (RAAS) A hormone cascade pathway that helps regulate blood pressure and blood volume.
repetitive DNA Nucleotide sequences, usually noncoding, that are present in many copies in a eukaryotic genome. The repeated units may be short and arranged tandemly (in series) or long and dispersed in the genome.
replication fork A Y-shaped region on a replicating DNA molecule where the parental strands are being unwound and new strands are being synthesized.
repressor A protein that inhibits gene transcription. In prokaryotes, repressors bind to the DNA in or near the promoter. In eukaryotes, repressors may bind to control elements within enhancers, to activators, or to other proteins in a way that blocks activators from binding to DNA.
reproductive isolation The existence of biological factors (barriers) that impede members of two species from producing viable, fertile offspring.
reproductive table An age-specific summary of the reproductive rates in a population.
residual volume The amount of air that remains in the lungs after forceful exhalation.
resource partitioning The division of environmental resources by coexisting species such that the niche of each species differs by one or more significant factors from the niches of all coexisting species.
respiratory pigment A protein that transports oxygen in blood or hemolymph.
response (1) In cellular communication, the change in a specific cellular activity brought about by a transduced signal from outside the cell. (2) In feedback regulation, a physiological activity triggered by a change in a variable.
resting potential The membrane potential characteristic of a nonconducting excitable cell, with the inside of the cell more negative than the outside.

restriction enzyme An endonuclease (type of enzyme) that recognizes and cuts DNA molecules foreign to a bacterium (such as phage genomes). The enzyme cuts at specific nucleotide sequences (restriction sites).
restriction fragment A DNA segment that results from the cutting of DNA by a restriction enzyme.
restriction fragment length polymorphism (RFLP) A single nucleotide polymorphism (SNP) that exists in the restriction site for a particular enzyme, thus making the site unrecognizable by that enzyme and changing the lengths of the restriction fragments formed by digestion with that enzyme. A RFLP can be in coding or noncoding DNA.
restriction site A specific sequence on a DNA strand that is recognized and cut by a restriction enzyme.
reticular formation A diffuse network of neurons in the core of the brainstem that filters information traveling to the cerebral cortex.
retina The innermost layer of the vertebrate eye, containing photoreceptor cells (rods and cones) and neurons; transmits images formed by the lens to the brain via the optic nerve.
retinal The light-absorbing pigment in rods and cones of the vertebrate eye.
retrotransposon A transposable element that moves within a genome by means of an RNA intermediate, a transcript of the retrotransposon DNA.
retrovirus An RNA virus that replicates by transcribing its RNA into DNA and then inserting the DNA into a cellular chromosome; an important class of cancercausing viruses.
reverse transcriptase An enzyme encoded by certain viruses (retroviruses) that uses RNA as a template for DNA synthesis.
reverse transcriptase-polymerase chain reaction (RT-PCR) A technique for determining expression of a particular gene. It uses reverse transcriptase and DNA polymerase to synthesize cDNA from all the mRNA in a sample and then subjects the cDNA to PCR amplification using primers specific for the gene of interest.
Rhizaria One of five supergroups of eukaryotes proposed in a current hypothesis of the evolutionary history of eukaryotes; a morphologically diverse protist clade that is defined by DNA similarities. *See also* Excavata, Chromalveolata, Archaeplastida, and Unikonta.
rhizobacterium A soil bacterium whose population size is much enhanced in the rhizosphere, the soil region close to a plant's roots.
rhizoid A long, tubular single cell or filament of cells that anchors bryophytes to the ground. Unlike roots, rhizoids are not composed of tissues, lack specialized conducting cells, and do not play a primary role in water and mineral absorption.
rhizosphere The soil region close to plant roots and characterized by a high level of microbiological activity.
rhodopsin A visual pigment consisting of retinal and opsin. Upon absorbing light, the retinal changes shape and dissociates from the opsin.
rhythm method A form of contraception that relies on refraining from sexual intercourse when conception is most likely to occur; also called natural family planning.

ribonucleic acid (RNA) A type of nucleic acid consisting of a polynucleotide made up of nucleotide monomers with a ribose sugar and the nitrogenous bases adenine (A), cytosine (C), guanine (G), and uracil (U); usually single-stranded; functions in protein synthesis, gene regulation, and as the genome of some viruses.
ribose The sugar component of RNA nucleotides.
ribosomal RNA (rRNA) RNA molecules that, together with proteins, make up ribosomes; the most abundant type of RNA.
ribosome A complex of rRNA and protein molecules that functions as a site of protein synthesis in the cytoplasm; consists of a large and a small subunit. In eukaryotic cells, each subunit is assembled in the nucleolus. *See also* nucleolus.
ribozyme An RNA molecule that functions as an enzyme, such as an intron that catalyzes its own removal during RNA splicing.
RNA interference (RNAi) A technique used to silence the expression of selected genes. RNAi uses synthetic double-stranded RNA molecules that match the sequence of a particular gene to trigger the breakdown of the gene's messenger RNA.
RNA polymerase An enzyme that links ribonucleotides into a growing RNA chain during transcription, based on complementary binding to nucleotides on a DNA template strand.
RNA processing Modification of RNA primary transcripts, including splicing out of introns, joining together of exons, and alteration of the 5_ and 3_ ends.
RNA splicing After synthesis of a eukaryotic primary RNA transcript, the removal of portions of the transcript (introns) that will not be included in the mRNA and the joining together of the remaining portions (exons).
rod A rodlike cell in the retina of the vertebrate eye, sensitive to low light intensity.
root An organ in vascular plants that anchors the plant and enables it to absorb water and minerals from the soil.
root cap A cone of cells at the tip of a plant root that protects the apical meristem.
root hair A tiny extension of a root epidermal cell, growing just behind the root tip and increasing surface area for absorption of water and minerals.
root pressure Pressure exerted in the roots of plants as the result of osmosis, causing exudation from cut stems and guttation of water from leaves.
root system All of a plant's roots, which anchor it in the soil, absorb and transport minerals and water, and store food.
rooted Describing a phylogenetic tree that contains a branch point (often, the one farthest to the left) representing the most recent common ancestor of all taxa in the tree.
rough ER That portion of the endoplasmic reticulum with ribosomes attached.
round window In the mammalian ear, the point of contact where vibrations of the stapes create a traveling series of pressure waves in the fluid of the cochlea.
***r*-selection** Selection for life history traits that maximize reproductive success in uncrowded environments; also called density-independent selection.
rubisco Ribulose bisphosphate (RuBP) carboxylase, the enzyme that catalyzes the first step of the Calvin cycle (the addition of CO2 to RuBP).

