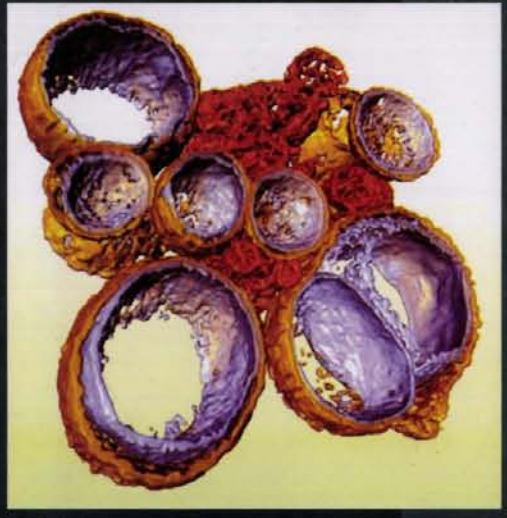

Illustrated Dictionary of Microbiology

Kiran Kapoor

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Preface

Microbiology is the study of microorganisms, which are unicellular or cell-cluster microscopic organisms. It is researched actively, and the field is advancing continually. Although microbes were first observed over three hundred years ago, the field of microbiology can be said to be in its infancy relative to older biological disciplines such as zoology and botany. Microbiology also involves a collection of techniques to study and manipulate these small creatures. Because of their size, special instruments and methods had to be developed to allow the performance of interpretable experiments on microorganisms. These methods are not restricted to microbes alone, but have also found utility in working with populations of cells from higher organisms.

This unique, illustrated dictionary of microbiology covers the whole field of pure and applied microbiology in one volume. It reflects the latest developments in the field, features entries from concise definitions of terms to review-length articles. With its wide-ranging description of different areas of microbiology, this illustrated dictionary is an indispensable reference for every researcher, lecturer and student. This illustrated reference work aims at defining and illustrating many life science terms used in microbiology. It is therefore the ideal tool for both research and multi-level education. In this work readers can find words, expressions, acronyms, abbreviations from various biological fields. For example, this microbiology dictionary defines terms from cell biology and molecular biology, chemistry, biochemistry, and physiology. This dictionary will allow readers to control and understand the scientific and technical terminology.

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A

AB5 toxins : AB5 toxins are six-component protein complexes secreted by a number of pathogenic bacteria. All share a similar structure and mechanism for entering targeted host cells. A complete AB5 toxin complex contains six protein units. Five—the B subunits—are similar or identical in structure; the remaining A subunit is unique. The A subunit (or a portion thereof) of an AB5 toxin is the portion of the complex responsible for toxicity. Typically it will have enzymatic activity inside the host cell. The B subunits form a pentameric (five-membered) ring, into which one end of the A subunit extends and is held. This B subunit ring is also capable of binding to a receptor on the surface of the host cell. (Without the B subunits, the A subunit has no way of attaching to or entering the cell, and thus no way to exert its toxic effect.)

Abiogenesis : Abiogenesis is the study of how life on Earth could have arisen from inanimate matter. It should not be confused with evolution, which is the study of how groups of living things change over time. Amino acids, often called "the building blocks of life", can form via natural chemical reactions unrelated to life, as demonstrated in the Miller-Urey experiment, which involved simulating the conditions of the early Earth. In all living things, these amino acids are organized into proteins, and the construction of these proteins is mediated by nucleic acids. Thus the question of how life on Earth originated is a question of how the first nucleic acids arose.The first living things on Earth are thought to be single cell prokaryotes. The oldest ancient fossil microbe-like objects are dated to be 3.5 Ga (billion years old), just a few hundred million years younger than Earth itself. By 2.4 Ga, the ratio of stable isotopes of carbon, iron and sulfur shows the action of living things on inorganic minerals and sediments and molecular biomarkers indicate photosynthesis, demonstrating that life on Earth was widespread by this time. On the other hand, the exact sequence of chemical events that led to the first nucleic acids is not known. Several hypotheses about early life have been proposed, most notably the iron-sulfur world theory (metabolism without genetics) and the RNA world hypothesis (RNA life-forms).

Until the early 19th century, people generally believed in the ongoing spontaneous generation of certain forms of life from non-living matter. This was paired with heterogenesis, beliefs where one form of life derives from a different form (*e.g.* bees from flowers). Classical notions of abiogenesis, now more precisely known as *spontaneous generation,* held that certain complex, living organisms are generated by decaying organic substances. According to Aristotle it was a readily observable truth that aphids arise from the dew which falls on plants, fleas from putrid matter, mice from dirty hay, crocodiles from rotting logs at the bottom of bodies of water, and so forth.

In the 17th century, such assumptions started to be questioned; for example, in 1646, Sir Thomas Browne published his *Pseudodoxia Epidemica* (subtitled *Enquiries into Very many Received Tenets, and Commonly Presumed Truths*), which was an attack on false beliefs and "vulgar errors." His conclusions were not widely accepted. For example, his contemporary, Alexander Ross wrote : "To question this (i.e., spontaneous generation) is to question reason, sense and experience. If he doubts of this let him go to Egypt, and there he will find the fields swarming with mice, begot of the mud of Nylus, to the great calamity of the inhabitants."

In 1665, Robert Hooke published the first drawings of a microorganism. Hooke was followed in 1676 by Anthony van Leeuwenhoek, who drew and described microorganisms that are now thought to have been protozoa and bacteria. Many felt the existence of microorganisms was evidence in support of spontaneous generation, since microorganisms seemed too simplistic for sexual reproduction, and asexual reproduction through cell division had not yet been observed.

The first solid evidence against spontaneous generation came in 1668 from Francesco Redi, who proved that no maggots appeared in meat when flies were prevented from laying eggs. It was gradually shown that, at least in the case of all the higher and readily visible organisms, the previous sentiment regarding spontaneous generation was false. The alternative seemed to be biogenesis : that every living thing came from a pre-existing living thing (*omne vivum ex ovo*, Latin for "every living thing from an egg"). In 1768, Lazzaro Spallanzani demonstrated that microbes were present in the air, and could be killed by boiling. In 1861, Louis Pasteur performed a series of experiments which demonstrated that organisms such as bacteria and fungi do not spontaneously appear in sterile, nutrient-rich media.

Acidogenesis ; Acidogenesis represents the second stage in the four stages of anaerobic digestion :

— *Hydrolysis* : A chemical reaction where particulates are solubilized and large polymers converted into simpler monomers;

— *Acidogenesis* : A biological reaction where simple monomers are converted into volatile fatty acids;

- *Acetogenesis* : A biological reaction where volatile fatty acids are converted into acetic acid, carbon dioxide, and hydrogen; and
- *Methanogenesis* : A biological reaction where acetates are converted into methane and carbon dioxide, while hydrogen is consumed.

Anaerobic digestion is a complex biochemical process of biologically-mediated reactions by a consortium of microorganisms to convert organic compounds into methane and carbon dioxide. It is a stabilization process, reducing odor, pathogens, and mass reduction.

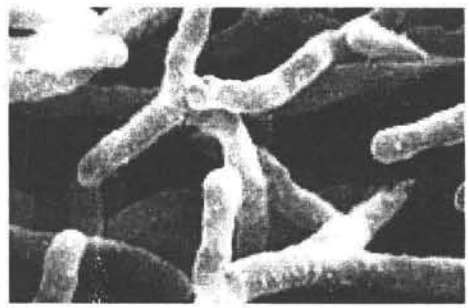
Hydrolytic bacteria form a variety of reduced end-products from the fermentation of a given substrate. One fundamental question which arises, concerns the metabolic features which control carbon and electron flow to a given reduced end-product during pure culture, and mixed methanogenic cultures of hydrolytic bacteria. *Thermoanaerobium brockii* is a representative thermophilic, hydrolytic bacterium, which ferments glucose, via the Embden-Meyerhof Parnas Pathway. *T. brockii* is an atypical hetero-lactic acid bacterium because it forms molecular hydrogen (H_2), in addition to lactic acid and ethanol. The reduced end-products of glucose fermentation are enzymatically-formed from pyruvate, via the following mechanisms : lactate by [[Fructose bisphosphatase | fructose 1-6]] all-phosphate (F6P) activated lactate dehydrogenase; H_2 by pyruvate ferredoxin oxidoreductase and hydrogenase; and ethanol via NADH- and NADPH-linked alcohol dehydrogenase.

Acquired Immunodeficiency Syndrome (AIDS) : AIDS is a disease of the human immune system caused by the human immunodeficiency virus (HIV). This condition progressively reduces the effectiveness of the immune system and leaves individuals susceptible to opportunistic infections and tumors. HIV is transmitted through direct contact of a mucous membrane or the bloodstream with a bodily fluid containing HIV, such as blood, semen, vaginal fluid, preseminal fluid, and breast milk. This transmission can involve anal, vaginal or oral sex, blood transfusion, contaminated hypodermic needles, exchange between mother and baby during pregnancy, childbirth, or breastfeeding, or other exposure to one of the above bodily fluids.

AIDS is now a pandemic. In 2007, it was estimated that 33.2 million people lived with the disease worldwide, and that AIDS had killed an estimated 2.1 million people, including 330,000 children. Over three-quarters of these deaths occurred in sub-Saharan Africa, retarding economic growth and destroying human capital. Genetic research indicates that HIV originated in west-central Africa during the late nineteenth or early twentieth century. AIDS was first recognized by the U.S. Centers for Disease Control and Prevention in 1981 and its cause, HIV, identified in the early 1980s.

Although treatments for AIDS and HIV can slow the course of the disease, there is currently no vaccine or cure. Antiretroviral treatment reduces both the mortality and the morbidity of HIV infection, but these drugs are expensive and routine access to antiretroviral medication is not available in all countries. Due to the difficulty in treating HIV infection, preventing infection is a key aim in controlling the AIDS epidemic, with health organizations promoting safe sex and needle-exchange programmes in attempts to slow the spread of the virus.

Actinomycetes : Actinomycetes are a group of Gram-positive bacteria with high G+C ratio. They include some of the most common soil life, playing an important role in decomposition of organic materials, such as cellulose and chitin and thereby playing a vital part in organic matter turnover and carbon cycle. This replenishes the supply of nutrients in the soil and is an important part of humus formation. Other Actinobacteria inhabit plants and animals, including a few pathogens, such as *Mycobacterium, Corynebacterium, Nocardia, Rhodococcus* and a few species of *Streptomyces*.



Actinobacteria

Actinobacteria are well known as secondary metabol'te producers and hence of high pharmacological and commercial interest. In 1940 Selman Waksman discovered that the soil bacteria he was studying made actinomycin, a discovery which granted him a Nobel Prize. Since then hundreds of naturally occurring antibiotics have been discovered in these terrestrial microorganisms, especially from the genus *Streptomyces*.

Some Actinobacteria form branching filaments, which somewhat resemble the mycelia of the unrelated fungi, among which they were originally classified under the older name Actinomycetes. Most members are aerobic, but a few, such as *Actinomyces israelii*, can grow under anaerobic conditions. Unlike the Firmicutes, the other main group of Gram-positive bacteria, they have DNA with a high GC-content and some Actinomycetes species produce external spores.

Some types of Actinobacteria are responsible for the peculiar odor emanating from the soil after rain, mainly on warmer climates.

