encounter selection factors that are different from and perhaps more severe than that experienced by the parent because the isolate is living in an environment slightly, or completely, different from that of the parent. These small isolated populations are not guaranteed to become new species, as they are more often likely to become extinct, yet it is clear in evolutionary history that allopatric speciation does occur.

See also SPECIATION.

allopolyploid A type of polyploid (having a nucleus that contains more than two sets of chromosomes) species, often a plant, resulting from two different species interbreeding and combining their chromosomes. Hybrids are often sterile because they do not have sets of homologous chromosomes, making pairing nonexistent unless two diploid hybrids double the chromosome numbers, resulting in a fertile allotetraploid that now contains two sets of homologous chromosomes. Plant breeders find that this is beneficial, since it is possible to breed the advantages of different species into one. Triticale (a "new" grain created by crossing rye and durum wheat) is an allopolyploid that was developed from wheat and rye. Some crops are naturally allopolyploid, such as cotton, oats, tall fescue, potatoes, wheat, and tobacco. It is estimated that half of all angiosperms (flowering plants) are polyploid.

allosteric binding sites A type of binding site contained in many ENZYMEs and RECEPTORs. As a consequence of the binding to allosteric binding sites, the interaction with the normal ligand (ligands are molecules that bind to proteins) may be either enhanced or reduced. Ligand binding can change the shape of a protein.

allosteric effector Specific small molecules that bind to a protein at a site other than a catalytic site and that modulate (by activation or INHIBITION) the biological activity.

allosteric enzyme An ENZYME that contains a region, separate from the region that binds the SUBSTRATE for catalysis, where a small regulatory molecule binds and affects that catalytic activity. This effector molecule may be structurally unrelated to the substrate, or it may be a second molecule of substrate. If the catalytic activity is enhanced by binding, the effector is called an activator; if it is diminished, the effector is called an INHIBITOR.

allosteric regulation The regulation of the activity of allosteric ENZYMEs.

See also ALLOSTERIC BINDING SITES; ALLOSTERIC ENZYME.

allosteric site A specific receptor site on an enzyme molecule not on the active site (the site on the surface of an enzyme molecule that binds the substrate molecule). Molecules bind to the allosteric site and change the shape of the active site, either enabling the substrate to bind to the active site or prevent the binding of the substrate.

The molecule that binds to the allosteric site is an inhibitor because it causes a change in the three-dimensional structure of the enzyme that prevents the substrate from binding to the active site.

allozyme An enzyme form, a variant of the same enzyme (protein) that is coded for by different alleles at a single locus.

See also ENZYME.

alpha helix Most proteins contain one or more stretches of amino acids that take on a particular shape in three-dimensional space. The most common forms are alpha helix and beta sheet.

Alpha helix is spiral shaped, constituting one form of the secondary structure of proteins, arising from a specific hydrogen-bonding structure; the carbonyl group (–C=O) of each peptide bond extends parallel to the axis of the helix and points directly at the –N–H group of the peptide bond four amino acids below it in the helix. A hydrogen bond forms between them [–N–H . . . . . O=C–] and plays a role in stabilizing the helix conformation. The alpha helix is right-handed and twists clockwise, like a corkscrew, and makes a complete turn every 3.6 amino acids. The distance between two turns is 0.54 nm. However, an alpha helix can also be left-handed. Most enzymes contain sections of alpha helix.

The alpha helix was discovered by Linus Pauling in 1948.

See also HELIX.

alternation of generations A life cycle in plants where there is both a multicellular diploid form (the sporophyte generation) and a multicellular haploid form (the gametophyte generation).

Gametophytes produce haploid gametes that fuse zygotes that are forming. These zygotes then develop into diploid sporophytes. Meiosis in the sporophytes produces haploid spores, with division by meiosis giving rise to the next generation of gametophytes.

Alternation of generations occurs in plants and certain species of ALGAE. Ferns and fern allies (such as the club moss) are common examples that display alternation of generations. The above ground parent fern plant (the diploid sporophyte, or spore-bearing plant) has two full sets of chromosomes (two of each kind of chromosome). It sheds its single-celled haploid spores, having one set of chromosomes (one of each kind), which fall to the ground, and these in turn grow into a different plant, the gametophyte or prothallus, also haploid. The gametophyte has special bodies within the plant called archegonia (female cells) and antheridia (male cells). Here sexual fertilization takes place, and a new diploid sporophyte then grows.

There are four main groups of plants considered to be "fern allies," a diverse group of vascular plants that are neither flowering plants nor ferns and that reproduce by shedding spore to initiate an alternation of generations. These are the Lycophyta (Lycopsida, the club mosses; Selaginellopsida, the spike mosses; and Isoëtopsida, the quillworts); the Archeophyta (Sphenopsida, the horsetails and scouring-rushes; Psilopsida, the whiskbrooms; and Ophioglossopsida, the adder's-tongues and grape-ferns); the Pteridophyta (ferns); and Spermatophyta (flowering plants).