ruminant An animal, such as a cow or a sheep, with multiple stomach compartments specialized for an herbivorous diet.
S phase The synthesis phase of the cell cycle; the portion of interphase during which DNA is replicated.
saccule In the vertebrate ear, a chamber in the vestibule behind the oval window that participates in the sense of balance.
salicylic acid A signaling molecule in plants that may be partially responsible for activating systemic acquired resistance to pathogens.
salivary gland A gland associated with the oral cavity that secretes substances that lubricate food and begin the process of chemical digestion.
salt A compound resulting from the formation of an ionic bond; also called an ionic compound.
saltatory conduction Rapid transmission of a nerve impulse along an axon, resulting from the action potential jumping from one node of Ranvier to another, skipping the myelin-sheathed regions of membrane.
sarcomere The fundamental, repeating unit of striated muscle, delimited by the Z lines.
sarcoplasmic reticulum (SR) A specialized endoplasmic reticulum that regulates the calcium concentration in the cytosol of muscle cells.
saturated fatty acid A fatty acid in which all carbons in the hydrocarbon tail are connected by single bonds, thus maximizing the number of hydrogen atoms that are attached to the carbon skeleton.
savanna A tropical grassland biome with scattered individual trees and large herbivores and maintained by occasional fires and drought.
scaffolding protein A type of large relay protein to which several other relay proteins are simultaneously attached, increasing the efficiency of signal transduction.
scanning electron microscope (SEM) A microscope that uses an electron beam to scan the surface of a sample, coated with metal atoms, to study details of its topography.
schizophrenia A severe mental disturbance characterized by psychotic episodes in which patients have a distorted perception of reality.
Schwann cell A type of glial cell that forms insulating myelin sheaths around the axons of neurons in the peripheral nervous system.
science An approach to understanding the natural world.
scion The twig grafted onto the stock when making a graft.
sclereid A short, irregular sclerenchyma cell in nutshells and seed coats. Sclereids are scattered throughout the parenchyma of some plants.
sclerenchyma cell A rigid, supportive plant cell type usually lacking a protoplast and possessing thick secondary walls strengthened by lignin at maturity.
scrotum A pouch of skin outside the abdomen that houses the testes; functions in maintaining the testes at the lower temperature required for spermatogenesis.
second law of thermodynamics The principle stating that every energy transfer or transformation increases the entropy of the universe. Usable forms of energy are at least partly converted to heat.

second messenger A small, nonprotein, watersoluble molecule or ion, such as a calcium ion (Ca2_) or cyclic AMP, that relays a signal to a cell's interior in response to a signaling molecule bound by a signal receptor protein.
secondary cell wall In plant cells, a strong and durable matrix that is often deposited in several laminated layers around the plasma membrane and provides protection and support.
secondary consumer A carnivore that eats herbivores.
secondary endosymbiosis A process in eukaryotic evolution in which a heterotrophic eukaryotic cell engulfed a photosynthetic eukaryotic cell, which survived in a symbiotic relationship inside the heterotrophic cell.
secondary growth Growth produced by lateral meristems, thickening the roots and shoots of woody plants.
secondary immune response The adaptive immune response elicited on second or subsequent exposures to a particular antigen. The secondary immune response is more rapid, of greater magnitude, and of longer duration than the primary immune response.
secondary oocyte An oocyte that has completed the first of the two meiotic divisions.
secondary production The amount of chemical energy in consumers' food that is converted to their own new biomass during a given time period.
secondary structure Regions of repetitive coiling or folding of the polypeptide backbone of a protein due to hydrogen bonding between constituents of the backbone (not the side chains).
secondary succession A type of succession that occurs where an existing community has been cleared by some disturbance that leaves the soil or substrate intact.
secretion (1) The discharge of molecules synthesized by a cell. (2) The discharge of wastes from the body fluid into the filtrate.
secretory phase That portion of the uterine (menstrual) cycle when the endometrium continues to thicken, becomes more vascularized, and develops glands that secrete a fluid rich in glycogen.
seed An adaptation of some terrestrial plants consisting of an embryo packaged along with a store of food within a protective coat.
seed coat A tough outer covering of a seed, formed from the outer coat of an ovule. In a flowering plant, the seed coat encloses and protects the embryo and endosperm.
seedless vascular plant An informal name for a plant that has vascular tissue but lacks seeds. Seedless vascular plants form a paraphyletic group that includes the phyla Lycophyta (club mosses and their relatives) and Pterophyta (ferns and their relatives).
selective permeability A property of biological membranes that allows them to regulate the passage of substances across them.
self-incompatibility The ability of a seed plant to reject its own pollen and sometimes the pollen of closely related individuals.