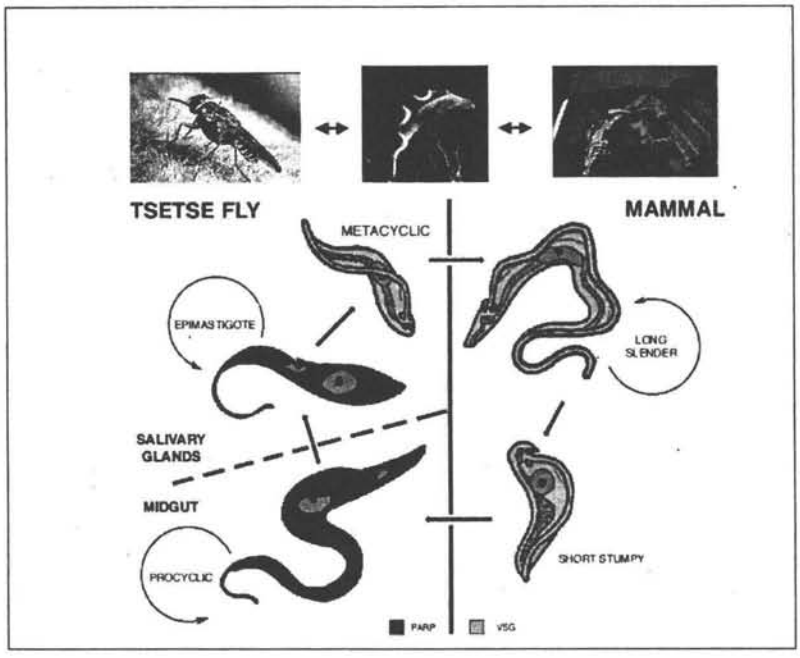
Adaptive immune system : The adaptive immune system is composed of highly specialized, systemic cells and processes that eliminate or prevent pathogenic challenges. Thought to have arisen in the first jawed vertebrates, the adaptive or "specific" immune system is activated by the "non-specific" and evolutionarily older innate immune system (which is the major system of host defense against pathogens in nearly all other living things). The adaptive immune response provides the vertebrate immune system with the ability to recognize and remember specific pathogens (to generate immunity), and to mount stronger attacks each time the pathogen is encountered. It is adaptive immunity because the body's immune system prepares itself for future challenges.

The system is highly adaptable because of somatic hypermutation (a process of accelerated somatic mutations), and V(D)J recombination (an irreversible genetic recombination of antigen receptor gene segments). This mechanism allows a small number of genes to generate a vast number of different antigen receptors, which are then uniquely expressed on each individual lymphocyte. Because the gene rearrangement leads to an irreversible change in the DNA of each cell, all of the progeny (offspring) of that cell will then inherit genes encoding the same receptor specificity, including the Memory B cells and Memory T cells that are the keys to long-lived specific immunity.

African trypanosomiasis : African trypanosomiasis is a parasitic disease of people and animals, caused by protozoa of the species *Trypanosoma brucei* (which includes *Trypanosoma gambiense*) and transmitted by the tsetse fly. The disease is endemic in some regions of Sub-Saharan Africa, covering about 36 countries and 60 million people. It is estimated that 50,000 to 70,000 people are currently infected, the number having declined somewhat in recent years. Three major epidemics have occurred in recent history, one lasting from 1896–1906 and the other two in 1920 and 1970. In 2008 there was an epidemic in Uganda.

Symptoms begin with fever, headaches, and joint pains. As the parasites enter through both the blood and lymph systems, lymph nodes often swell up to tremendous sizes. Winterbottom's sign, the tell-tale swollen lymph nodes along the back of the neck, may appear. If untreated, the disease slowly overcomes the defenses of the infected person, and symptoms spread to include anemia, endocrine, cardiac, and kidney diseases and disorders. The disease then enters a neurological phase when the parasite passes through the blood-brain barrier. The symptoms of the second phase give the disease its name; besides confusion and reduced coordination, the sleep cycle is disturbed with bouts of fatigue punctuated with manic periods progressing to daytime slumber and night-time insomnia.

Without treatment, the disease is invariably fatal, with progressive mental deterioration leading to coma and death. Damage caused in the neurological phase can be irreversible.

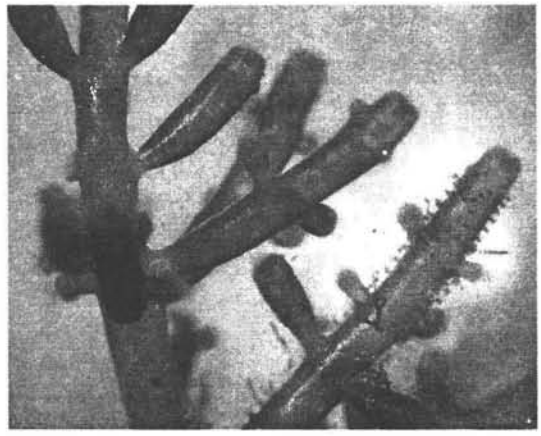


African trypanosomiasis : Life cycle

Algae : Algae are a large and diverse group of simple, typically autotrophic organisms, ranging from unicellular to multicellular forms. The largest and most complex marine forms are called seaweeds. They are photosynthetic, like plants, and "simple" because they lack the many distinct organs found in land plants. For that reason they are currently excluded from being considered plants.

Though the prokaryotic *Cyanobacteria* (commonly referred to as Blue-green Algae) were traditionally included as "Algae" in older textbooks, many modern sources regard this as outdated and restrict the term *Algae* to eukaryotic organisms. All true algae therefore have a nucleus enclosed within a membrane and chloroplasts bound in one or more membranes. Algae constitute a paraphyletic and polyphyletic group, as they do not include all the descendants of the last universal ancestor nor do they all descend from a common algal ancestor, although their chloroplasts seem to have a single origin.

Algae lack the various structures that characterize land plants, such as phyllids and rhizoids in nonvascular plants, or leaves, roots, and other organs that are found in tracheophytes. Many are photoautotrophic, although some groups contain members that are mixotrophic, deriving energy both from photosynthesis and uptake of organic carbon either by osmotrophy, myzotrophy, or phagotrophy. Some unicellular species rely entirely on external energy sources and have limited or no photosynthetic apparatus.



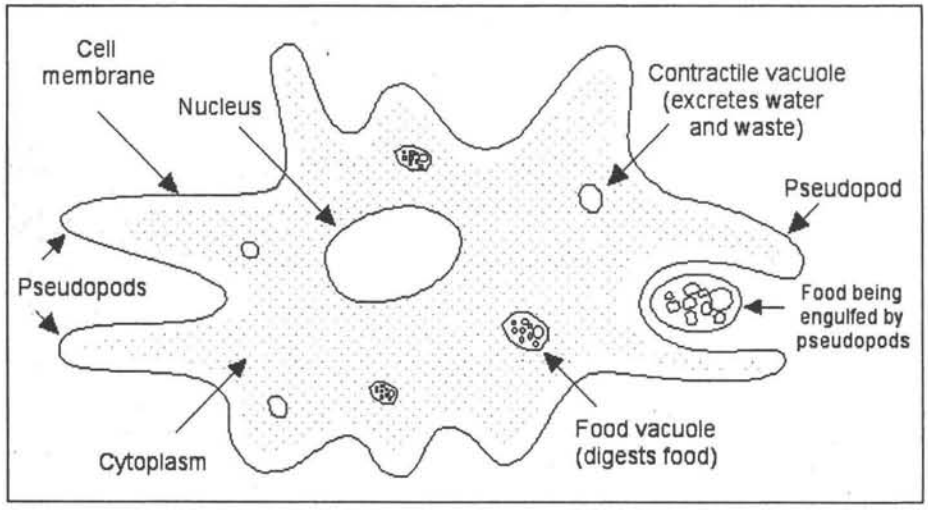
Laurencia, a marine genus of Red Algae

Nearly all algae have photosynthetic machinery ultimately derived from the Cyanobacteria, and so produce oxygen as a by-product of photosynthesis, unlike other photosynthetic bacteria such as purple and green sulfur bacteria. Fossilized filamentous algae from the Vindhya basin have been dating back to 1.6 to 1.7 billion years ago. The first alga to have its genome sequenced was Cyanidioschyzon merolae.

Algae fuel : Algae fuel is a biofuel from algae. The record oil prices, competing demands between foods and other biofuel sources and the world food crisis have ignited interest in algaculture (farming algae) for making vegetable oil, biodiesel, bioethanol, biogasoline, biomethanol, biobutanol and other biofuels. Among algal fuels' attractive characteristics : they do not affect fresh water resources, can be produced using ocean and wastewater, and are biodegradable and relatively harmless to the environment if spilled. Algae cost more per pound yet can yield over 30 times more energy per acre than other, second-generation biofuel crops. One biofuels company has claimed that algae can produce more oil in an area the size of a two car garage than a football field of soybeans, because almost the entire algal organism can use sunlight to produce lipids, or oil. The United States

Department of Energy estimates that if algae fuel replaced all the petroleum fuel in the United States, it would require 15,000 square miles (40,000 square kilometers), which is a few thousand square miles larger than Maryland. This is less than 1/7th the area of corn harvested in the United States in 2000. As of 2008, such fuels remain too expensive to replace other commercially available fuels, with the cost of various algae species typically between US$5–10 per Kg. But several companies and government agencies are funding efforts to reduce capital and operating costs and make algae oil production commercially viable.

Amoeba : Amoeba is a genus of protozoan.The amoeba was first discovered by August Johann Rösel von Rosenhof in 1757. Early naturalists referred to *Amoeba* as the *Proteus animalcule* after the Greek god Proteus who could change his shape. The name "amibe" was given to it by Bory de Saint-Vincent, from the Greek *amoibè*, meaning change.



Amoeba

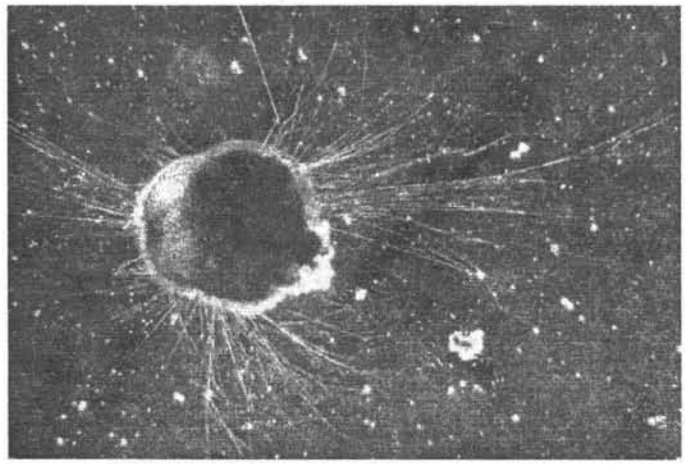
The cell's organelles and cytoplasm are enclosed by a cell membrane, obtaining its food through phagocytosis. Amoebae have a single large tubular pseudopod at the anterior end, and several secondary ones branching to the sides. The most famous species, *Amoeba proteus*, is 700-800 μm in length but the species *Amoeba dubia* is as large as a millimeter, and visible to the naked eye. Its most recognizable features include one or more nuclei and a simple contractile vacuole to maintain osmotic equilibrium. Food enveloped by the amoeba is stored and digested in vacuoles. Amoebae, like other single-celled eukaryotic organisms, reproduce

asexually via mitosis and cytokinesis, not to be confused with binary fission, which is how prokaryotes (bacteria) reproduce. In cases where the amoeba are forcibly divided, the portion that retains the nucleus will survive and form a new cell and cytoplasm, while the other portion dies. Amoebas also have no definite shape.

The amoeba is remarkable for its very large genome. The species *Amoeba protea* has 290 billion base pairs in its genome, and there are 670 billion base pairs in the genome of *Amoeba dubia*. The human genome is small by contrast, with its count of 2.9 billion base pairs.

Like most cells, amoebae are adversely affected by excessive osmotic pressure caused by extremely saline or dilute water. Amoebae will prevent the influx of salt in saline water, resulting in a net loss of water as the cell becomes isotonic with the environment, causing the cell to shrink. Placed into fresh water, amoebae will also attempt to match the concentration of the surrounding water, causing the cell to swell and sometimes burst.

Amoeboids : Amoeboids are unicellular life-forms characterized by their irregularity of shape. "Amoeboid" and "amoeba" are sometimes used interchangeably in less formal contexts, especially in the context of characterizing an organism by the method of locomotion. Amoeboids are unicellular life-forms characterized by their similarity to amoebae.



Foraminiferan (Ammonia tepida)

Amoeboids mainly consist of contractile vacuoles, a nucleus, and cytoplasm as their basic structure. They move and feed by means of temporary cytoplasmic projections, called pseudopods (false feet).They have appeared in a number of

different groups. Some cells in multicellular animals may be amoeboid, for instance human white blood cells, which consume pathogens. Many protists also exist as individual amoeboid cells, or take such a form at some point in their life-cycle. The most famous such organism is Amoeba proteus; the name amoeba is variously used to describe its close relatives, other organisms similar to it, or the amoeboids in general.