In some examples of alternation of generations—for example, in certain algae species such as in some green or brown forms—the alternation of generations takes on two different approaches. Where the sporophytes and gametophytes are structurally different, the two generations are heteromorphic. If the sporophytes and gametophytes look the same and have different chromosome pairs, the generations are said to be isomorphic.

altruistic behavior The aiding of another individual at one's own risk or expense. This can be in the form of one animal sending out a distress call to warn others of impending trouble, although putting itself in danger by giving out its location. Strangers coming to the rescue of other strangers, such as victims in an accident, hurricane, or earthquake, is another example of altruistic behavior.

alveolus (plural, alveoli) Latin for "hollow cavity." There are several definitions for alveolus. It is a thin, multilobed air sac that exchanges gases in the lungs of mammals and reptiles at the end of each bronchiole, a very fine respiratory tube in the lungs. An alveolus is lined with many blood capillaries where the exchange of carbon dioxide and oxygen takes place.

It is also the name given to the socket in the jawbone in which a tooth is rooted by means of the periodontal membrane, the connective tissue that surrounds the root and anchors it.

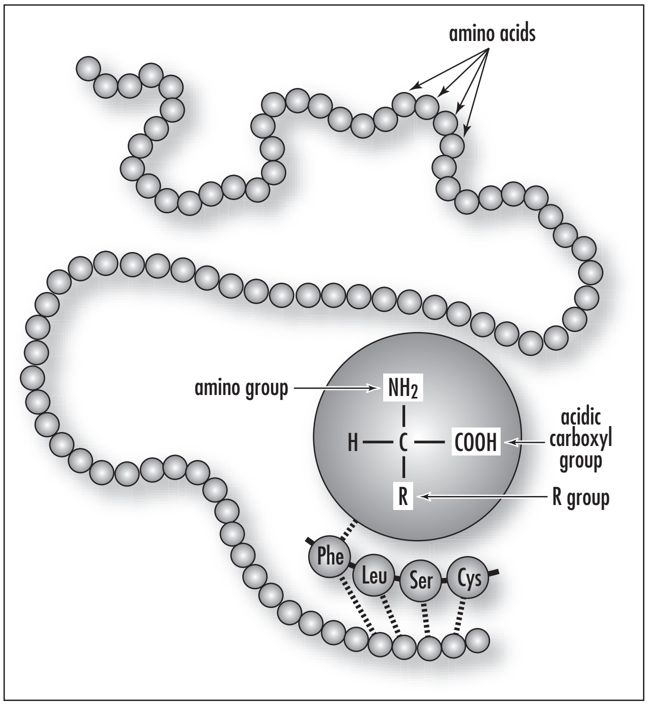
Furthermore, it is the term used to describe a single hexagonal beehive cell found in a honeycomb. It is also the term that refers to the milk-secreting sacs of the mammary gland.

ambidentate LIGANDs, such as $(NCS)^-$, that can bond to a CENTRAL ATOM through either of two or more donor atoms.

amicyanin An ELECTRON TRANSFER PROTEIN containing a TYPE 1 COPPER site, isolated from certain bacteria.

amino acid An organic molecule possessing both acidic carboxylic acid (–COOH) and basic amino ($-NH_2$) groups attached to the same tetrahedral carbon atom.

Amino acids are the principal building blocks of proteins and enzymes. They are incorporated into



Amino acids comprise a group of 20 different kinds of small molecules that link together in long chains to form proteins. Often referred to as the "building blocks" of proteins. *(Courtesy of Darryl Leja, NHGRI, National Institutes of Health)*

proteins by transfer RNA according to the genetic code while messenger RNA is being decoded by ribosomes. The amino acid content dictates the spatial and biochemical properties of the protein or enzyme during and after the final assembly of a protein. Amino acids have an average molecular weight of about 135 daltons. While more than 50 have been discovered, 20 are essential for making proteins, long chains of bonded amino acids.

Some naturally occurring amino acids are alanine, arginine, asparagine, aspartic acid, cysteine, glutamine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, and valine.

The two classes of amino acids that exist are based on whether the R-group is hydrophobic or hydrophilic. Hydrophobic or nonpolar amino acids tend to repel the aqueous environment and are located mostly in the interior of proteins. They do not ionize or participate in the formation of hydrogen bonds. On the other hand, the hydrophilic or polar amino acids tend to interact with the aqueous environment, are usually involved in the formation of hydrogen bonds, and are usually found on the exterior surfaces of proteins or in their reactive centers. It is for this reason that certain amino acid R-groups allow enzyme reactions to occur.

The hydrophilic amino acids can be further subdivided into polar with no charge, polar with negatively charged side chains (acidic), and polar with positively charged side chains (basic).

While all amino acids share some structural similarities, it is the side groups, or "R"-groups as they are called, that make the various amino acids chemically and physically different from each other so that they react differently with the environment. These groupings, found among the 20 naturally occurring amino acids, are ionic (aspartic acid, arginine, glutamic acid, lysine, and histidine), polar (asparagine, serine, threonine, cysteine, tyrosine, and glutamine), and nonpolar amino acids (alanine, glycine, valine, leucine, isoleucine, methionine, phenylalanine, tryptophan, and proline).

Amino acids are also referred to as amphoteric, meaning they can react with both acids and alkali, which makes them effective buffers in biological systems. A buffer is a solution where the pH usually stays constant when an acid or base is added.

In 1986 scientists found a 21st amino acid, selenocysteine. In 2002 two teams of researchers from Ohio State University identified the 22nd genetically encoded amino acid, called pyrrolysine, a discovery that is the biological equivalent of physicists finding a new fundamental particle or chemists discovering a new element.