semelparity Reproduction in which an organism produces all of its offspring in a single event; also known as big-bang reproduction.
semen The fluid that is ejaculated by the male during orgasm; contains sperm and secretions from several glands of the male reproductive tract.
semicircular canals A three-part chamber of the inner ear that functions in maintaining equilibrium.
semiconservative model Type of DNA replication in which the replicated double helix consists of one old strand, derived from the parental molecule, and one newly made strand.
semilunar valve A valve located at each exit of the heart, where the aorta leaves the left ventricle and the pulmonary artery leaves the right ventricle.
seminal vesicle A gland in males that secretes a fluid component of semen that lubricates and nourishes sperm.
seminiferous tubule A highly coiled tube in the testis in which sperm are produced.
senescence The growth phase in a plant or plant part (as a leaf) from full maturity to death.
sensitive period A limited phase in an animal's development when learning of particular behaviors can take place; also called a critical period.
sensor In homeostasis, a receptor that detects a stimulus.
sensory adaptation The tendency of sensory neurons to become less sensitive when they are stimulated repeatedly.
sensory neuron A nerve cell that receives information from the internal or external environment and transmits signals to the central nervous system.
sensory reception The detection of a stimulus by sensory cells.
sensory receptor An organ, cell, or structure within a cell that responds to specific stimuli from an organism's external or internal environment.
sensory transduction The conversion of stimulus energy to a change in the membrane potential of a sensory receptor cell.
sepal A modified leaf in angiosperms that helps enclose and protect a flower bud before it opens.
septum (plural, **septa**) One of the cross-walls that divide a fungal hypha into cells. Septa generally have pores large enough to allow ribosomes, mitochondria, and even nuclei to flow from cell to cell.
serial endosymbiosis A hypothesis for the origin of eukaryotes consisting of a sequence of endosymbiotic events in which mitochondria, chloroplasts, and perhaps other cellular structures were derived from small prokaryotes that had been engulfed by larger cells.
serotonin A neurotransmitter, synthesized from the amino acid tryptophan, that functions in the central nervous system.
set point In homeostasis in animals, a value maintained for a particular variable, such as body temperature or solute concentration.
seta (plural, **setae**) The elongated stalk of a bryophyte sporophyte.
sex chromosome A chromosome responsible for determining the sex of an individual.

sex-linked gene A gene located on either sex chromosome. Most sex-linked genes are on the X chromosome and show distinctive patterns of inheritance; there are very few genes on the Y chromosome.
sexual dimorphism Differences between the secondary sex characteristics of males and females.
sexual reproduction A type of reproduction in which two parents give rise to offspring that have unique combinations of genes inherited from both parents via the gametes.
sexual selection A form of selection in which individuals with certain inherited characteristics are more likely than other individuals to obtain mates.
Shannon diversity An index of community diversity symbolized by *H* and represented by the equation *H* _ –(*p*A ln *p*A _ *p*B ln *p*B _ *p*C ln *p*C _ . . .), where A, B, C . . . are species, *p* is the relative abundance of each species, and ln is the natural logarithm.
shared ancestral character A character, shared by members of a particular clade, that originated in an ancestor that is not a member of that clade.
shared derived character An evolutionary novelty that is unique to a particular clade.
shoot system The aerial portion of a plant body, consisting of stems, leaves, and (in angiosperms) flowers.
short tandem repeat (STR) Simple sequence DNA containing multiple tandemly repeated units of two to five nucleotides. Variations in STRs act as genetic markers in STR analysis, used to prepare genetic profiles.
short-day plant A plant that flowers (usually in late summer, fall, or winter) only when the light period is shorter than a critical length.
short-term memory The ability to hold information, anticipations, or goals for a time and then release them if they become irrelevant.
sickle-cell disease A recessively inherited human blood disorder in which a single nucleotide change in the _-globin gene causes hemoglobin to aggregate, changing red blood cell shape and causing multiple symptoms in afflicted individuals.
sieve plate An end wall in a sieve-tube element, which facilitates the flow of phloem sap in angiosperm sieve tubes.
sieve-tube element A living cell that conducts sugars and other organic nutrients in the phloem of angiosperms; also called a sievetube member. Connected end to end, they form sieve tubes.
sign stimulus An external sensory cue that triggers a fixed action pattern by an animal.
signal In animal behavior, transmission of a stimulus from one animal to another. The term is also used in the context of communication in other kinds of organisms and in cell-to-cell communication in all multicellular organisms.
signal peptide A sequence of about 20 amino acids at or near the leading (amino) end of a polypeptide that targets it to the endoplasmic reticulum or other organelles in a eukaryotic cell.
signal transduction The linkage of a mechanical, chemical, or electromagnetic stimulus to a specific cellular response.

signal transduction pathway A series of steps linking a mechanical, chemical, or electrical stimulus to a specific cellular response.
signal-recognition particle (SRP) A protein-RNA complex that recognizes a signal peptide as it emerges from a ribosome and helps direct the ribosome to the endoplasmic reticulum (ER) by binding to a receptor protein on the ER.
silent mutation A nucleotide-pair substitution that has no observable effect on the phenotype; for example, within a gene, a mutation that results in a codon that codes for the same amino acid.
simple fruit A fruit derived from a single carpel or several fused carpels.
simple sequence DNA A DNA sequence that contains many copies of tandemly repeated short sequences.
single bond A single covalent bond; the sharing of a pair of valence electrons by two atoms.
single circulation A circulatory system consisting of a single pump and circuit, in which blood passes from the sites of gas exchange to the rest of the body before returning to the heart.
single nucleotide polymorphism (SNP) A single base-pair site in a genome where nucleotide variation is found in at least 1% of the population.
single-lens eye The camera-like eye found in some jellies, polychaete worms, spiders, and many molluscs.
single-strand binding protein A protein that binds to the unpaired DNA strands during DNA replication, stabilizing them and holding them apart while they serve as templates for the synthesis of complementary strands of DNA.
sinoatrial (SA) node A region in the right atrium of the heart that sets the rate and timing at which all cardiac muscle cells contract; the pacemaker.
sister chromatids Two copies of a duplicated chromosome attached to each other by proteins at the centromere and, sometimes, along the arms. While joined, two sister chromatids make up one chromosome. Chromatids are eventually separated during mitosis or meiosis II.
sister taxa Groups of organisms that share an immediate common ancestor and hence are each other's closest relatives.
skeletal muscle A type of striated muscle that is generally responsible for the voluntary movements of the body.
sliding-filament model The idea that muscle contraction is based on the movement of thin (actin) filaments along thick (myosin) filaments, shortening the sarcomere, the basic unit of muscle organization.
slow block to polyspermy The formation of the fertilization envelope and other changes in an egg's surface that prevent fusion of the egg with more than one sperm. The slow block begins about 1 minute after fertilization.
slow-twitch fiber A muscle fiber that can sustain long contractions.
small interfering RNA (siRNA) One of multiple small, single-stranded RNA molecules generated by cellular machinery from a long, linear, double-stranded RNA molecule. The siRNA associates with one or more proteins in a complex that can degrade or prevent translation of an mRNA with a complementary sequence.