As amoebas themselves are polyphyletic and subject to some imprecision in definition, the term "Amoeboid" does not provide identification of an organism, and is better understood as description of locomotion. When used in the broader sense, the term can include the following groups : Acanthamoeba, Acrasis, Adelphamoeba, Amoeba, Astramoeba, Balamuthia, Cashia, Chaos, Clydonella, Dactylamoeba, Dientamoeba, Dinamoeba, Discamoeba, Echinamoeba, Endamoeba, Entamoeba, Filamoeba, Flabelulla, Flagellipodium, Flamella, Gephyramoeba, Gibbodiscus, Glaeseria, Gocevia, Gruberella, Gyromitus, Hartmannella, Heteramoeba, Hollandella, Histomonas, Hyalodiscus, Hydramoeba, Hyperamoeba, Iodamoeba, Korotnevella, Labyrinthula, Learamoeba, Leptomyxa, Lingulamoeba, Macropharyngomonas, Malamoeba, Mastigamoeba, Mastigella, Mastigina, Mayorella, Metachaos, Micronuclearia, Monopylocystis, Naegleria, Neoparamoeba, Neovahlkampfia, Nollandia, Nuclearia, Oscillosignum, Paragocevia, Paramoeba, Paratetramitus, Paravahlkampfia, Parvamoeba, Pelomyxa, Pernina, Pfiesteria, Polychaos, Pontifex, Phreatamoeba, Platyamoeba, Protoacanthamoeba, Protonaegleria, Psalteriomonas, Pseudomastigamoeba, Plaesiobystra, Rhizamoeba, Rosculus, Rugipes, Saccamoeba, Sappinia, Sawyeria, Stachyamoeba, Stereomyxa, Striamoeba, Striolatus, Stygamoeba, Subulamoeba, Tetramitus, Thecamoeba, Theratromyxa, Trichamoeba, Trichosphaerium, Trienamoeba, Trimastigamoeba, Unda, Vahlkampfia, Vampyrella, Vampyrellium, Vannella, Vexillifera, and Willaertia.

Amoeboids may be divided into several morphological categories based on the form and structure of the pseudopods. Those where the pseudopods are supported by regular arrays of microtubules are called actinopods, and forms where they are not are called rhizopods, further divided into lobose, filose, and reticulose amoebae. There is also a strange group of giant marine amoeboids, the xenophyophores, that do not fall into any of these categories.

Anatomical pathology : Anatomical pathology is a medical specialty that is concerned with the diagnosis of disease based on the gross, microscopic, chemical, immunologic and molecular examination of organs, tissues, and whole bodies (autopsy). Anatomical pathology is itself divided in subspecialties, the main ones being surgical pathology, cytopathology and forensic pathology. To be licensed to practice pathology, one has to complete medical school and secure a license to practice medicine. An approved residency program and certification (in the U.S.,

the American board of Pathology) is usually required to obtain employment or hospital privileges. Anatomical pathology is one of two branches of pathology, the other being clinical pathology, the diagnosis of disease through the laboratory analysis of bodily fluids and/or tissues. Often, pathologists practice both anatomical and clinical pathology, a combination known as general pathology. The distinction between anatomic and clinical pathology is increasingly blurred by the introduction of technologies that require new expertise and the need to provide patients and referring physicians with integrated diagnostic reports. Similar specialties exist in veterinary pathology.

Anthrax : Anthrax is an acute disease caused by *Bacillus anthracis*. It affects both humans and animals and most forms of the disease are highly lethal. There are effective vaccines against anthrax, and some forms of the disease respond well to antibiotic treatment. Like many other members of the genus *Bacillus*, *Bacillus anthracis* can form dormant spores that are able to survive in harsh conditions for extremely long periods of time—even decades or centuries. Such spores can be found on all continents, even Antarctica. When spores are inhaled, ingested, or come into contact with a skin lesion on a host they may reactivate and multiply rapidly.

Anthrax commonly infects wild and domesticated herbivorous mammals which ingest or inhale the spores while browsing—in fact, ingestion is thought to be the most common route by which herbivores contract anthrax. Carnivores living in the same environment may become infected by consuming infected animals. Diseased animals can spread anthrax to humans, either by direct contact (e.g. inoculation of infected blood to broken skin) or consumption of diseased animals' flesh.

Anthrax spores can be produced in vitro and used as a biological weapon. Anthrax does not spread directly from one infected animal or person to another, but spores can be transported by clothing or shoes and the body of an animal that died of anthrax can also be a source of anthrax spores. The name *anthrax* comes from *anthrakitis*, the Greek word for *anthracite* (coal), in reference to the black skin lesions victims develop in a cutaneous skin infection.

Antibiotic resistance : Antibiotic resistance is the ability of a microorganism to withstand the effects of antibiotics. It is a specific type of drug resistance. Antibiotic resistance evolves via natural selection acting upon random mutation, but it can also be engineered by applying an evolutionary stress on a population. Once such a gene is generated, bacteria can then transfer the genetic information in a horizontal fashion (between individuals) by plasmid exchange. If a bacterium carries several resistance genes, it is called multiresistant or, informally, a superbug. The term antimicrobial resistance is sometimes used to explicitly encompass organisms other than bacteria.

Antibiotic resistance can also be introduced artificially into a microorganism through transformation protocols. This can aid in implanting artificial genes into the microorganism. If the resistance gene is linked with the gene to be implanted, the antibiotic can be used to kill off organisms that lack the new gene.

Antibiotic resistance can be a result of horizontal gene transfer, and also of unlinked point mutations in the pathogen genome and a rate of about 1 in 108 per chromosomal replication. The antibiotic action against the pathogen can be seen as an environmental pressure; those bacteria which have a mutation allowing them to survive will live on to reproduce. They will then pass this trait to their offspring, which will result in a fully resistant colony.

Several studies have demonstrated that patterns of antibiotic usage greatly affect the number of resistant organisms which develop. Overuse of broad-spectrum antibiotics, such as second- and third-generation cephalosporins, greatly hastens the development of methicillin resistance. Other factors contributing towards resistance include incorrect diagnosis, unnecessary prescriptions, improper use of antibiotics by patients, the impregnation of household items and children's toys with low levels of antibiotics, and the administration of antibiotics by mouth in livestock for growth promotion.

Researchers have recently demonstrated the bacterial protein LexA may play a key role in the acquisition of bacterial mutations. In common usage, an antibiotic is a substance or compound (also called chemotherapeutic agent) that kills or inhibits the growth of bacteria. Antibiotics belong to the group of antimicrobial compounds used to treat infections caused by microorganisms, including fungi and protozoa.

Antibiotic : The term "antibiotic" was coined by Selman Waksman in 1942 to describe any substance produced by a micro-organism that is antagonistic to the growth of other micro-organisms in high dilution. This original definition excluded naturally occurring substances, such as gastric juice and hydrogen peroxide (they kill bacteria but are not produced by micro-organisms), and also excluded synthetic compounds such as the sulfonamides (which are antimicrobial agents). Many antibiotics are relatively small molecules with a molecular weight less than 2000 Da.

With advances in medicinal chemistry, most antibiotics are now modified chemically from original compounds found in nature, as is the case with beta-lactams (which include the penicillins, produced by fungi in the genus *Penicillium*, the cephalosporins, and the carbapenems). Some antibiotics are still produced and isolated from living organisms, such as the aminoglycosides; in addition, many more have been created through purely synthetic means, such as the quinolones.

Although potent antibiotic compounds for treatment of human diseases caused by bacteria (such as tuberculosis, bubonic plague, or leprosy) were not isolated and identified until the twentieth century, cures for infection were described in ancient Chinese medicine using plants with antibiotic-like properties over 2,500 years ago. Many other ancient cultures, including the ancient Egyptians, ancient Greeks and medieval Arabs already used molds and plants to treat infections. Cinchona bark became widely used as a therapeutic agent in the 17th century for the treatment of malaria, the disease caused by protozoan parasites of the genus *Plasmodium*.

Originally known as antiobiosis, antibiotics were drugs that had actions against bacteria. The term antibiosis which means 'against life' was introduced by the French bacteriologist Vuillemin as a descriptive name of the phenomenon exibited by these drugs. (Antibiosis was first described in 1877 in bacteria when Louis Pasteur and Robert Koch observed that an airborne bacillus could inhibit the growth of *Bacillus anthracis*.). These drugs were later renamed antibiotics by Selman Wakeman, an american microbiologist in 1942.

Chemotherapy as a science and the story of antibiotic development began in Germany with Paul Ehrlich, a German medical scientist in the late 1880s. Dr. Ehrlich noted that certain dyes would bind to and color human, animal or bacterial cells, while others did not. He then extended the idea that it might be possible to make certain dyes or chemicals that would act as a magic bullet or selective drug that would bind to and kill bacteria while not harming the human host. After much experimentation, screening hundreds of dyes against various organisms, he discovered the first medicinally useful drug, the man-made antibiotic, Salvarsan. However, the adverse side-effect profile of salvarsan, coupled with the later discovery of the antibiotic penicillin, superseded its use as an antibiotic. The work of Ehrlich, which marked the birth of the antibiotic revolution, was followed by the discovery of Prontosil by Domagk in 1932. Prontosil, the first commercially available antibacterial antibiotic was developed by a research team led by Gerhard Domagk (who received the 1939 Nobel Prize for Medicine for his efforts) at the Bayer Laboratories of the IG Farben conglomerate in Germany. Prontosil had a relatively broad effect against Gram-positive cocci but not against enterobacteria. The discovery and development of this first sulfonamide drug opened the era of antibiotics.

Antibodies : Also known as immunoglobulins, (Ig), are gamma globulin proteins that are found in blood or other bodily fluids of vertebrates, and are used by the immune system to identify and neutralize foreign objects, such as bacteria and viruses. They are typically made of basic structural units—each with two large heavy chains and two small light chains—to form, for example, monomers with one unit, dimers with two units or pentamers with five units. Antibodies are

produced by a kind of white blood cell called a plasma cell. There are several different types of antibody heavy chains, and several different kinds of antibodies, which are grouped into different *isotypes* based on which heavy chain they possess. Five different antibody isotypes are known in mammals, which perform different roles, and help direct the appropriate immune response for each different type of foreign object they encounter.

Although the general structure of all antibodies is very similar, a small region at the tip of the protein is extremely variable, allowing millions of antibodies with slightly different tip structures to exist. This region is known as the hypervariable region. Each of these variants can bind to a different target, known as an antigen. This huge diversity of antibodies allows the immune system to recognize an equally wide diversity of antigens. The unique part of the antigen recognized by an antibody is called an epitope. These epitopes bind with their antibody in a highly specific interaction, called induced fit, that allows antibodies to identify and bind only their unique antigen in the midst of the millions of different molecules that make up an organism. Recognition of an antigen by an antibody *tags* it for attack by other parts of the immune system. Antibodies can also neutralize targets directly by, for example, binding to a part of a pathogen that it needs to cause an infection.

The large and diverse population of antibodies is generated by random combinations of a set of gene segments that encode different antigen binding sites (or *paratopes*), followed by random mutations in this area of the antibody gene, which create further diversity. Antibody genes also re-organize in a process called class switching that changes the base of the heavy chain to another, creating a different isotype of the antibody that retains the antigen specific variable region. This allows a single antibody to be used by several different parts of the immune system. Production of antibodies is the main function of the humoral immune system.

Antigen : An antigen is a substance that prompts the generation of antibodies and can cause an immune response. The word originated from the notion that they can stimulate antibody generation. We now know that the immune system does not consist of only antibodies. The modern definition encompasses all substances that can be recognized by the adaptive immune system. In the strict sense, immunogens are those substances that elicit a response from the immune system, whereas antigens are defined as substances that bind to specific antibodies. Not all antigens produce an immunogenic response, but all immunogens are antigens.

Antigens are usually proteins or polysaccharides. This includes parts (coats, capsules, cell walls, flagella, fimbrae, and toxins) of bacteria, viruses, and other microorganisms. Lipids and nucleic acids are antigenic only when combined with

proteins and polysaccharides. Non-microbial exogenous (non-self) antigens can include pollen, egg white, and proteins from transplanted tissues and organs or on the surface of transfused blood cells. Cells present their antigens to the immune system via a histocompatibility molecule. Depending on the antigen presented and the type of the histocompatibility molecule, several types of immune cells can become activated.