Amino acid supplements are widely used in exercise and dietary programs.

See also PROTEIN.

amino acid residue (in a polypeptide) When two or more amino acids combine to form a peptide, the elements of water are removed, and what remains of each amino acid is called amino acid residue. Amino acid residues are therefore structures that lack a hydrogen atom of the amino group (–NH–CHR–COOH), or the hydroxy moiety of the carboxy group (NH_2–CHR–CO–), or both (–NH–CHR–CO–); all units of a peptide chain are therefore amino acid residues. (Residues of amino acids that contain two amino groups or two carboxy groups may be joined by isopeptide bonds, and so may not have the formulas shown.) The residue in a peptide that has an amino group that is free, or at least not acylated by another amino acid residue (it may, for example, be acylated or formylated), is called N-terminal; it is the N-terminus. The residue that has a free carboxy group, or at least does not acylate another amino acid residue (it may, for example, acylate ammonia to give –NH–CHR–CO–NH_2), is called C-terminal.

The following is a list of symbols for amino acids (use of the one-letter symbols should be restricted to the comparison of long sequences):

A	Ala	Alanine
B	Asx	Asparagine or aspartic acid
C	Cys	Cysteine
D	Asp	Aspartic acid
E	Glu	Glutamic acid
F	Phe	Phenylalanine
G	Gly	Glycine
H	His	Histidine
I	Ile	Isoleucine
K	Lys	Lysine
L	Leu	Leucine
M	Met	Methionine
N	Asn	Asparagine
P	Pro	Proline
Q	Gln	Glutamine
R	Arg	Arginine
S	Ser	Serine
T	Thr	Threonine
V	Val	Valine
W	Trp	Tryptophan
Y	Tyr	Tyrosine
Z	Glx	Glutamine or glutamic acid

aminoacyl-tRNA synthetases **(aaRSs)** When ribosomes pair a tRNA (transfer ribonucleic acid) with a codon (three bases in a DNA or RNA sequence), an amino acid is expected to be carried by the tRNA. Since each tRNA is matched with its amino acid before it meets the ribosome, the ribosome has no way of knowing if the match was made. The match is made by a family of enzymes called aminoacyl-tRNA synthetases. These enzymes charge each tRNA with the proper amino acid via a covalent ester bond, allowing each tRNA to make the proper translation from the genetic code of DNA into the amino acid code of proteins. Cells make at least 20 different aminoacyl-tRNS synthetases, one for each of the amino acids.

Aminoacyl-tRNA synthetases belong to two classes, depending on which amino acid they specify. Class I enzymes usually are monomeric and attach to the carobxyl of their specific amino acid to the 2' OH of adenosine 76 in the tRNA molecule. Class II enzymes are either dimeric or tetrameric and attach to their amino acids at the 3' OH. These enzymes catalyze first by activating the amino acid by forming an aminoacyl-adenylate. Here the carboxyl of the amino acid is linked to the alpha-phosphate of ATP, displacing pyrophosphate. After the corrected tRNA is bound, the aminoacyl group of the aminoacyl-adenylate is transferred to the 2' or 3' terminal OH of the tRNA.

Recent studies have shown that aminoacyl-tRNA synthetases can tell the difference between the right and the wrong tRNA before they ever start catalysis, and if the enzyme binds aminoacyl-adenylate first, it is even more specific during tRNA binding. Previous studies have also proved that aminoacyl-tRNA synthetases reject wrong tRNAs during catalysis. Other research has shown that specific aaRSs play roles in cellular fidelity, tRNA processing, RNA splicing, RNA trafficking, apoptosis, and transcriptional and translational regulation. These new revelations may present new evolutionary models for the development of cells and perhaps opportunities for pharmaceutical advancements.

amino group **(–NH_2)** A functional group (group of atoms within a molecule that is responsible for certain properties of the molecule and reactions in which it takes part), common to all amino acids, that consists of a nitrogen atom bonded covalently to two hydrogen atoms, leaving a lone valence electron on the nitrogen atom capable of bonding to another atom. It can act as a base in solution by accepting a hydrogen ion and carrying a charge of +1. Any organic compound that has an amino group is called an amine and is a derivative of the inorganic compound ammonia, NH_3. A primary amine has one hydrogen atom replaced, such as in the amino group. A secondary amine has two hydrogens replaced. A tertiary amine has all three hydrogens replaced. Amines are created by decomposing organic matter.

amniocentesis Amniocentesis is the removal of about two tablespoons of amniotic fluid via a needle inserted through the maternal abdomen into the uterus and amniotic sac. This is done to gain information about the condition, and even the sex, of the fetus. The fluid contains cells from the fetus and placenta.

Some women have a greater chance of giving birth to a baby with a chromosome problem, and amniocentesis can provide the answers if performed at about 16 weeks gestation (second trimester) or later. Chromosome analysis and alpha-fetoprotein (AFP) tests are two such tests, and these check for chromosome abnormalities such as Down's syndrome and whether there are any openings in the fetal skin, such as in the spine, that could lead to neural-tube defects like spina bifida or anencephaly, or inherited disorders such as cystic fibrosis.