In some cases, siRNA can also block transcription by promoting chromatin modification.
small intestine The longest section of the alimentary canal, so named because of its small diameter compared with that of the large intestine; the principal site of the enzymatic hydrolysis of food macromolecules and the absorption of nutrients.
smooth ER That portion of the endoplasmic reticulum that is free of ribosomes.
smooth muscle A type of muscle lacking the striations of skeletal and cardiac muscle because of the uniform distribution of myosin filaments in the cells; responsible for involuntary body activities.
social learning Modification of behavior through the observation of other individuals.
sociobiology The study of social behavior based on evolutionary theory.
sodium-potassium pump A transport protein in the plasma membrane of animal cells that actively transports sodium out of the cell and potassium into the cell.
soil horizon A soil layer with physical characteristics that differ from those of the layers above or beneath.
solute A substance that is dissolved in a solution.
solute potential (ΨS) A component of water potential that is proportional to the molarity of a solution and that measures the effect of solutes on the direction of water movement; also called osmotic potential, it can be either zero or negative.
solution A liquid that is a homogeneous mixture of two or more substances.
solvent The dissolving agent of a solution. Water is the most versatile solvent known.
somatic cell Any cell in a multicellular organism except a sperm or egg or their precursors.
somite One of a series of blocks of mesoderm that exist in pairs just lateral to the notochord in a vertebrate embryo.
soredium (plural, **soredia**) In lichens, a small cluster of fungal hyphae with embedded algae.
sorus (plural, **sori**) A cluster of sporangia on a fern sporophyll. Sori may be arranged in various patterns, such as parallel lines or dots, which are useful in fern identification.
Southern blotting A technique that enables specific nucleotide sequences to be detected in samples of DNA. It involves gel electrophoresis of DNA molecules and their transfer to a membrane (blotting), followed by nucleic acid hybridization with a labeled probe.
spatial learning The establishment of a memory that reflects the environment's spatial structure.
spatial summation A phenomenon of neural integration in which the membrane potential of the postsynaptic cell is determined by the combined effect of EPSPs or IPSPs produced nearly simultaneously by different synapses.
speciation An evolutionary process in which one species splits into two or more species.

species A population or group of populations whose members have the potential to interbreed in nature and produce viable, fertile offspring, but do not produce viable, fertile offspring with members of other such groups.
species diversity The number and relative abundance of species in a biological community.
species richness The number of species in a biological community.
species-area curve The biodiversity pattern that shows that the larger the geographic area of a community is, the more species it has.
spermatogenesis The continuous and prolific production of mature sperm cells in the testis.
spermatogonium (plural, **spermatogonia**) A cell that divides mitotically to form spermatocytes.
sphincter A ringlike band of muscle fibers that controls the size of an opening in the body, such as the passage between the esophagus and the stomach.
spiral cleavage A type of embryonic development in protostomes in which the planes of cell division that transform the zygote into a ball of cells are diagonal to the vertical axis of the embryo. As a result, the cells of each tier sit in the grooves between cells of adjacent tiers.
spliceosome A large complex made up of proteins and RNA molecules that splices RNA by interacting with the ends of an RNA intron, releasing the intron and joining the two adjacent exons.
spontaneous process A process that occurs without an overall input of energy; a process that is energetically favorable.
sporangium (plural, **sporangia**) A multicellular organ in fungi and plants in which meiosis occurs and haploid cells develop.
spore (1) In the life cycle of a plant or alga undergoing alternation of generations, a haploid cell produced in the sporophyte by meiosis. A spore can divide by mitosis to develop into a multicellular haploid individual, the gametophyte, without fusing with another cell. (2) In fungi, a haploid cell, produced either sexually or asexually, that produces a mycelium after germination.
sporocyte A diploid cell, also known as a spore mother cell, that undergoes meiosis and generates haploid spores.
sporophyll A modified leaf that bears sporangia and hence is specialized for reproduction.
sporophyte In organisms (plants and some algae) that have alternation of generations, the multicellular diploid form that results from the union of gametes. The sporophyte produces haploid spores by meiosis that develop into gametophytes.
sporopollenin A durable polymer that covers exposed zygotes of charophyte algae and forms the walls of plant spores, preventing them from drying out.
stabilizing selection Natural selection in which intermediate phenotypes survive or reproduce more successfully than do extreme phenotypes.
stamen The pollen-producing reproductive organ of a flower, consisting of an anther and a filament.