Antimicrobial : An antimicrobial is a substance that kills or inhibits the growth of microorganisms such as bacteria, fungi, or protozoans, as well as destroying viruses. Antimicrobial drugs either kill microbes (microbicidal) or prevent the growth of microbes (microbistatic). Disinfectants are anti-microbial substances used on non-living objects. The history of antimicrobials begins with the observations of Pasteur and Joubert, who discovered that one type of bacteria could prevent the growth of another. They did not know at that time that the reason one bacteria failed to grow was that the other bacteria was producing an antibiotic. Technically, antibiotics are only those substances that are produced by one microorganism that kill, or prevent the growth, of another microorganism. Of course, in today's common usage, the term antibiotic is used to refer to almost any drug that cures a bacterial infection. Antimicrobials include not just antibiotics, but synthetically formed compounds as well.

The discovery of antimicrobials like penicillin and tetracycline paved the way for better health for millions around the world. Before 1941, the year penicillin was discovered, no true cure for gonorrhea, strep throat, or pneumonia existed. Patients with infected wounds often had to have a wounded limb removed, or face death from infection. Now, most of these infections can be easily cured with a short course of antimicrobials. However, the future effectiveness of antimicrobial therapy is somewhat in doubt. Microorganisms, especially bacteria, are becoming resistant to more and more antimicrobial agents. Bacteria found in hospitals appear to be especially resilient, and are causing increasing difficulty for the sickest patients–those in the hospital. Currently, bacterial resistance is combated by the discovery of new drugs. However, microorganisms are becoming resistant more quickly than new drugs are being found.

Antiseptics : Antiseptics are antimicrobial substances that are applied to living tissue/skin to reduce the possibility of infection, sepsis, or putrefaction. They are generally distinguished from antibiotics that are antiseptics which have the ability to be transported by the body through the lymphatic system to destroy bacteria within the body, and from disinfectants, which destroy microorganisms found on non-living objects. Some antiseptics are true germicides, capable of destroying microbes (bacteriocidal), whilst others are bacteriostatic and only prevent or inhibit their growth. Antibacterials are antiseptics that have the proven ability to act

against bacteria especially if they target systems which kill only bacteria. Microbicides which kill virus particles are called viricides or antivirals.

Antiviral drugs : Antiviral drugs are a class of medication used specifically for treating viral infections. Like antibiotics for bacteria, specific antivirals are used for specific viruses. Unlike antibiotics, however, antiviral drugs do not destroy the virus, they only inhibit their development.Antiviral drugs are one class of antimicrobials, a larger group which also includes antibiotic, antifungal and antiparasitic drugs. They are relatively harmless to the host, and therefore can be used to treat infections. They should be distinguished from viricides, which actively destroy virus particles outside the body. Most of the antivirals now available are designed to help deal with HIV, herpes viruses, the hepatitis B and C viruses, which can cause liver cancer, and influenza A and B viruses. Researchers are now working to extend the range of antivirals to other families of pathogens. Designing safe and effective antiviral drugs is difficult, because viruses use the host's cells to replicate. This makes it difficult to find targets for the drug that would interfere with the virus without harming the host organism's cells.

The emergence of antivirals is the product of a greatly expanded knowledge of the genetic and molecular function of organisms, allowing biomedical researchers to understand the structure and function of viruses, major advances in the techniques for finding new drugs, and the intense pressure placed on the medical profession to deal with the human immunodeficiency virus (HIV), the cause of the deadly acquired immunodeficiency syndrome (AIDS) pandemic. Almost all anti-microbials, including anti-virals, are subject to drug resistance as the pathogens mutate over time, becoming less susceptible to the treatment.

Antonie Philips van Leeuwenhoek : Antonie Philips van Leeuwenhoek (in Dutch also Anthonie, Antoni or Theunis, in English Antony or Anton) (born on October 24, 1632—baptized on November 4, and buried on August 30, 1723) was a Dutch tradesman and scientist from Delft, the Netherlands. He is commonly known as "the Father of Microbiology", and considered to be the first microbiologist. He is best known for his work on the improvement of the microscope and for his contributions towards the establishment of microbiology. Using his handcrafted microscopes he was the first to observe and describe single celled organisms, which he originally referred to as animalcules, and which we now refer to as microorganisms. He was also the first to record microscopic observations of muscle fibers, bacteria, spermatozoa and blood flow in capillaries (small blood vessels). Van Leeuwenhoek never wrote a book, just letters.

Antonie was the son of the basket maker Philip Thonisz and Grietje Jacobs. At age 16, he secured an apprenticeship with a Scottish cloth merchant in Amsterdam. In 1653 Van Leeuwenhoek saw his first simple microscope, a

magnifying glass mounted on a small stand used by textile merchants, capable of magnifying to a power of 3. He soon acquired one for his own use. In 1654, he left Amsterdam, moved back to Delft for the rest of his life and started his own lucrative drapery business there. On July 11, he married Barbara de Mey, the daughter of a cloth merchant and settled as a linen-draper. He was registered as Anthoni Leeuwenhouck. Four out of his five children died young. In 1660, he was appointed chamberlain of the Lord Regents of Delft. In 1666 his wife died and in 1671 he married Cornelia Swalmius, the daughter of a minister. Van Leeuwenhoek outlived his second wife, who died in 1694.

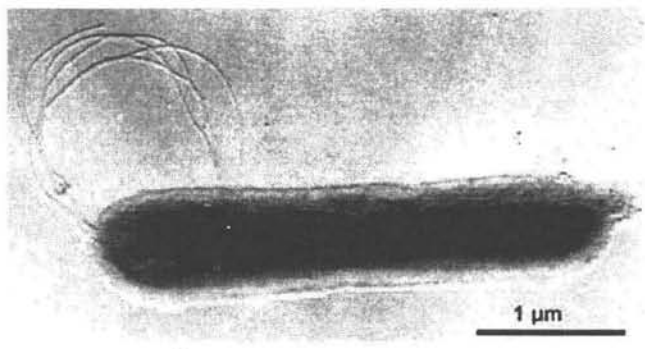
Antonie Philips van Leeuwenhoek

Van Leeuwenhoek's interest in microscopes and a familiarity with glass processing led to one of the most significant, and simultaneously well-hidden, technical insights in the history of science. By placing the middle of a small rod of soda lime glass in a hot flame, Van Leeuwenhoek could pull the hot section apart like taffy to create two long whiskers of glass. By then reinserting the end of one whisker into the flame, he could create a very small, high-quality glass sphere. These spheres became the lenses of his microscopes, with the smallest spheres providing the highest magnifications. An experienced businessman, Leeuwenhoek realized that if his simple method for creating the critically important lens was revealed, the scientific community of his time would likely disregard or even forget his role in microscopy. He therefore allowed others to believe that he was laboriously spending most of his nights and free time grinding increasingly tiny lenses to use in microscopes, even though this belief conflicted both with his construction of hundreds of microscopes and his habit of building a new microscope whenever he chanced upon an interesting specimen that he wanted to preserve.

Van Leeuwenhoek used samples and measurements to estimate numbers of microorganisms in units of water. Van Leeuwenhoek made good use of the huge

lead provided by his method. He studied a broad range of microscopic phenomena, and shared the resulting observations freely with groups such as the English Royal Society. Such work firmly established his place in history as one of the first and most important explorers of the microscopic world.

Aquifex aeolicus : Aquifex aeolicus is a rod-shaped bacterium with a length of 2 to 6 micrometers and a diameter of around half a micrometer. It is one of a handful of species in the Aquificae phylum, an unusual group of thermophilic bacteria that are thought to be some of the oldest species of bacteria. A. aeolicus grows best in water between 85 to 95°C, and can be found near underwater volcanoes or hot springs. It requires oxygen to survive (though it can grow in levels of oxygen as low as 7.5 ppm), and its method of respiration produces water as a byproduct. ("Aquifex" means "water-maker.") Members of the species tend to form large cell conglomerations, comprised of up to 100 individual cells. It was discovered around islands north of Sicily.



Aquifex aeolicus

The genome of A. aeolicus has been successfully mapped. This was made easier by the fact that the length of the genome is only about a third of the length of the genome for E. coli. Comparison of the Aquifex aeolicus genome to other organisms showed that around 16% of its genes originated from the Archaea domain.

Aquificae : Aquificae phylum is a diverse collection of bacteria that live in harsh environmental settings. They have been found in hot springs, sulfur pools, and thermal ocean vents. Members of the genus Aquifex, for example, are productive in water between 85 to 95°C. They are the dominant members of most terrestrial neutral to alkaline hot springs above 60 degrees celsius. They are autotrophs, and are the primary carbon fixers in these environments. They are true bacteria (domain bacteria) as opposed to the other inhabitants of extreme environments, the Archaea. There is currently no consensus regarding the taxonomy of genera

within Aquificae. One standard text claims that only the genera Aquifex, Calderobacterium, Hydrogenobacter, and Thermocrinis belong in the Aquificales order. Another claims that, in addition to genera within the Aquificaceae and Hydrogenothermaceae families, the following genera are incertae sedis (unclassified), but within Aquificae : Balnearium, Desulfurobacterium, EX-H1 group, and Thermovibrio.

Archaea : The Archaea are a group of single-celled microorganisms. A single individual or species from this domain is called an archaeon (sometimes spelled "archeon"). They have no cell nucleus or any other organelles within their cells. In the past they were viewed as an unusual group of bacteria and named archaebacteria but since the Archaea have an independent evolutionary history and show many differences in their biochemistry from other forms of life, they are now classified as a separate domain in the three-domain system. In this system, introduced by Carl Woese, the three main branches of evolutionary descent are the Archaea, Eukarya and Bacteria. Archaea are further divided into four recognized phyla, but many more phyla may exist. Of these groups the Crenarchaeota and the Euryarchaeota are most intensively studied. Classifying the Archaea is still difficult, since the vast majority of these organisms have never been studied in the laboratory and have only been detected by analysis of their nucleic acids in samples from the environment. Although archaea have, in the past, been classed with bacteria as prokaryotes, this classification has been described as outdated, since it fails to distinguish between the three very distinct domains of life.

Generally, archaea and bacteria are quite similar in size and shape, although a few archaea have very unusual shapes, such as the flat and square-shaped cells of Haloquadra walsbyi. Despite this visual similarity to bacteria, archaea possess genes and several metabolic pathways that are more closely related to those of eukaryotes : notably the enzymes involved in transcription and translation. Other aspects of archaean biochemistry are unique, such as their reliance on ether lipids in their cell membranes. The archaea exploit a much greater variety of sources of energy than eukaryotes : ranging from familiar organic compounds such as sugars, to using ammonia, metal ions or even hydrogen gas as nutrients. Salt-tolerant archaea (the Halobacteria) use sunlight as a source of energy, and other species of archaea fix carbon; however, unlike plants and cyanobacteria, no species of archaea is known to do both. Archaea reproduce asexually and divide by binary fission, fragmentation, or budding; in contrast to bacteria and eukaryotes, no species of archaea are known that form spores.

Initially, archaea were seen as extremophiles that lived in harsh environments, such as hot springs and salt lakes, but they have since been found in a broad range of habitats, such as soils, oceans, and marshlands. Archaea are particularly numerous in the oceans, and the archaea in plankton may be one of the most

abundant groups of organisms on the planet. Archaea are now recognized as a major part of life on Earth and may play an important role in both the carbon cycle and nitrogen cycle. No clear examples of archaeal pathogens or parasites are known, but they are often mutualists or commensals. One example are the methanogenic archaea that inhabit the gut of humans and ruminants, where they are present in vast numbers and aid in the digestion of food. Archaea have some importance in technology, with methanogens used to produce biogas and as part of sewage treatment, and enzymes from extremophile archaea that can resist high temperatures and organic solvents are exploited in biotechnology.

Early in the 20th century, prokaryotes were regarded as a single group of organisms and classified based on their biochemistry, morphology and metabolism. For example, microbiologists tried to classify microorganisms based on the structures of their cell walls, their shapes, and the substances they consume. However, a new approach was proposed in 1965, using the sequences of the genes in these organisms to work out which prokaryotes are genuinely related to each other. This approach, known as phylogenetics, is the main method used today.