While the procedure is relatively safe, some problems that can occur are miscarriage (1 in 200, or 0.5 percent chance), cramping, and infections (less than 1 in 1,000).

Amniocentesis can also be performed during the second and third trimesters to determine fetal lung maturity, to verify the health of the fetus in cases of Rh sensitivity, and to identify any infections.

First used in 1882 to remove excess amniotic fluid, it is often used in late pregnancy to test for anemia in fetuses with Rh disease and to check if the fetal lungs are advanced enough for delivery to occur.

amnion The amnion is a thin, but tough, transparent membranous sac and innermost of the four extra embryonic membranes (allantois, yolk sac, chorion) that encloses the embryo of reptiles, birds, and mammals. These membranes hold the amniotic fluid and form a protective layer for the fetus, insulating it from bacteria and infection.

See also EMBRYO.

amniotes Any of the vertebrates such as reptiles, birds, and mammals that have an amnion surrounding the embryo.

amniotic egg A calcium based or leathery shelled water-retaining egg that enables reptiles, birds, and egg-laying mammals, such as the monotremes (duck-billed platypus and two species of echidna, spiny anteaters), to complete their life cycles on dry land.

amoebic dysentery Dysentery caused by a protozoan parasite (*Entamoeba histolytica*), mostly caused by poor sanitary conditions and transmitted by contaminated food or water.

amphibian Cold-blooded, or ectothermic, vertebrates in the class Amphibia. These include the frogs and toads (order Anura, or Salientia), salamanders and newts (order Urodela, or Caudata), and the caecilians, limbless amphibians (order Apoda, or Gymnophiona). There are more than 11,000 species of amphibians, and they are believed to be the first vertebrate species to live on land.

Located between the fish and reptiles on the evolutionary scale, they are the most primitive of the terrestrial vertebrates and undergo a metamorphosis from water-breathing limbless larva (tadpole) to land-loving, or partly terrestrial, air-breathing four-legged adult.

Eggs are typically deposited in water or a wet protected place, although some do lay eggs in dry places. The eggs are not shelled and do not possess the membranes that are common in reptiles or higher vertebrates. Adults have moist skins with no scales or small scales, and they are specialized in living habitats. Each has its own evolutionary adaptations from the jumping ability (over 17 feet in some cases) of frogs and toads, to the limbless caecilians, to the long tails of the salamanders and newts. For example, frogs can enter aestivation, a period of dormancy similar to hibernation, when experiencing long periods of heat or drought conditions, and they can breathe through their skin in a process called cutaneous gas exchange. The most poisonous frog known, *Phyllobates terribilis,* only needs 0.00000007 ounce of skin secretion to kill a predator, while an antibiotic secreted from the African clawed frog (*Xenopus laevis*) may someday be used to treat burns and cystic fibrosis.

Over the last 50 years, many species of amphibians around the world have declined markedly in numbers; some species have become extinct. In many instances, these declines are attributable to adverse human influences acting locally, such as deforestation, draining of wetlands, and pollution.

However, in 1988, herpetologists (scientists who study amphibians) from many parts of the world reported declines in amphibian populations in protected, or pristine, habitats such as national parks and nature reserves, where such local effects could not be blamed. This suggested that there may be one or more global factors that are affecting climatic and atmospheric changes and adversely affecting amphibians, such as increased UV-B radiation, widespread pollution, acid rain, and disease. In effect, the decline could be the result of human-induced changes to the global ecosystem and could have far-reaching consequences for human survival.

amphipathic molecule A molecule that has both a hydrophilic (water soluble, polar) region and a hydrophobic (water hating, nonpolar) region. The hydrophilic part is called the head, while the hydrophobic part is called the tail. Lipids (phospholipids, cholesterol and other sterols, glycolipids [lipids with sugars attached], and sphingolipids) are examples of amphipathic molecules.

Amphipathic molecules act as surfactants, materials that can reduce the surface tension of a liquid at low concentrations, and are used in wetting agents, demisters, foaming agents, and emulsifiers.

anabolism The processes of metabolism that result in the synthesis of cellular components from precursors of low molecular weight.

See also METABOLISM.

anaerobic Any organism or environmental or cellular process that does not require the use of free oxygen. Certain bacteria such as *Actinomyces israeli, Bacteroides fragilis, Prevotella melaninogenica, Clostridium difficile,* and *Peptostreptococcus* are anaerobes.

In effect, an anaerobic organism does not need oxygen for growth. Many anaerobes are even sensitive to oxygen. Obligate (strict) anaerobes grow only in the absence of oxygen. Facultative anaerobes can grow either in the presence or in the absence of oxygen.

See also AEROBIC.

anagenesis A pattern of evolutionary change along a single, unbranching lineage involving the transformation of an entire population, sometimes so different from the ancestral population that it can be called a separate species. Examples would be one taxon replacing another or the transformation of a single ancestral species into a single descendant species. Anagenesis is also known as phyletic evolution and is the opposite of CLADOGENESIS.

In medicine, it refers to the regeneration of tissue or structure.

analog A DRUG whose structure is related to that of another drug but whose chemical and biological properties may be quite different.