standard metabolic rate (SMR) Metabolic rate of a resting, fasting, and nonstressed ectotherm at a particular temperature.
starch A storage polysaccharide in plants, consisting entirely of glucose monomers joined by α glycosidic linkages.
start point In transcription, the nucleotide position on the promoter where RNA polymerase begins synthesis of RNA.
statocyst A type of mechanoreceptor that functions in equilibrium in invertebrates by use of statoliths, which stimulate hair cells in relation to gravity.
statolith (1) In plants, a specialized plastid that contains dense starch grains and may play a role in detecting gravity. (2) In invertebrates, a dense particle that settles in response to gravity and is found in sensory organs that function in equilibrium.
stele The vascular tissue of a stem or root.
stem A vascular plant organ consisting of an alternating system of nodes and internodes that support the leaves and reproductive structures.
stem cell Any relatively unspecialized cell that can produce, during a single division, one identical daughter cell and one more specialized daughter cell that can undergo further differentiation.
steroid A type of lipid characterized by a carbon skeleton consisting of four fused rings with various chemical groups attached.
sticky end A single-stranded end of a doublestranded restriction fragment.
stigma (plural, **stigmata**) The sticky part of a flower's carpel, which receives pollen grains.
stimulus In feedback regulation, a fluctuation in a variable that triggers a response.
stramenopile A protist in which a "hairy" flagellum (one covered with fine, hairlike projections) is paired with a shorter, smooth flagellum.
stratum (plural, **strata**) A rock layer formed when new layers of sediment cover older ones and compress them.
striated muscle Muscle in which the regular arrangement of filaments creates a pattern of light and dark bands.
strigolactones A class of plant hormone that inhibits shoot branching, triggers the germination of parasitic plant seeds, and stimulates the association of plant roots with mycorrhizal fungi.
strobilus (plural, **strobili**) The technical term for a cluster of sporophylls known commonly as a cone, found in most gymnosperms and some seedless vascular plants.
stroke The death of nervous tissue in the brain, usually resulting from rupture or blockage of arteries in the head.
stroke volume The volume of blood pumped by a heart ventricle in a single contraction.
stroma The dense fluid within the chloroplast surrounding the thylakoid membrane and containing ribosomes and DNA; involved in the synthesis of organic molecules from carbon dioxide and water.
stromatolite Layered rock that results from the activities of prokaryotes that bind thin films of sediment together.

structural isomer One of several compounds that have the same molecular formula but differ in the covalent arrangements of their atoms.
substrate The reactant on which an enzyme works.
substrate feeder An animal that lives in or on its food source, eating its way through the food.
substrate-level phosphorylation The enzymecatalyzed formation of ATP by direct transfer of a phosphate group to ADP from an intermediate substrate in catabolism.
sugar sink A plant organ that is a net consumer or storer of sugar. Growing roots, shoot tips, stems, and fruits are examples of sugar sinks supplied by phloem.
sugar source A plant organ in which sugar is being produced by either photosynthesis or the breakdown of starch. Mature leaves are the primary sugar sources of plants.
sulfhydryl group A chemical group consisting of a sulfur atom bonded to a hydrogen atom.
suprachiasmatic nucleus (SCN) A group of neurons in the hypothalamus of mammals that functions as a biological clock.
surface tension A measure of how difficult it is to stretch or break the surface of a liquid. Water has a high surface tension because of the hydrogen bonding of surface molecules.
surfactant A substance secreted by alveoli that decreases surface tension in the fluid that coats the alveoli.
survivorship curve A plot of the number of members of a cohort that are still alive at each age; one way to represent age-specific mortality.
suspension feeder An aquatic animal, such as a sponge, clam, or baleen whale, that feeds by sifting small organisms or food particles from the water.
sustainable agriculture Long-term productive farming methods that are environmentally safe.
sustainable development Development that meets the needs of people today without limiting the ability of future generations to meet their needs.
swim bladder In aquatic osteichthyans, an air sac that enables the animal to control its buoyancy in the water.
symbiont The smaller participant in a symbiotic relationship, living in or on the host.
symbiosis An ecological relationship between organisms of two different species that live together in direct and intimate contact.
sympathetic division One of three divisions of the autonomic nervous system; generally increases energy expenditure and prepares the body for action.
sympatric speciation The formation of new species in populations that live in the same geographic area.
symplast In plants, the continuum of cytoplasm connected by plasmodesmata between cells.
synapse The junction where a neuron communicates with another cell across a narrow gap via a neurotransmitter or an electrical coupling.

synapsid Member of an amniote clade distinguished by a single hole on each side of the skull. Synapsids include the mammals.
synapsis The pairing and physical connection of duplicated homologous chromosomes during prophase I of meiosis.
systematics A scientific discipline focused on classifying organisms and determining their evolutionary relationships.
systemic acquired resistance A defensive response in infected plants that helps protect healthy tissue from pathogenic invasion.
systemic circuit The branch of the circulatory system that supplies oxygenated blood to and carries deoxygenated blood away from organs and tissues throughout the body.
systems biology An approach to studying biology that aims to model the dynamic behavior of whole biological systems based on a study of the interactions among the system's parts.
systole The stage of the cardiac cycle in which a heart chamber contracts and pumps blood.
systolic pressure Blood pressure in the arteries during contraction of the ventricles.
T cells The class of lymphocytes that mature in the thymus; they include both effector cells for the cell-mediated immune response and helper cells required for both branches of adaptive immunity.
taproot A main vertical root that develops from an embryonic root and gives rise to lateral (branch) roots.
tastant Any chemical that stimulates the sensory receptors in a taste bud.
taste bud A collection of modified epithelial cells on the tongue or in the mouth that are receptors for taste in mammals.
TATA box A DNA sequence in eukaryotic promoters crucial in forming the transcription initiation complex.
taxis An oriented movement toward or away from a stimulus.
taxon (plural, **taxa**) A named taxonomic unit at any given level of classification.
taxonomy A scientific discipline concerned with naming and classifying the diverse forms of life.
telomerase An enzyme that catalyzes the lengthening of telomeres in eukaryotic germ cells.
telomere The tandemly repetitive DNA at the end of a eukaryotic chromosome's DNA molecule. Telomeres protect the organism's genes from being eroded during successive rounds of replication. *See also* repetitive DNA.
telophase The fifth and final stage of mitosis, in which daughter nuclei are forming and cytokinesis has typically begun.
temperate broadleaf forest A biome located throughout midlatitude regions where there is sufficient moisture to support the growth of large, broadleaf deciduous trees.
temperate grassland A terrestrial biome that exists at midlatitude regions and is dominated by grasses and forbs.