Archaea were first classified as a separate group of prokaryotes in 1977 by Carl Woese and George E. Fox in phylogenetic trees based on the sequences of ribosomal RNA (rRNA) genes. These two groups were originally named the Archaebacteria and Eubacteria and treated as kingdoms or subkingdoms, which Woese and Fox termed Urkingdoms. Woese argued that this group of prokaryotes is a fundamentally different sort of life. To emphasize this difference, these two domains were later renamed Archaea and Bacteria.

At first, only the methanogens were placed in this new domain, and the archaea were seen as extremophiles that exist only in habitats such as hot springs and salt lakes. By the end of the 20th century, microbiologists realized that the archaea are a large and diverse group of organisms that are widely distributed in nature and are common in much less extreme habitats, such as soils and oceans. This new appreciation of the importance and ubiquity of archaea came from using the polymerase chain reaction to detect prokaryotes in samples of water or soil from their nucleic acids alone. This allows the detection and identification of organisms that cannot be cultured in the laboratory, which is often difficult.

Archaeocin : Archaeocin is the name given to a new type of potentially useful antibiotic that is derived from the Archaea group of organisms. Eight archaeocins have been partially or fully characterized, but hundreds of archaeocins are believed to exist, especially within the haloarchaea. Production of these archaeal proteinaceous antimicrobials is a nearly universal feature of the rod-shaped haloarchaea.

Asymptomatic bacteriuria : It is bacteriuia without accompanying symptoms of a urinary tract infection (such as frequent urination, painful urination or fever). It

is more common in women, in the elderly, in residents of long-term care facilities, and in patients with diabetes, bladder catheters and spinal cord injuries. Patients with a long-term Foley catheter uniformly show bacteriuria. Screening for asymptomatic bacteriuria with urine culture and treatment with antibiotics is recommended during pregnancy, because it significantly reduces symptomatic urinary tract infections, low birth weight, and preterm delivery. This has not been proven for older people or people with diabetes, bladder catheters or spinal cord injuries. Kidney transplant recipients, children with vesicoureteral reflux or others with structural abnormalities of the urinary tract, people with infected kidney stones and those who are having urological procedures might be more likely to benefit from treatment with antibiotics for asymptomatic bacteriuria. The presence of simultaneous pyuria does not warrant treatment by itself.

Autoimmune diseases : Autoimmune diseases arise from an overactive immune response of the body against substances and tissues normally present in the body. In other words, the body really attacks its own cells. This may be restricted to certain organs (e.g. in thyroiditis) or involve a particular tissue in different places (e.g. Goodpasture's disease which may affect the basement membrane in both the lung and the kidney). The treatment of autoimmune diseases is typically with immunosuppression—medication which decreases the immune response.

In both autoimmune and inflammatory diseases the condition arises through aberrant reactions of the human adaptive or innate immune systems. In autoimmunity, the patient's immune system is activated against the body's own proteins. In inflammatory diseases, it is the overreaction of the immune system, and its subsequent downstream signaling (TNF, IFN, etc), which causes problems.

A substantial minority of the population suffers from these diseases, which are often chronic, debilitating, and life-threatening. There are more than eighty illnesses caused by autoimmunity. It has been estimated that autoimmune diseases are among the ten leading causes of death among women in all age groups up to 65 years.

Currently, a considerable amount of research is being conducted into treatment of these conditions. According to a report from Frost & Sullivan, the total alliance payouts in the autoimmune/inflammation segment from 1997 to 2002 totaled $489.8 million, where Eli Lilly, Suntory, Procter & Gamble, Encysive, and Novartis together account for 98.6 percent of alliance payouts.

Autotroph : An autotroph is an organism that produces complex organic compounds from simple inorganic molecules using energy from light (by photosynthesis) or inorganic chemical reactions. Autotrophs are the producers in a food chain, such as plants on land or algae in water. Bacteria which derive energy from oxidizing inorganic compounds (such as hydrogen sulfide, ammonium and ferrous iron) are chemoautotrophs, and include the lithotrophs.

Autotrophs are fundamental to the food chains of all ecosystems. They take energy from the environment in the form of sunlight or inorganic chemicals and use it to create energy-rich molecules such as carbohydrates. This mechanism is called primary production. Other organisms, called heterotrophs, take in autotrophs as food to carry out functions necessary for their life. Thus, heterotrophs—all animals, almost all fungi, as well as most bacteria and protozoa—depend on autotrophs for the energy and raw materials they need. Heterotrophs obtain energy by breaking down organic molecules (carbohydrates, fats, and proteins) obtained in food. Carnivorous organisms ultimately rely on autotrophs because the nutrients obtained from their heterotroph prey come from autotrophs they consumed.

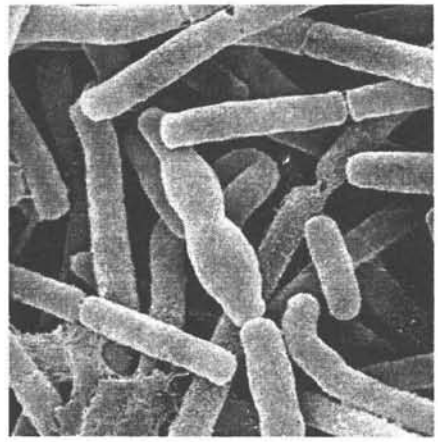
There are some species of organisms that require organic compounds as a source of carbon, but are able to use light or inorganic compounds as a source of energy. Such organisms are not defined as autotrophic, but rather as heterotrophic. An organism that obtains carbon from organic compounds but obtains energy from light is called a photoheterotroph, while an organism that obtains carbon from organic compounds but obtains energy from the oxidation of inorganic compounds is termed a chemoheterotroph. Evidence suggests that some fungi may also obtain energy from radiation. Such radiotrophic fungi were found growing inside a reactor of the Chernobyl nuclear power plant.

Auxotrophy : Auxotrophy is the inability of an organism to synthesize a particular organic compound required for its growth (as defined by IUPAC). An auxotroph is an organism that displays this characteristic; auxotrophic is the corresponding adjective. Auxotrophy is the opposite of prototrophy. In genetics, a strain is said to be auxotrophic if it carries a mutation that renders it unable to synthesize an essential compound. For example a yeast mutant in which a gene of the uracil synthesis pathway is inactivated is a uracil auxotroph. Such a strain is unable to synthesize uracil and will only be able to grow if uracil can be taken up from the environment. This is the opposite of a uracil prototroph, or in this case a wild-type strain, which can still grow in the absence of uracil. Auxotrophic genetic markers are often used in molecular genetics; they were famously used in Beadle and Tatum's Nobel prize-winning work on the one gene-one enzyme hypothesis.

Researchers have used strains of E. coli auxotrophic for specific amino acids to introduce non-natural amino acid analogues into proteins. For instance cells auxotrophic for the amino acid phenylalanine can be grown in media supplemented with an analogue such as para-azido phenylalanine. It is important to remember that many living things, including humans, are auxotrophic for large classes of compounds required for growth and must obtain these compounds through diet.

B

Bacillus anthracis : It is a Gram-positive spore-forming, rod-shaped bacterium, with a width of 1-1.2μm and a length of 3-5μm. It can be grown in an ordinary nutrient medium under aerobic or anaerobic conditions. It bears close genotypical and phenotypical resemblance to *Bacillus cereus* and *Bacillus thuringiensis*. All three species share cellular dimensions and morphology. All form oval spores located centrally in a non-swollen sporangium. *Bacillus anthracis* spores in particular are highly resilient, surviving extremes of temperature, low-nutrient environments, and harsh chemical treatment over decades or centuries.



Bacillus anthracis

Casimir Davaine first isolated this bacterium from the blood of sheep suffering from anthrax. *B. anthracis* was the first bacterium conclusively demonstrated to cause disease, by Robert Koch in 1877. The species name *anthracis* is from the Greek *anthrakis*, meaning *coal* and referring to the most common form of the disease, cutaneous anthrax, in which large black skin lesions are formed.

Bacillus coagulans : It is a lactic acid forming bacterial species within the genus *Bacillus*. The organism was first isolated and described in 1932 and was elaborated in the fifth edition of Bergey's Manual of Determinative Bacteriology. It was initially considered to be a spore-forming *Lactobacillus*. Since *Bacillus coagulans* exhibits characteristics typical of both genera *Lactobacillus* and *Bacillus*, its taxonomic position between the families *Lactobacillaceae* and *Bacillaceae* was often debated. However, in the seventh edition of Bergey's, it was finally transferred to the genus Bacillus. DNA-based technology was used in distinguishing between the two genera of bacteria which are morphologically similar and possess similar physiological and biochemical characteristics.

B. coagulans is a Gram-positive, spore-forming, motile rod (0.9μm by 3.0μm to 5.0μm in size), aerobic to microaerophilic and as all other species in genus *Bacillus*, forms endospores, which are resistant to chemical and physical agents. It may appear Gram-negative when entering the stationary phase of growth. The temperature optimum for growth is 50°C. IMViC Tests VP and MR (methyl-red) tests are positive. Nitrate tests are negative.

Bacillus coagulans has been added by the EFSA to their Qualified Presumption of Safety (QPS) list and has been approved for veterinary purposes as GRAS by the FDA's Center for Veterinary Medicine, as well as by the EU and is listed by AAFCO for use as a direct fed microbial in livestock production. Its main use is thus is veterinary applications, especially as a probiotic in pigs and shrimp. There are also references to use of this bacterium in humans, especially in improving the vaginal flora, improving abdominal pain and bloating in IBS patients and increasing immune response to viral challenges. The bacterium has also been assessed for safety as a food ingredient. Spores can be activated in the acidic environment of the stomach and start germinating and to proliferate in the intestine.

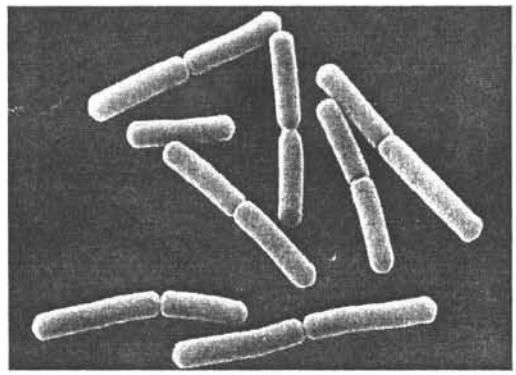
Bacillus : It is a genus of rod-shaped bacteria and a member of the division Firmicutes. *Bacillus* species are either obligate or facultative aerobes, and test positive for the enzyme catalase. Ubiquitous in nature, *Bacillus* includes both free-living and pathogenic species. Under stressful environmental conditions, the cells produce oval endospores that can stay dormant for extended periods. These characteristics originally defined the genus, but not all such species are closely related, and many have been moved to other genera

Many *Bacillus* species are able to secrete large quantities of enzymes. *Bacillus amyloliquefaciens* is a species of *Bacillus* that is the source of a natural antibiotic protein barnase (a ribonuclease), alpha amylase used in starch hydrolysis, the protease subtilisin used with detergents, and the BamH1 restriction enzyme used in DNA research.

A portion of the *Bacillus thuringiensis* genome was incorporated into corn (and cotton) crops. The resulting GMOs are therefore resistant to some nematode pests.

Bacillus subtilis is one of the best understood prokaryotes, in terms of molecular biology and cell biology. Its superb genetic amenability and relatively large size have provided the powerful tools required to investigate a bacterium from all possible aspects. Recent improvements in fluorescence microscopy techniques have provided novel and amazing insight into the dynamic structure of a single cell organism. Research on *Bacillus subtilis* has been at the forefront of bacterial molecular biology and cytology, and the organism is a model for differentiation, gene/protein regulation, and cell cycle events in bacteria.

Bacillus subtilis : A Gram-positive, catalase-positive bacterium commonly found in soil. A member of the genus *Bacillus*, *B. subtilis* is rod-shaped, and has the ability to form a tough, protective endospore, allowing the organism to tolerate extreme environmental conditions. Unlike several other well-known species, *B. subtilis* has historically been classified as an obligate aerobe, though recent research has demonstrated that this is not strictly correct.



Bacillus subtilis

B. subtilis is not considered a human pathogen; it may contaminate food but rarely causes food poisoning. *B. subtilis* produces the proteolytic enzyme subtilisin. *B. subtilis* spores can survive the extreme heating that is often used to cook food, and it is responsible for causing *ropiness*—a sticky, stringy consistency caused by bacterial production of long-chain polysaccharides—in spoiled bread dough.