See also CONGENER.

analogy The similarity of structure between two species that are not closely related; usually attributed to convergent evolution. Structures that resemble each other due to a similarity in function without any simi-

A photomicrograph of *Clostridium botulinum,* a strictly anaerobic bacterium, stained with Gentian violet. The bacterium *C. botulinum* produces a nerve toxin that causes the rare but serious paralytic illness botulism. *(Courtesy of Centers for Disease Control and Prevention)*

larity in underlying structure (or origin) are called analogous structures. For example, birds and bats each have their forelimbs modified as wings. They are analogous because they evolved independently after the earliest birds and bats diverged from their common ancestor, who did not have wings. However, the details of their structures are quite different.

anation Replacement of the LIGAND water by an anion in a COORDINATION entity.

androgens Steroid sex hormones, such as testosterone secreted by the testes in males, and others secreted by the adrenal cortex in humans and higher animals, as well as by the adrenal glands and ovaries in mammals. Androgens stimulate the development and maintenance of the male reproductive system such as sperm production, sexual behavior, and muscle development. Secondary sex characteristics such as the growth of pubic hair in females is also a product of androgens, as is the deepening of the voice at puberty.

Testosterone is present in a number of forms, such as free testosterone, as testosterone bound to a protein, sex hormone binding globulin (SHBG), and as dihydrotestosterone. Testosterone and synthetic androgens (anabolic steroids) have been used for infertility, athletic enhancement, erectile dysfunction, and libido problems, but their use can cause side effects such as muscle weakness, muscle atrophy, little facial and body hair, and even changes in the size of the genitalia. Prolonged use can damage the liver, and their use is banned in many sports.

Other androgens are androsterone (excreted in urine), which reinforces masculine characteristics; dihydrotestosterone, which is a metabolite synthesized mainly in the liver from free testosterone by the enzyme 5-alpha-reductase and which levels are proportionally correlated to sex drive as well as erectile capabilities; and dehydroepiandrosterone, which are adrenal androgens that have been linked to puberty and aging.

See also HORMONE.

androgynous Term applied to flowering plants that have both staminate and pistillate flowers, or to cryptograms (ferns, mosses, fungi, algae) where the antheridia and archegonia are together.

anemia Condition in which there is a reduction in the number of red blood cells or amount of HEMOGLOBIN per unit volume of blood below the reference interval for a similar individual of the species under consideration, often causing pallor and fatigue.

See also HEMOGLOBIN.

aneuploidy Aneuploidy is the gain or loss of individual chromosomes from the normal diploid set of 46 and is the most common cytogenetic abnormality caused when homologous chromosomes fail to separate during the first division of meiosis.

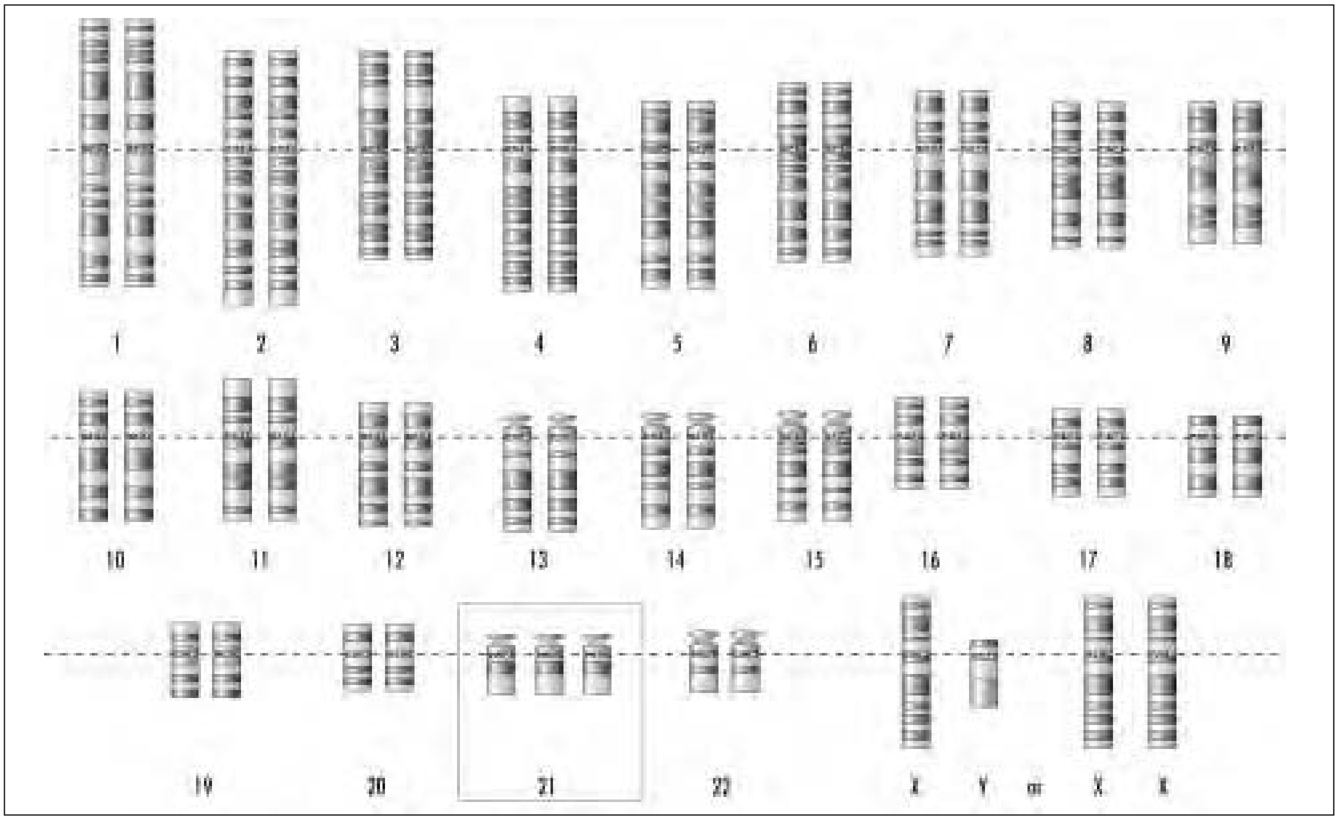
When a loss of a chromosome occurs, it is called monosomy and is rarely seen in live births, since most monosomic embryos and fetuses are lost to spontaneous abortion at very early stages of pregnancy. One exception to this is the loss of an X chromosome, which produces Turner syndrome in about one out of every 5,000 female births.