temperate phage A phage that is capable of replicating by either a lytic or lysogenic cycle.
temperature A measure of the intensity of heat in degrees, reflecting the average kinetic energy of the molecules.
template strand The DNA strand that provides the pattern, or template, for ordering, by complementary base pairing, the sequence of nucleotides in an RNA transcript.
temporal summation A phenomenon of neural integration in which the membrane potential of the postsynaptic cell in a chemical synapse is determined by the combined effect of EPSPs or IPSPs produced in rapid succession.
tendon A fibrous connective tissue that attaches muscle to bone.
terminator In bacteria, a sequence of nucleotides in DNA that marks the end of a gene and signals RNA polymerase to release the newly made RNA molecule and detach from the DNA.
territoriality A behavior in which an animal defends a bounded physical space against encroachment by other individuals, usually of its own species.
tertiary consumer A carnivore that eats other carnivores.
tertiary structure The overall shape of a protein molecule due to interactions of amino acid side chains, including hydrophobic interactions, ionic bonds, hydrogen bonds, and disulfide bridges.
testcross Breeding an organism of unknown genotype with a homozygous recessive individual to determine the unknown genotype. The ratio of phenotypes in the offspring reveals the unknown genotype.
testis (plural, **testes**) The male reproductive organ, or gonad, in which sperm and reproductive hormones are produced.
testosterone A steroid hormone required for development of the male reproductive system, spermatogenesis, and male secondary sex characteristics; the major androgen in mammals.
tetanus The maximal, sustained contraction of a skeletal muscle, caused by a very high frequency of action potentials elicited by continual stimulation.
tetrapod A vertebrate clade whose members have limbs with digits. Tetrapods include mammals, amphibians, and birds and other reptiles.
thalamus An integrating center of the vertebrate forebrain. Neurons with cell bodies in the thalamus relay neural input to specific areas in the cerebral cortex and regulate what information goes to the cerebral cortex.
thallus (plural, **thalli***)* A seaweed body that is plantlike, consisting of a holdfast, stipe, and blades, yet lacks true roots, stems, and leaves.
thermocline A narrow stratum of abrupt temperature change in the ocean and in many temperate-zone lakes.
thermodynamics The study of energy transformations that occur in a collection of matter. *See* first law of thermodynamics; second law of thermodynamics.
thermoreceptor A receptor stimulated by either heat or cold.
thermoregulation The maintenance of internal body temperature within a tolerable range.
theropod Member of a group of dinosaurs that were bipedal carnivores.

thick filament A filament composed of staggered arrays of myosin molecules; a component of myofibrils in muscle fibers.
thigmomorphogenesis A response in plants to chronic mechanical stimulation, resulting from increased ethylene production. An example is thickening stems in response to strong winds.
thigmotropism A directional growth of a plant in response to touch.
thin filament A filament consisting of two strands of actin and two strands of regulatory protein coiled around one another; a component of myofibrils in muscle fibers.
threatened species A species that is considered likely to become endangered in the foreseeable future.
threshold The potential that an excitable cell membrane must reach for an action potential to be initiated.
thrombus A fibrin-containing clot that forms in a blood vessel and blocks the flow of blood.
thylakoid A flattened, membranous sac inside a chloroplast. Thylakoids often exist in stacks called grana that are interconnected; their membranes contain molecular "machinery" used to convert light energy to chemical energy.
thymus A small organ in the thoracic cavity of vertebrates where maturation of T cells is completed.
thyroid gland An endocrine gland, located on the ventral surface of the trachea, that secretes two iodine-containing hormones, triiodothyronine (T3) and thyroxine (T4), as well as calcitonin.
thyroxine (T4) One of two iodine-containing hormones that are secreted by the thyroid gland and that help regulate metabolism, development, and maturation in vertebrates.
Ti plasmid A plasmid of a tumor-inducing bacterium (the plant pathogen *Agrobacterium*) that integrates a segment of its DNA (T DNA) into a chromosome of a host plant. The Ti plasmid is frequently used as a vector for genetic engineering in plants.
tidal volume The volume of air a mammal inhales and exhales with each breath.
tight junction A type of intercellular junction between animal cells that prevents the leakage of material through the space between cells.
tissue An integrated group of cells with a common structure, function, or both.
tissue system One or more tissues organized into a functional unit connecting the organs of a plant.
Toll-like receptor (TLR) A membrane receptor on a phagocytic white blood cell that recognizes fragments of molecules common to a set of pathogens.
tonicity The ability of a solution surrounding a cell to cause that cell to gain or lose water.
top-down model A model of community organization in which predation influences community organization by controlling herbivore numbers, which in turn control plant or phytoplankton numbers, which in turn control nutrient levels; also called the trophic cascade model.