B. subtilis can divide asymmetrically, producing an endospore that is resistant to environmental factors such as heat, acid, and salt, and which can persist in the environment for long periods of time. The endospore is formed at times of nutritional stress, allowing the organism to persist in the environment until

conditions become favorable. Prior to the process to produce the spore the bacterium might become motile, through the production of flagella, and also take up DNA from the environment.

Bacillus thuringiensis (Bt) : A Gram-positive, soil-dwelling bacterium of the genus *Bacillus*. Additionally, *B. thuringiensis* also occurs naturally in the gut of caterpillars of various types of moths and butterflies, as well as on the dark surface of plants.

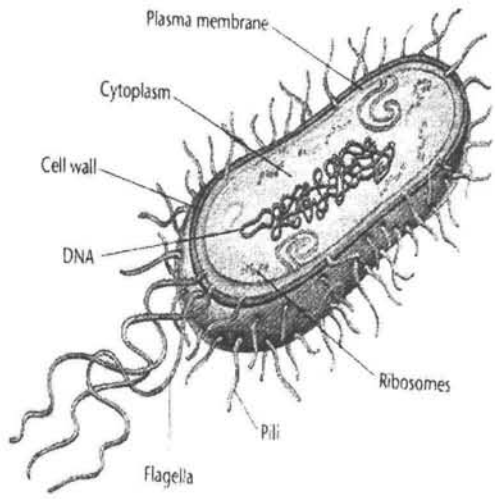
B. thuringiensis was discovered 1901 in Japan by Ishiwata and 1911 in Germany by Ernst Berliner, who discovered a disease called *Schlaffsucht* in flour moth caterpillars. *B. thuringiensis* is closely related to *B. cereus*, a soil bacterium, and *B. anthracis*, the cause of anthrax : the three organisms differ mainly in their plasmids. Like other members of the genus, all three are aerobes capable of producing endospores. Zakharyan R.A et al. first reported the presence of plasmids in *B. thuringiensis* and suggested involvement of the plasmids in endospore/crystal formation. They also described the presence of large plasmid in the Cry+ variant of *B. thuringiensis*

Upon sporulation, *B. thuringiensis* forms crystals of proteinaceous insecticidal d-endotoxins (Cry toxins) which are encoded by *cry* genes,. It was determined that the "cry" genes are harbored in the plasmids in most strains of *B. thuringiensis* Cry toxins have specific activities against species of the orders Lepidoptera (moths and butterflies), Diptera (flies and mosquitoes), Coleoptera (beetles), hymenoptera (wasps, bees, ants and sawflies) and nematodes. Thus, *B. thuringiensis* serves as an important reservoir of Cry toxins and *cry* genes for production of biological insecticides and insect-resistant genetically modified crops. When insects ingest toxin crystals the alkaline pH of their digestive tract causes the toxin to become activated. It becomes inserted into the insect's gut cell membranes forming a pore resulting in swelling, cell lysis and eventually killing the insect.

Bacteraemia : Is the presence of bacteria in the blood. The blood is normally a sterile environment, so the detection of bacteria in the blood (most commonly with blood cultures) is always abnormal.Bacteria can enter the bloodstream as a severe complication of infections (like pneumonia or meningitis), during surgery (especially when involving mucous membranes such as the gastrointestinal tract), or due to catheters and other foreign bodies entering the arteries or veins (including intravenous drug abuse).

Bacteremia can have several consequences. The immune response to the bacteria can cause sepsis (blood poisoning) and septic shock, which has a relatively high mortality rate. Bacteria can also use the blood to spread to other parts of the body (which is called hematogenous spread), causing infections away from the original site of infection. Examples include endocarditis or osteomyelitis. Treatment is with antibiotics, and prevention with antibiotic prophylaxis can be given in situations where problems are to be expected.

Bacteria : The bacteria are a large group of unicellular microorganisms. Typically a few micrometres in length, bacteria have a wide range of shapes, ranging from spheres to rods and spirals. Bacteria are ubiquitous in every habitat on Earth, growing in soil, acidic hot springs, radioactive waste, water, and deep in the Earth's crust, as well as in organic matter and the live bodies of plants and animals. There are typically 40 million bacterial cells in a gram of soil and a million bacterial cells in a millilitre of fresh water; in all, there are approximately five nonillion (5×1030) bacteria on Earth, forming much of the world's biomass. Bacteria are vital in recycling nutrients, with many steps in nutrient cycles depending on these organisms, such as the fixation of nitrogen from the atmosphere and putrefaction. However, most bacteria have not been characterized, and only about half of the phyla of bacteria have species that can be grown in the laboratory. The study of bacteria is known as bacteriology, a branch of microbiology.



Typical structure of Bacteria

There are approximately ten times as many bacterial cells in the human flora of bacteria as there are human cells in the body, with large numbers of bacteria on the skin and as gut flora. The vast majority of the bacteria in the body are rendered harmless by the protective effects of the immune system, and a few are beneficial. However, a few species of bacteria are pathogenic and cause infectious diseases, including cholera, syphilis, anthrax, leprosy and bubonic plague. The most common fatal bacterial diseases are respiratory infections, with tuberculosis alone killing about 2 million people a year, mostly in sub-Saharan Africa. In developed

countries, antibiotics are used to treat bacterial infections and in agriculture, so antibiotic resistance is becoming common. In industry, bacteria are important in sewage treatment, the production of cheese and yoghurt through fermentation, as well as in biotechnology, and the manufacture of antibiotics and other chemicals.

Once regarded as plants constituting the class Schizomycetes, bacteria are now classified as prokaryotes. Unlike cells of animals and other eukaryotes, bacterial cells do not contain a nucleus and rarely harbour membrane-bound organelles. Although the term bacteria traditionally included all prokaryotes, the scientific classification changed after the discovery in the 1990s that prokaryotes consist of two very different groups of organisms that evolved independently from an ancient common ancestor. These evolutionary domains are called Bacteria and Archaea.

Bacteria were first observed by Antonie van Leeuwenhoek in 1676, using a single-lens microscope of his own design. He called them "animalcules" and published his observations in a series of letters to the Royal Society. The name bacterium was introduced much later, by Christian Gottfried Ehrenberg in 1838. Louis Pasteur demonstrated in 1859 that the fermentation process is caused by the growth of microorganisms, and that this growth is not due to spontaneous generation. (Yeasts and molds, commonly associated with fermentation, are not bacteria, but rather fungi.) Along with his contemporary, Robert Koch, Pasteur was an early advocate of the germ theory of disease. Robert Koch was a pioneer in medical microbiology and worked on cholera, anthrax and tuberculosis. In his research into tuberculosis, Koch finally proved the germ theory, for which he was awarded a Nobel Prize in 1905. In Koch's postulates, he set out criteria to test if an organism is the cause of a disease; these postulates are still used today.

Though it was known in the nineteenth century that bacteria are the cause of many diseases, no effective antibacterial treatments were available. In 1910, Paul Ehrlich developed the first antibiotic, by changing dyes that selectively stained Treponema pallidum—the spirochaete that causes syphilis—into compounds that selectively killed the pathogen. Ehrlich had been awarded a 1908 Nobel Prize for his work on immunology, and pioneered the use of stains to detect and identify bacteria, with his work being the basis of the Gram stain and the Ziehl-Neelsen stain.

Bacterial adhesin : Adherence is often an essential step in bacterial pathogenesis or infection, required for colonizing a new host. To effectively adhere to host surfaces, many bacteria produce multiple adherence factors called adhesins. For example, nontypeable Haemophilus influenzae expresses the adhesins Hia, Hap, Oap and a hemagglutinating pili. Adhesins are attractive vaccine candidates because they are often essential to infection and are surface-located, making them readily accessible to antibodies.

The effectiveness of anti-adhesin antibodies is illustrated by studies with FimH, the adhesin of uropathogenic Escherichia coli (UPEC). In animal models, passive immunization with anti FimH-antibodies and vaccination with the protein significantly reduced colonization by UPEC. Moreover, the Bordetella pertussis adhesins FHA and pertactin are components of 3 of the 4 acellular pertussis vaccines currently licensed for use in the U.S.

Bacterial capsule : The cell capsule is a very large organelle of some prokaryotic cells, such as bacterial cells. It is a layer that lies outside the cell wall of bacteria. It is a well organized layer, not easily washed off, and it can be the cause of various diseases. It is usually composed of polysaccharides, but could be composed of other materials (e.g., polypeptide in B. anthracis). Because most capsules are water soluble, they are difficult to stain using standard stains because most stains do not adhere to the capsule. For examination under the microscope, the bacteria and their background are stained darker than the capsule, which doesn't stain. When viewed, bacterial cells as well as the surface they are on, are stained dark, while the capsule remains pale or colorless and appears as a ring around the cell.

Due to the fact that the capsule helps to protect bacteria against phagocytosis, it is considered a virulence factor. A capsule-specific antibody may be required for phagocytosis to occur. Capsules also contain water which protects bacteria against desiccation. They also exclude bacterial viruses and most hydrophobic toxic materials such as detergents. Further than that, bacterial capsules allow bacteria to adhere to surfaces and other cells.

Bacterial conjugation : Bacterial conjugation is the transfer of genetic material between bacteria through direct cell-to-cell contact. Discovered in 1946 by Joshua Lederberg and Edward Tatum, conjugation is a mechanism of horizontal gene transfer—as are transformation and transduction—although these mechanisms do not involve cell-to-cell contact.

Bacterial conjugation is often incorrectly regarded as the bacterial equivalent of sexual reproduction or mating. It is not actually sexual, as it does not involve the fusing of gametes and the creation of a zygote, nor is there equal exchange of genetic material. It is merely the transfer of genetic information from a donor cell to a recipient. In order to perform conjugation, one of the bacteria, the donor, must play host to a conjugative or mobilizable genetic element, most often a conjugative or mobilizable plasmid or transposon. Most conjugative plasmids have systems ensuring that the recipient cell does not already contain a similar element.

The genetic information transferred is often beneficial to the recipient cell. Benefits may include antibiotic resistance, other xenobiotic tolerance, or the ability to utilize a new metabolite. Such beneficial plasmids may be considered bacterial endosymbionts. Some conjugative elements may also be viewed as genetic

parasites on the bacterium, and conjugation as a mechanism that was evolved by the mobile element to spread itself into new hosts.

The prototype for conjugative plasmids is the F-plasmid, also called the F-factor. The F-plasmid is an episome (a plasmid that can integrate itself into the bacterial chromosome by genetic recombination) of about 100 kb length. It carries its own origin of replication, the oriV, as well as an origin of transfer, or oriT. There can only be one copy of the F-plasmid in a given bacterium, either free or integrated (two immediately before cell division). The host bacterium is called F-positive or F-plus (denoted F+). Strains that lack F plasmids are called F-negative or F-minus (F-).

Among other genetic information, the F-plasmid carries a tra and a trb locus, which together are about 33 kb long and consist of about 40 genes. The tra locus includes the pilin gene and regulatory genes, which together form pili on the cell surface, polymeric proteins that can attach themselves to the surface of F- bacteria and initiate the conjugation. Though there is some debate on the exact mechanism, the pili themselves do not seem to be the structures through which the actual exchange of DNA takes place; rather, some proteins coded in the tra or trb loci seem to open a channel between the bacteria.

When conjugation is initiated, via a mating signal, a relaxase enzyme creates a nick in one plasmid DNA strand at the origin of transfer, or oriT. The relaxase may work alone or in a complex of over a dozen proteins, known collectively as a relaxosome. In the F-plasmid system, the relaxase enzyme is called TraI and the relaxosome consists of TraI, TraY, TraM, and the integrated host factor, IHF. The transferred, or T-strand, is unwound from the duplex plasmid and transferred into the recipient bacterium in a 5'-terminus to 3'-terminus direction. The remaining strand is replicated, either independent of conjugative action (vegetative replication, beginning at the oriV) or in concert with conjugation (conjugative replication similar to the rolling circle replication of lambda phage). Conjugative replication may necessitate a second nick before successful transfer can occur. A recent report claims to have inhibited conjugation with chemicals that mimic an intermediate step of this second nicking event.

If the F-plasmid becomes integrated into the host genome, donor chromosomal DNA may be transferred along with plasmid DNA. The certain amount of chromosomal DNA that is transferred depends on how long the bacteria remain in contact; for common laboratory strains of E. coli the transfer of the entire bacterial chromosome takes about 100 minutes. The transferred DNA can be integrated into the recipient genome via recombination.