The more common gain of a single chromosome is called trisomy and has been associated with various cancers. A common autosomal trisomy is Down's syndrome in humans.

Another form of aneuploidy is called nullisomy, which is the loss of both pairs of homologous chromosomes and is almost always fatal to humans, since humans have no extra disposable chromosomes in the genome.

Tetrasomy is the gain of an extra pair of homologous chromosomes and is a rare chromosomal aberration. It can cause metopic craniosynostosis, facial anomalies, cranial asymmetry, atrioseptal defects, hydronephrosis, flexion contractures of the lower limbs, sensorineural hearing loss, and mental retardation.

angiosperm A flowering plant. There are close to 250,000 species of flowering plants, second in abundance only to insects. All have three basic organs (roots, stems, and leaves) and represent the most abundant and advanced terrestrial plants, which include trees, herbaceous plants, herbs, shrubs, all grasses, and some aquatic plants. Angiosperms are the source of most of the food on which human beings and other mammals rely and of many raw materials and natural products that provide the infrastructure for modern civilizations.

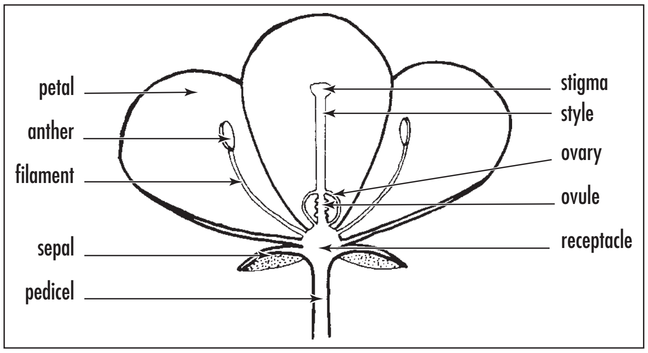


An example of aneuploidy for an individual possessing three copies of a particular chromosome instead of the normal two copies. ***(Courtesy of Darryl Leja, NHGRI, National Institutes of Health)***

Angiosperms are divided into two large groups. The dicotyledonea, or dicotyledons (also called magnoliopsida), the larger of the two groups, includes trees and shrubs and herbaceous plants. Dicots have two seed leaves (cotyledons) in the embryo. The smaller of the two groups is the monocotyledoneae, or monocotyledons (also called liliopsida), that include rice, corn, palms, bananas, coconuts, grasses, lilies, orchids, and garden plants. Monocots have a single seed leaf in the embryo.

The life cycles of the angiosperms have several advantages over those of conifers, or gymnosperms, the only other group of seed-bearing plants, and from which scientists believe the angiosperms evolved during the Cretaceous era some 145 million years ago. They reproduce via flowers instead of cones; their ovules are embedded in female sporophylls instead of being exposed on a bare ground surface (e.g., apple); the gametophyte is reduced; and seeds are enclosed in fruits that develop from the ovary or related structures.

Angiosperms have a true flower that is either a highly modified shoot with modified stem and leaves or a condensed and reduced compound strobilus (conelike structure) or inflorescence (flower cluster). Floral parts are in the form of sepals, petals, stamens, and carpels, while the ovules—the structure that develops in the plant ovary and contains the female gametophyte—are contained within the megasporophylls that are sealed in most angiosperm families. Pollination is facilitated by wind, water, or many animals. Self-pollination as well as parthenogenesis, a process by which embryonic development is initiated directly from an unfertilized cell, are common. Double fertilization occurs in all members of the phylum to produce the unusual stored food tissue called endosperm. Sexual reproduction in flowering plants occurs by this process of double fertilization in which one fertilization event forms an



A schematic of a typical angiosperm flower.

embryo, and a second fertilization event produces endosperm, a polyploid embryo-nourishing tissue found only in the angiosperms. Seeds are dispersed through a variety of forms such as fruits, follicles, capsules, berries, drupes, samaras, nuts, and achenes. *Angiosperm* is a combination of the Latin word *angi-* (enclosed) and the Greek word *sperma* (seed).

anion An atom or molecule that has a negative charge; a negatively charged ion.