topoisomerase A protein that breaks, swivels, and rejoins DNA strands. During DNA replication, topoisomerase helps to relieve strain in the double helix ahead of the replication fork.
topsoil A mixture of particles derived from rock, living organisms, and decaying organic material (humus).
torpor A physiological state in which activity is low and metabolism decreases.
torsion In gastropods, a developmental process in which the visceral mass rotates up to 180°, causing the animal's anus and mantle cavity to be positioned above its head.
totipotent Describing a cell that can give rise to all parts of the embryo and adult, as well as extraembryonic membranes in species that have them.
trace element An element indispensable for life but required in extremely minute amounts.
trait One of two or more detectable variants in a genetic character.
trans fat An unsaturated fat, formed artificially during hydrogenation of oils, containing one or more *trans* double bonds.
transcription The synthesis of RNA using a DNA template.
transcription factor A regulatory protein that binds to DNA and affects transcription of specific genes.
transcription initiation complex The completed assembly of transcription factors and RNA polymerase bound to a promoter.
transcription unit A region of DNA that is transcribed into an RNA molecule.
transduction (1) A process in which phages (viruses) carry bacterial DNA from one bacterial cell to another. When these two cells are members of different species, transduction results in horizontal gene transfer. (2) In cellular communication, the conversion of a signal from outside the cell to a form that can bring about a specific cellular response; also called *signal transduction*.
transfer RNA (tRNA) An RNA molecule that functions as a translator between nucleic acid and protein languages by carrying specific amino acids to the ribosome, where they recognize the appropriate codons in the mRNA.
transformation (1) The conversion of a normal animal cell to a cancerous cell. (2) A change in genotype and phenotype due to the assimilation of external DNA by a cell. When the external DNA is from a member of a different species, transformation results in horizontal gene transfer.
transgenic Pertaining to an organism whose genome contains a gene introduced from another organism of the same or a different species.
translation The synthesis of a polypeptide using the genetic information encoded in an mRNA molecule. There is a change of "language" from nucleotides to amino acids.
translocation (1) An aberration in chromosome structure resulting from attachment of a chromosomal fragment to a nonhomologous chromosome. (2) During protein synthesis, the third stage in the elongation cycle, when the RNA carrying the growing polypeptide moves from the A site to the P site on the ribosome. (3) The transport of organic nutrients in the phloem of vascular plants.
transmission The passage of a nerve impulse along axons.

transmission electron microscope (TEM) A microscope that passes an electron beam through very thin sections stained with metal atoms and is primarily used to study the internal ultrastructure of cells.
transpiration The evaporative loss of water from a plant.
transport epithelium One or more layers of specialized epithelial cells that carry out and regulate solute movement.
transport protein A transmembrane protein that helps a certain substance or class of closely related substances to cross the membrane.
transport vesicle A small membranous sac in a eukaryotic cell's cytoplasm carrying molecules produced by the cell.
transposable element A segment of DNA that can move within the genome of a cell by means of a DNA or RNA intermediate; also called a transposable genetic element.
transposon A transposable element that moves within a genome by means of a DNA intermediate.
transverse (T) tubule An infolding of the plasma membrane of skeletal muscle cells.
triacylglycerol A lipid consisting of three fatty acids linked to one glycerol molecule; also called a fat or triglyceride.
triiodothyronine (T3) One of two iodine-containing hormones that are secreted by the thyroid gland and that help regulate metabolism, development, and maturation in vertebrates.
trimester In human development, one of three 3-month-long periods of pregnancy.
triple response A plant growth maneuver in response to mechanical stress, involving slowing of stem elongation, thickening of the stem, and a curvature that causes the stem to start growing horizontally.
triplet code A genetic information system in which a set of three-nucleotide-long words specify the amino acids for polypeptide chains.
triploblastic Possessing three germ layers: the endoderm, mesoderm, and ectoderm. Most eumetazoans are triploblastic.
trisomic Referring to a diploid cell that has three copies of a particular chromosome instead of the normal two.
trochophore larva Distinctive larval stage observed in some lophotrochozoan animals, including some annelids and molluscs.
trophic efficiency The percentage of production transferred from one trophic level to the next.
trophic structure The different feeding relationships in an ecosystem, which determine the route of energy flow and the pattern of chemical cycling.
trophoblast The outer epithelium of a mammalian blastocyst. It forms the fetal part of the placenta, supporting embryonic development but not forming part of the embryo proper.
tropic hormone A hormone that has an endocrine gland or cells as a target.
tropical dry forest A terrestrial biome characterized by relatively high temperatures and precipitation overall but with a pronounced dry season.

tropical rain forest A terrestrial biome characterized by relatively high precipitation and temperatures year-round.
tropics Latitudes between 23.5° north and south.
tropism A growth response that results in the curvature of whole plant organs toward or away from stimuli due to differential rates of cell elongation.
tropomyosin The regulatory protein that blocks the myosin-binding sites on actin molecules.
troponin complex The regulatory proteins that control the position of tropomyosin on the thin filament.
true-breeding Referring to organisms that produce offspring of the same variety over many generations of self-pollination.
tubal ligation A means of sterilization in which a woman's two oviducts (fallopian tubes) are tied closed to prevent eggs from reaching the uterus. A segment of each oviduct is removed.
tube foot One of numerous extensions of an echinoderm's water vascular system. Tube feet function in locomotion and feeding.
tumor-suppressor gene A gene whose protein product inhibits cell division, thereby preventing the uncontrolled cell growth that contributes to cancer.
tundra A terrestrial biome at the extreme limits of plant growth. At the northernmost limits, it is called arctic tundra, and at high altitudes, where plant forms are limited to low shrubby or matlike vegetation, it is called alpine tundra.
tunicate Member of the clade Urochordata, sessile marine chordates that lack a backbone.
turgid Swollen or distended, as in plant cells. (A walled cell becomes turgid if it has a lower water potential than its surroundings, resulting in entry of water.)
turgor pressure The force directed against a plant cell wall after the influx of water and swelling of the cell due to osmosis.
turnover The mixing of waters as a result of changing water-temperature profiles in a lake.
turnover time The time required to replace the standing crop of a population or group of populations (for example, of phytoplankton), calculated as the ratio of standing crop to production.
twin study A behavioral study in which researchers compare the behavior of identical twins raised apart with that of identical twins raised in the same household.
tympanic membrane Another name for the eardrum, the membrane between the outer and middle ear.
uniformitarianism The principle that mechanisms of change are constant over time. *See* catastrophism.
Unikonta One of five supergroups of eukaryotes proposed in a current hypothesis of the evolutionary history of eukaryotes. This clade, which is supported by studies of myosin proteins and DNA, consists of amoebozoans and opisthokonts. *See also* Excavata, Chromalveolata, Rhizaria, and Archaeplastida.