A culture of cells containing non-integrated F plasmids usually contains a few that have accidentally become integrated, and these are responsible for those low-

frequency chromosomal gene transfers which do occur in such cultures. Some strains of bacteria with an integrated F-plasmid can be isolated and grown in pure culture. Because such strains transfer chromosomal genes very efficiently, they are called Hfr (high frequency of recombination). The *E. coli* genome was originally mapped by interrupted mating experiments, in which various Hfr cells in the process of conjugation were sheared from recipients after less than 100 minutes (initially using a Waring blender) and investigating which genes were transferred.

Bacterial fruit blotch (BFB) : BFB is a disease of watermelon and other cucurbit crops caused by bacterium *Acidovorax avenae* subsp. *citrulli*. The disease is seed borne and is first noticed as small water-soaked lesions on seedlings. Bacterial fruit blotch can cause crop losses if allowed to progress in fields. Prevention is possible via several methods. The best prevention against Bacterial fruit blotch is to grow cucurbits in an area of the world that is not succeptable to the disease due to unfavorable environmental conditions. If this is not possible, having seed tested via a grow out, sweat box, or Polymerase Chain Reaction method to ensure that it is clean prior to planting is a good idea. Several companies test seed via these methods, such as STA, Seminis, and Syngenta.

Bacterial gliding : Bacterial gliding is a process whereby a bacterium can move under its own power. This process does not involve the use of flagella, which is a more common means of motility in bacteria. For many bacteria, the mechanism of gliding is unknown or only partially known, and it seems likely that in fact different bacteria use distinct mechanisms to achieve what is currently referred to as gliding. Gliding is prominent in cyanobacteria, myxobacteria and the cytophaga-flavobacteria. The only understood mechanism involves using type IV pili in such bacteria as Pseudomonas aeruginosa and Myxococcus xanthus. In addition, for Myxococcus xanthus A-motility (one of the two motility mechanisms this bacterium has) two other mechanisms have been proposed, one involving ejection of a polysaccharide slime from nozzles at either end of the body , and the other using "focal adhesion complexes" distributed along the cell body .

Bacterial lawn : Bacterial lawn is a term used by microbiologists to describe the appearance of bacterial colonies when all the individual colonies on a petri-dish agar plate merge together to form a field or mat of bacteria. Bacterial lawns find use in screens for antibiotic resistance and bacteriophage titering. Bacterial lawns (often of Serratia marcescens) are also used extensively when as an assay method when using bacteriophage as tracers in studies of groundwater flow.

Although occasionally used as a synonym for biofilm, the term primarily applies to the simple, clonal, unstructured mats of organisms that typically only form on laboratory growth media. Biofilms—the aggregated form of microorganisms most commonly found in nature— are generally more complex and diverse and marked by larger quantities of extracellular structural matrix relative to the cellular biomass

Bacterial oxidation (BIOX) : BIOX is a biohydrometallurgical process developed for pre-cyanidation treatment of refractory gold ores or concentrates. The bacterial culture is a mixed culture of *Thiobacillus ferrooxidans, Thiobacillus thiooxidans* and *Leptospirillum ferrooxidans*. The bacterial oxidation process comprises contacting refractory sulfide ROM ore or concentrate with a strain of the bacterial culture for a suitable treatment period under an optimum operating environment. The bacteria oxidise the sulfide minerals, thus liberating the occluded gold for subsequent recovery via cyanidation.

Under controlled continuous plant conditions, the number of bacterial cells and their activity is optimised to attain the highest rate of sulfide oxidation. The bacteria require a very acidic environment, a temperature of between 30 and 45°C, and a steady supply of oxygen and carbon dioxide for optimum growth and activity. The unusual operating conditions for the bacteria are not favourable for the growth of most other microbes, thus eliminating the need for sterility during the bacterial oxidation process. Because organic substances are toxic to the bacteria, they are non-pathogenic and incapable of causing disease. The bacteria employed in the process do not, therefore, pose a health risk to humans or any animals.

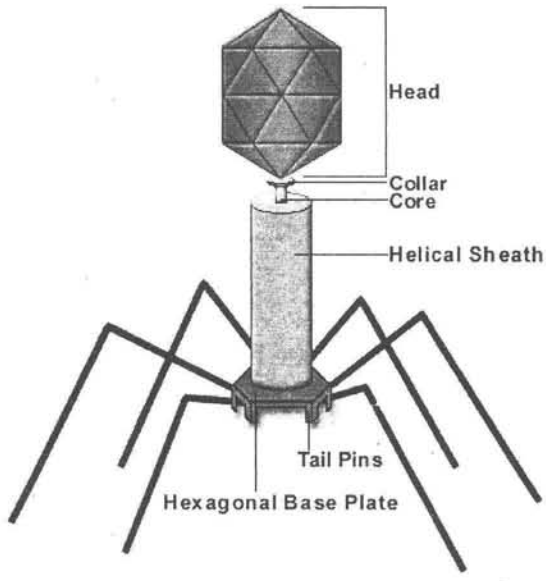
The bacterial oxidation of iron sulfide minerals produces iron(III) sulfate and sulfuric acid, and in the case of arsenopyrite, arsenic acid is also produced. The arsenic is removed from the liquor by coprecipitation with the iron and sulfate in a two stage neutralisation process. This produces a solid neutralisation precipitate containing largely calcium sulfate, basic iron(III) arsenate and iron(III) hydroxide. The iron(III) arsenate is sufficiently insoluble and stable to allow the neutralisation product to be safely disposed of on a slimes dam. The neutralisation liquor, purified to contain an acceptable level of arsenic, can be re-used in the milling, flotation or bacterial oxidation circuits.

Bacteriocins : Bacteriocins are proteinaceous toxins produced by bacteria to inhibit the growth of similar or closely related bacterial strain(s). They are typically considered to be narrow spectrum antibiotics, though this has been debated They are phenomenologically analogous to yeast and paramecium killing factors, and are structurally, functionally, and ecologically diverse. Bacteriocins were first discovered by A. Gratia in 1925. He was involved in the process of searching for ways to kill bacteria, which also resulted in the development of antibiotics and the discovery of bacteriophage, all within a span of a few years. He called his first discovery a colicine because it killed E. coli.

Bacteriocins are categorized in several ways, including producing strain, common resistance mechanisms, and mechanism of killing. There are several large categories of bacteriocin which are only phenomenologically related. These include the bacteriocins from gram-positive bacteria, the colicins, the microcins, and the

bacteriocins from Archaea. The bacteriocins from E. coli are called colicins. They are the longest studied bacteriocins. They are a diverse group of bacteriocins and do not include all the bacteriocins produced by E. coli. For example the bacteriocins produced by Staphylococcus warneri, are called as warnerin or warnericin. In fact; one of the oldest known so-called colicins was called colicin V and is now know as microcin V. It is much smaller and produced and secreted in a different manner than the classic colicins. The bacteriocins of lactic acid-fermenting bacteria are called lantibiotics. This naming system is problematic for a number of reasons. First, naming bacteriocins by what they putatively kill would be more accurate if their killing spectrum were contiguous with genus or species designations. The bacteriocins frequently possess spectra that exceed the bounds of their named taxa and almost never kill the majority of the taxa for which they are named. Further, the original naming is generally derived not from the sensitive strain the bacteriocin kills, but instead the organism that produces the bacteriocin.

Bacteriophage :A bacteriophage is any one of a number of viruses that infect bacteria. The term is commonly used in its shortened form, phage. Typically, bacteriophages consist of an outer protein capsid enclosing genetic material. The genetic material can be ssRNA, dsRNA, ssDNA, or dsDNA between 5,000 and 500,000 nucleotides long with either circular or linear arrangement. Bacteriophages are much smaller than the bacteria they destroy—usually between 20 and 200 nm in size.



Bacteriophage

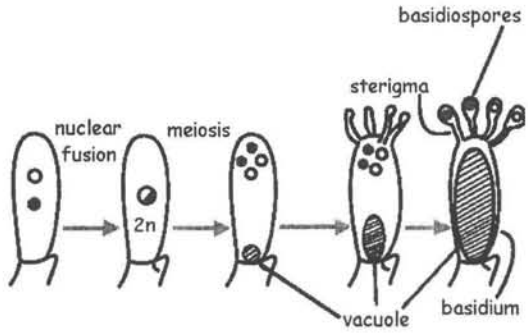
Phages are estimated to be the most widely distributed and diverse entities in the biosphere. Phages are ubiquitous and can be found in all reservoirs populated by bacterial hosts, such as soil or the intestines of animals. One of the densest natural sources for phages and other viruses is sea water, where up to 9×108 virions per milliliter have been found in microbial mats at the surface, and up to 70% of marine bacteria may be infected by phages. They have been used for over 60 years as an alternative to antibiotics in the former Soviet Union and Eastern Europe. They are seen as a possible therapy against multi drug resistant strains of many bacteria.

Bacteriuria : Bacteriuria denotes the presence of bacteria in urine not due to contamination from urine sample collection. Urine is normally a sterile bodily fluid, not containing bacteria. Bacteria in the urine, especially gram-negative rods, usually indicate a urinary tract infection (either cystitis or pyelonephritis), although bacteriuria can also occur in prostatitis. Escherichia coli is the most common bacterium isolated from urine samples.

Bacteria can be detected with a dipstick test for nitrite or by urinary microscopy, although bacterial culture remains the most specific and formal test (the golden standard). Bacteriuria can be confirmed if a single bacterial species is isolated in a concentration greater than 100000 colony forming units per millilitre of urine in clean-catch midstream urine specimens (one for men, two consecutive specimens with the same bacterium for women). For urine collected via bladder catheterisation, the threshold is 100 colony forming units of a single species per millilitre.

Bacteroidetes : Bacteroidetes is composed of three large classes of bacteria that are widely distributed in the environment, including in soil, in sediments, sea water and in the guts of animals. By far, the Bacteroidales class are the most well-studied, including the genus Bacteroides (an abundant organism in the feces of warm-blooded animals including humans), and Porphyromonas, a group of organisms inhabiting the human oral cavity. Members of the genus Bacteroides are opportunistic pathogens. Rarely are members of the other two classes pathogenic to humans. Researcher Jeffrey Gordon and his colleagues found that obese humans and mice had intestinal flora (gut flora) with a lower percentage of Bacteroidetes and relatively more bacteria from the Firmicutes family. However, they are unsure if Bacteroidetes prevent obesity or if these intestinal flora are merely preferentially selected by intestinal conditions in those who are not obese.

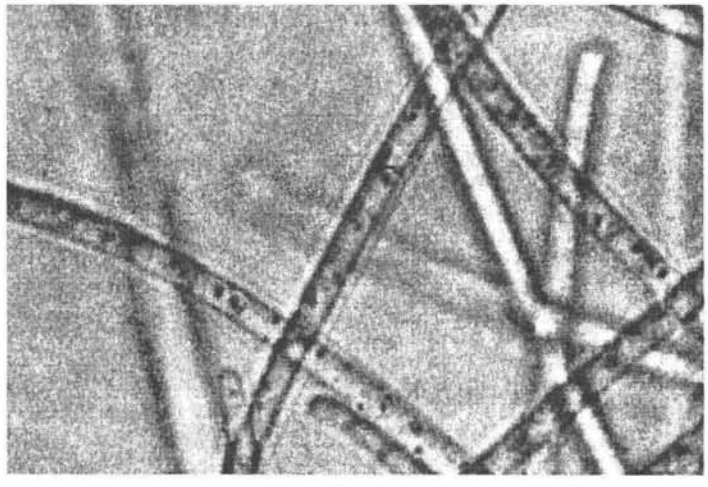
Basidiospore : A basidiospore is a reproductive spore produced by Basidiomycete fungi. Basidiospores typically each contain one haploid nucleus that is the product of meiosis, and they are produced by specialized fungal cells called basidia. Most basidiospores are forcibly discharged, and are thus considered ballistospores.



Basidiospores

When basidiospores encounter a favorable substrate, they may germinate, typically by forming hyphae. These hyphae grow outward from the original spore, forming an expanding circle of mycelium. The circular shape of a fungal colony explains the formation of fairy rings, and also the circular lesions of skin-infecting fungi that cause ringworm. Some basidiospores germinate repetitively by forming small spores instead of hyphae.