See also ION.

anisotropy The property of molecules and materials to exhibit variations in physical properties along different molecular axes of the substance.

annual A plant that completes its entire life cycle—germinates, grows, flowers, and seeds—in a single year or growing season.

See also BIENNIAL; PERENNIAL.

antagonist A DRUG or a compound that opposes the physiological effects of another. At the RECEPTOR level, it is a chemical entity that opposes the RECEPTOR-associated responses normally induced by another bioactive agent.

anterior Referring to the head end of a bilaterally symmetrical animal; the front of an animal.

anther In angiosperms, it is the terminal pollen sac of the stamen. The pollen grains with male gametes form inside the anther. It is the pollen that fertilizes the ovules. The anther is the primary male reproductive structure at the apex of the flower's stamen, the male sexual organ.

See also STAMEN.

antheridium The multicellular male sex organ or gametangium where motile male gametes (sperm) are formed and protected in algae, fungi, bryophytes (mosses, liverworts, etc.), and pteridophytes (ferns).

anthrax Bacterial disease of animals and humans caused by contamination with spores from *Bacillus anthracis* through inhalation or skin entry (cutaneous); can be used as an agent of bioterrorism.

See also BACTERIA.

anti In the representation of STEREOCHEMICAL relationships, *anti* means "on opposite sides" of a reference plane, in contrast to *syn,* which means "on the same side."

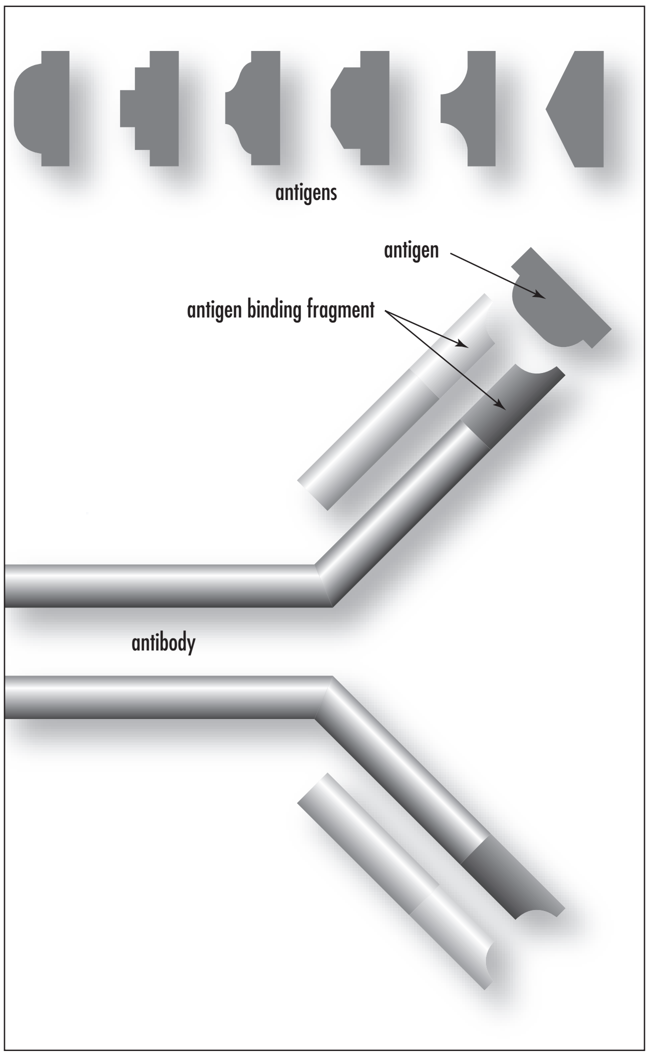
antibiotic A chemical agent that is produced synthetically or by an organism that is harmful to another organism. It is used to combat disease, either topically or by ingestion, in humans, animals, and plants. It can be made from a mold or bacterium and kills or slows the growth of other microbes, in particular bacteria. Penicillin, one of the most famous antibiotics, was accidentally discovered by the British bacteriologist SIR ALEXANDER FLEMING in 1928.

Antibiotic resistance can occur when antibiotics are used repetitively. While most of the targeted bacteria are killed by a dose of antibiotics, some escape death, and these remaining bacteria have or develop a genetic resistance to the antibiotic. Unfortunately, this resistance trait can be passed on to their offspring.

See also DRUG.

antibody A soluble immunoglobulin blood protein produced by the B cells, white blood cells, that develop in the bone marrow (also known as B lymphocytes, plasma cells) in response to an antigen (a foreign substance). Antibodies are produced in response to disease and help the body fight against a particular disease by binding to the antigen and killing it, or making it more vulnerable to action by white blood cells. They help the body develop an immunity to diseases.

Each antibody has two light (L) and two heavy (H) immunoglobulin polypeptide chains linked together by disulfide bonds, with two antigen-binding sites. There are more than 1,000 possible variations, yet each antibody recognizes only one specific antigen. Antibodies are normally bound to a B cell, but when an antibody encounters an antigen, the B cell produces copies of the antibody with the assistance of helper T cells (a lymphocyte that undergoes a developmental stage in the thymus). The released antibodies then go after and bind to the antigen, either killing it or marking it for destruction by phagocytes.