unsaturated fatty acid A fatty acid that has one or more double bonds between carbons in the hydrocarbon tail. Such bonding reduces the number of hydrogen atoms attached to the carbon skeleton.
uric acid A product of protein and purine metabolism and the major nitrogenous waste product of insects, land snails, and many reptiles. Uric acid is relatively nontoxic and largely insoluble.
vaccine A harmless variant or derivative of a pathogen that stimulates a host's immune system to mount defenses against the pathogen.
vacuole A membrane-bounded vesicle whose specialized function varies in different kinds of cells.
valence The bonding capacity of a given atom; usually equals the number of unpaired electrons required to complete the atom's outermost (valence) shell.
van der Waals interactions Weak attractions between molecules or parts of molecules that result from transient local partial charges.
variation Differences between members of the same species.
vas deferens In mammals, the tube in the male reproductive system in which sperm travel from the epididymis to the urethra.
vasa recta The capillary system in the kidney that serves the loop of Henle.
vascular cambium A cylinder of meristematic tissue in woody plants that adds layers of secondary vascular tissue called secondary xylem (wood) and secondary phloem.
vasectomy The cutting and sealing of each vas deferens to prevent sperm from entering the urethra.
vasocongestion The filling of a tissue with blood, caused by increased blood flow through the arteries of that tissue.
vasoconstriction A decrease in the diameter of blood vessels caused by contraction of smooth muscles in the vessel walls.
vasodilation An increase in the diameter of blood vessels caused by relaxation of smooth muscles in the vessel walls.
vector An organism that transmits pathogens from one host to another.
vegetal pole The point at the end of an egg in the hemisphere where most yolk is concentrated; opposite of animal pole.
vegetative reproduction Cloning of plants by asexual means.
vein (1) In animals, a vessel that carries blood toward the heart. (2) In plants, a vascular bundle in a leaf.
ventilation The flow of air or water over a respiratory surface.
ventral Pertaining to the underside, or bottom, of an animal with radial or bilateral symmetry.
ventricle (1) A heart chamber that pumps blood out of the heart. (2) A space in the vertebrate brain, filled with cerebrospinal fluid.
venule A vessel that conveys blood between a capillary bed and a vein.
vernalization The use of cold treatment to induce a plant to flower.
vertebrate A chordate animal with a backbone, including sharks and rays, ray-finned fishes, coelacanths, lungfishes, amphibians, reptiles, and mammals.
vesicle A membranous sac in the cytoplasm of a eukaryotic cell.

vessel A continuous water-conducting micropipe found in most angiosperms and a few nonflowering vascular plants.
vessel element A short, wide water-conducting cell found in the xylem of most angiosperms and a few nonflowering vascular plants. Dead at maturity, vessel elements are aligned end to end to form micropipes called vessels.
vestigial structure A feature of an organism that is a historical remnant of a structure that served a function in the organism's ancestors.
villus (plural, **villi**) (1) A finger-like projection of the inner surface of the small intestine. (2) A finger-like projection of the chorion of the mammalian placenta. Large numbers of villi increase the surface areas of these organs.
viral envelope A membrane, derived from membranes of the host cell, that cloaks the capsid, which in turn encloses a viral genome.
viroid A plant pathogen consisting of a molecule of naked, circular RNA a few hundred nucleotides long.
virulent Describing a pathogen against which an organism has little specific defense.
virulent phage A phage that replicates only by a lytic cycle.
virus An infectious particle incapable of replicating outside of a cell, consisting of an RNA or DNA genome surrounded by a protein coat (capsid) and, for some viruses, a membranous envelope.
visceral mass One of the three main parts of a mollusc; the part containing most of the internal organs. *See also* foot, mantle.
visible light That portion of the electromagnetic spectrum that can be detected as various colors by the human eye, ranging in wavelength from about 380 nm to about 750 nm.
vital capacity The maximum volume of air that a mammal can inhale and exhale with each breath.
vitamin An organic molecule required in the diet in very small amounts. Many vitamins serve as coenzymes or parts of coenzymes.
viviparous Referring to a type of development in which the young are born alive after having been nourished in the uterus by blood from the placenta.
voltage-gated ion channel A specialized ion channel that opens or closes in response to changes in membrane potential.
water potential (Ψ) The physical property predicting the direction in which water will flow, governed by solute concentration and applied pressure.
water vascular system A network of hydraulic canals unique to echinoderms that branches into extensions called tube feet, which function in locomotion and feeding.
wavelength The distance between crests of waves, such as those of the electromagnetic spectrum.
wetland A habitat that is inundated by water at least some of the time and that supports plants adapted to water-saturated soil.
wild type The phenotype most commonly observed in natural populations; also refers to the individual with that phenotype.

X-linked gene A gene located on the X chromosome; such genes show a distinctive pattern of inheritance.
X-ray crystallography A technique used to study the three-dimensional structure of molecules. It depends on the diffraction of an X-ray beam by the individual atoms of a crystallized molecule.
yeast Single-celled fungus. Yeasts reproduce asexually by binary fission or by the pinching of small buds off a parent cell. Many fungal species can grow both as yeasts and as a network of filaments; relatively few species grow only as yeasts.
zygote The diploid cell produced by the union of haploid gametes during fertilization; a fertilized egg.

Список прийнятих скорочень:
adj – adjective – прикметник
adv – adverb – прислівник
conj – conjunction – сполучник
n – noun – іменник
num – numeral – числівник
part – particle – частка
pl – plural – множина
sing – singular – однина
pron – pronoun – займенник
v – verb – дієслово

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