An antibody is a blood protein that is produced in response to and that counteracts an antigen. Antibodies are produced in response to disease and help the body fight against particular diseases. In this way, antibodies help the body develop an immunity to disease. *(Courtesy of Darryl Leja, NHGRI, National Institutes of Health)*

There are five immunoglobulins: IgC, IgA, IgM, IgD, and IgE.

IgA, or immunoglobulin A, comprises about 10–15 percent of the body's total immunoglobulins and is found in external secretions such as saliva, tears, breast milk, and mucous, both intestinal and bronchial. They are secreted on the surface of the body as a first defense against bacteria and viral antigens in an attempt to prevent them from entering the body.

IgM or immunoglobulin M antibodies are produced in response to new or repeat infections and stay in the body for a short time after infection. They make up from 5 to 10 percent of the total immunoglobulins and are the first to show up in the serum after an antigen enters. IgM is produced during the primary immune response. It is the IgMs that capture and bind antigens to form large insoluble complexes that are cleared from the blood.

IgG or immunoglobulin G (gamma globulin) antibodies remain in the body for long periods of time after infection and are the most common type, comprising about 80 percent of the body's total immunoglobulins. They are in the serum and are produced in substantial quantities during the secondary immune response, and along with IgM activate the complement system, which results in the destruction of the membrane of pathogens. The IgGs act by agglutinating, by opsonising, by activating complement-mediated reactions against cellular pathogens, and by neutralizing toxins.

IgE or immunoglobulin E is associated with mast cells, which are basophils, a type of granular white blood cell that has left the bloodstream and entered a tissue. Mast cells release histamine and heparin, chemicals that mediate allergic reactions. Not surprisingly, IgE is responsible for immediate hypersensitivity (allergic) reactions and immune defense against parasites.

IgD or immunoglobulin D is a specialized immunoglobulin, but its function is currently unknown. It is found in small amounts in the serum.

anticodon A specialized sequence of three nucleotides on a tRNA (transfer ribonucleic acid) molecule. The anticodon associates with a complementary triplet of bases—the codon—on an mRNA (messenger RNA) molecule during protein synthesis.

The tRNA molecule acts like a "ferry" whose job is to "pick up a passenger" (read the code from the mRNA) and then "shuttle it" (dock to the corresponding amino acid) into place. The other end of the tRNA molecule has an acceptor site where the tRNA's specific amino acid will bind.

The 20 amino acids in the table below can create 64 different tRNA molecules, 61 for tRNA coding and three codes for chain termination (pairing up with "stop codons" that end the mRNA message), and each amino acid can create more than one set of codons.

See also CODON.

Amino Acid:

A = Adeninez
C = Cytosine
G = Guanine
U = Uracil

Alanine	GCC, GCA, GCG, GCU
Arginine	AGA, AGG, CGU, CGA, CGC, CGG
Asparagine	AAC, AAU
Aspartic Acid	GAC, GAU
Cysteine	UGC, UGU
Glutamic Acid	GAA, GAG
Glutamine	CAA, CAG
Glycine	GGA, GGC, GGG, GGU
Histidine	CAC, CAU
Isoleucine	AUA, AUC, AUU
Leucine	UUA, UUG, CUA, CUC, CUG, CUU
Lycine	AAA, AAG
Methionine (initiation)	AUG
Phenylalanine	UUC, UUU
Proline	CCA, CCC, CCG, CCU
Serine	UCA, UCC, UCG, UCU, AGC, AGU
Threonine	ACA, ACC, ACG, ACU
Tryptophan	UGG
Tyrosine	UAC, UAU
Valine	GUA, GUC, GUG, GUU
"Stop"	UAA, UAG, UGA

antidiuretic hormone (**ADH**) Also known as vasopressin, ADH is a nine–amino acid peptide secreted from the posterior pituitary gland. The hormone is packaged in secretory vesicles with a carrier protein called neurophysin within hypothalamic neurons, and both are released upon hormone secretion. The single most important effect of antidiuretic hormone is to conserve body water by reducing the output of urine. It binds to receptors in the distal or collecting tubules of the kidney and promotes reabsorption of water back into the circulation.

The release of ADH is based on plasma osmolarity, the concentration of solutes in the blood. For example, loss of water (e.g., sweating) results in a concentration of blood solutes, so plasma osmolarity increases. Osmoreceptors, neurons in the hypothalamus, stimulate secretion from the neurons that produce ADH. If the plasma osmolarity falls below a certain threshold, the osmoreceptors do nothing and no ADH is released. However, when osmolarity increases above the threshold, the osmoreceptors stimulate the neurons and ADH is released.

antiferromagnetic *See* FERROMAGNETIC.

antigen A foreign substance, a macromolecule, that is not indigenous to the host organism and therefore elicits an immune response.

antimetabolite A structural ANALOG of an intermediate (substrate or COENZYME) in a physiologically occurring metabolic pathway that acts by replacing the natural substrate, thus blocking or diverting the biosynthesis of physiologically important substances.

antisense molecule An OLIGONUCLEOTIDE or ANALOG thereof that is complementary to a segment of RNA (ribonucleic acid) or DNA (deoxyribonucleic acid) and that binds to it and inhibits its normal function.

aphotic zone The deeper part of the ocean beneath the photic zone, where light does not penetrate sufficiently for photosynthesis to occur.

See also OCEANIC ZONE.