Beggiatoa : Beggiatoa is a filamentous (septate) genus of proteobacteria, and are among the largest prokaryotes, with cells about 200 micrometres in diameter. Beggiatoa can be considered an indicator species since they are present and flourish in marine environments which have been subject to pollution, where the bacteria become visible as a whitish layer.



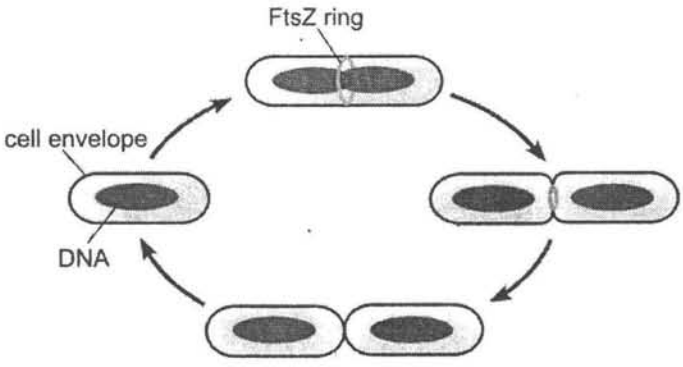
Beggiatoa

Members of this genus are chemosynthetic, meaning that they utilize inorganic substances for the energy to make carbohydrates. B. gigantea obtains the energy required to survive by oxidizing compounds of sulfur; this characteristic means it is classified in the leucothiobacteria. Hydrogen sulfide is the compound typically oxidized, however its deficiency results in the use of elemental sulfur (oxidized to sulfuric acid) or of thiosulfate.

Beggiatoa and other related filamentous bacteria can cause settling problems in sewage treatment plants, industrial waste lagoons in canning, paper pulping, brewing, milling, causing the phenomenon called Bulking. Beggiatoa are also able to detoxify hydrogen sulfide in soil.

Bifidobacterium : Bifidobacterium is a genus of Gram-positive, non-motile, often branched anaerobic bacteria. Bifidobacteria are one of the major genera of bacteria that make up the gut flora, the bacteria that reside in the colon. Bifidobacteria aid in digestion, are associated with a lower incidence of allergies and also prevent some forms of tumor growth. Some bifidobacteria are being used as probiotics. Before the 1960s, Bifidobacterium species were collectively referred to as "Lactobacillus bifidus".

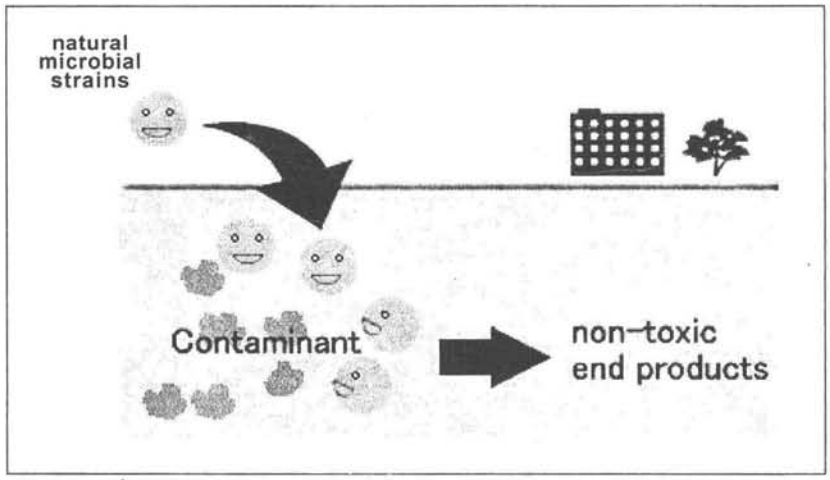
Binary fission : Is the form of asexual reproduction and cell division used by all prokaryotic and some eukaryotic organisms. This process results in the reproduction of a living prokaryotic cell by division into two parts which each have the potential to grow to the size of the original cell. Mitosis and cytokinesis are not the same as binary fission. The ability of some multicellular animals, such as echinoderms and flatworms, to regenerate two whole organisms after having been cut in half, is also not the same as binary fission. Neither is vegetative reproduction of plants.



Binary fission begins with DNA replication. DNA replication starts from an origin of replication, which opens up into a replication bubble (note : prokaryotic DNA

replication usually has only 1 origin of replication, whereas eukaryotes have multiple origins of replication). The replication bubble separates the DNA double strand, each strand acts as template for synthesis of a daughter strand by semiconservative replication, until the entire prokaryotic DNA is duplicated.

Bioaugmentation : Is the introduction of a group of natural microbial strains or a genetically engineered variant to treat contaminated soil or water. Usually the steps involve studying the indigenous varieties present in the location to determine if biostimulation is possible. If the indigenous variety do not have the metabolic capability to perform the remediation process, exogenous varieties with such sophisticated pathways are introduced.

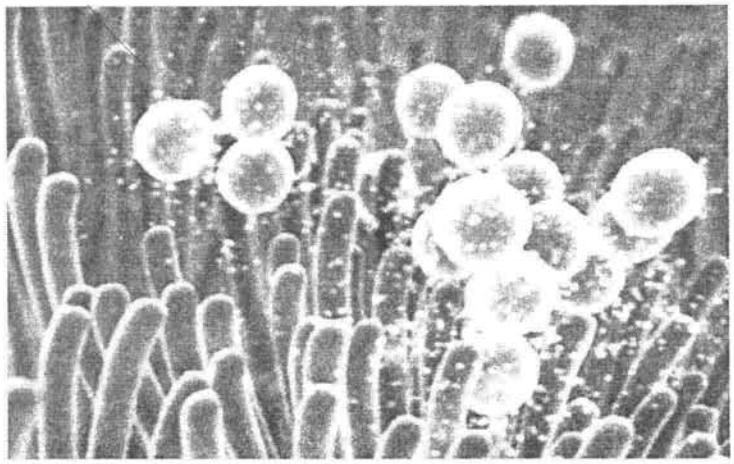


Bioaugmentation

Bioaugmentation is commonly used in municipal wastewater treatment to restart activated sludge bioreactors. At sites where soil and groundwater are contaminated with chlorinated ethenes, such as tetrachloroethylene and trichloroethylene, bioaugmentation is used to ensure that the *in situ* microorganisms can completely degrade these contaminants to ethylene and chloride, which are non-toxic. Bioaugmentation is typically only applicable to bioremediation of chlorinated ethenes, although there are emerging cultures with the potential to biodegrade other compounds including chloroethanes, chloromethanes, and MTBE. The first reported application of bioaugmentation for chlorinated ethenes was at Kelly Air Force Base, TX.

Bioaugmentation is typically performed in conjunction with the addition of electron donor (biostimulation) to achieve geochemical conditions in groundwater that favor the growth of the dechlorinating microorganisms in the bioaugmentation culture.

Biofilm : A biofilm is a structured community of microorganisms encapsulated within a self-developed polymeric matrix and adherent to a living or inert surface. Biofilms are also often characterized by surface attachment, structural heterogeneity, genetic diversity, complex community interactions, and an extracellular matrix of polymeric substances.



A Biofilm

Single-celled organisms generally exhibit two distinct modes of behavior. The first is the familiar free floating, or planktonic, form in which single cells float or swim independently in some liquid medium. The second is an attached state in which cells are closely packed and firmly attached to each other and usually form a solid surface. A change in behavior is triggered by many factors, including quorum sensing, as well as other mechanisms that vary between species. When a cell switches modes, it undergoes a phenotypic shift in behavior in which large suites of genes are up- and down- regulated.

Formation of a biofilm begins with the attachment of free-floating microorganisms to a surface. These first colonists adhere to the surface initially through weak, reversible van der Waals forces. If the colonists are not immediately separated from the surface, they can anchor themselves more permanently using cell adhesion structures such as pili.

The first colonists facilitate the arrival of other cells by providing more diverse adhesion sites and beginning to build the matrix that holds the biofilm together. Some species are not able to attach to a surface on their own but are often able to anchor themselves to the matrix or directly to earlier colonists. It is during this colonization that the cells are able to communicate via quorum sensing. Once

colonization has begun, the biofilm grows through a combination of cell division and recruitment. The final stage of biofilm formation is known as development, and is the stage in which the biofilm is established and may only change in shape and size. This development of biofilm allows for the cells to become more antibiotic resistant.

Biological warfare (BW) : Is the use of pathogens (bacteria, viruses, or other disease-causing agents) as biological weapons (or bioweapons). Using nonliving toxic products, even if produced by living organisms (e.g. toxins), is considered chemical warfare under the provisions of the Chemical Weapons Convention. A biological weapon may be intended to kill, incapacitate, or seriously impede an individual as well as entire cities or places. It may also be defined as the material or defense against such employment. BW is a military technique that can be used by nation-states or non-national groups. In the latter case, or if a nation-state uses it clandestinely, it may also be considered bioterrorism.

Biological warfare is the deliberate use of disease and natural poisons to incapacitate humans. It employs pathogens as weapons. Pathogens are the micro-organism, whether bacterial, viral or protozoic, that cause disease. There are four kinds of biological warfare agents : bacteria, viruses, rickettsiae and fungi. Biological weapons are distinguished by being living organisms, that reproduce within their host victims, who then become contagious with a deadly, if weakening, multiplier effect. Toxins in contrast do not reproduce in the victim and need only the briefest of incubation periods; they kill within a few hours.

Biosphere : The biosphere is the global sum of all ecosystems. It can also be called the zone of life on Earth. From the broadest biophysiological point of view, the biosphere is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, hydrosphere, and atmosphere. This biosphere is postulated to have evolved, beginning through a process of biogenesis or biopoesis, at least some 3.5 billion years ago.

While this concept has a geological origin, it is an indication of the impact of both Darwin and Maury on the earth sciences. The biosphere's ecological context comes from the 1920s, preceding the 1935 introduction of the term "ecosystem" by Sir Arthur Tansley. Vernadsky defined ecology as the science of the biosphere. It is an interdisciplinary concept for integrating astronomy, geophysics, meteorology, biogeography, evolution, geology, geochemistry, hydrology and, generally speaking, all life and earth sciences.

Nearly every part of the planet, from the polar ice caps to the Equator, supports life of some kind. Recent advances in microbiology have demonstrated that microbes live deep beneath the Earth's terrestrial surface, and that the total mass

of microbial life in so-called "uninhabitable zones" may, in biomass, exceed all animal and plant life on the surface. The actual thickness of the biosphere on earth is difficult to measure. Birds typically fly at altitudes of 650 to 1800 meters, and fish that live deep underwater can be found down to -8,372 meters in the Puerto Rico Trench.

There are more extreme examples for life on the planet : Rüppell's Vulture has been found at altitudes of 11,300 meters; Bar-headed Geese migrate at altitudes of at least 8,300 meters (over Mount Everest); Yaks live at elevations between 3,200 to 5,400 meters above sea level; mountain goats live up to 3,050 meters. Herbivorous animals at these elevations depend on lichens, grasses, and herbs but the biggest tree is the Tine palm or mountain coconut found 3,400 meters above sea level.

Microscopic organisms live at such extremes that, taking them into consideration puts the thickness of the biosphere much greater. Culturable microbes have been found in the Earth's upper atmosphere as high as 41 km (Wainwright et al., 2003, in FEMS Microbiology Letters). It is unlikely, however, that microbes are active at such altitudes, where temperatures and air pressure are extremely low and ultraviolet radiation very high. More likely these microbes were brought into the upper atmosphere by winds or possibly volcanic eruptions. Barophilic marine microbes have been found at more than 10 km depth in the Marianas Trench.

Microbes are not limited to the air, water or the Earth's surface. Culturable thermophilic microbes have been extracted from cores drilled more than 5 km into the Earth's crust in Sweden, from rocks between 65-75C. Temperature increases rapidly with increasing depth into the Earth's crust. The speed at which the temperature increases depends on many factors, including type of crust (continental vs. oceanic), rock type, geographic location, etc. The upper known limit of microbial is 122C, and it is likely that the limit of life in the "deep biosphere" is defined by temperature rather than absolute depth.

Our biosphere is divided into a number of biomes, inhabited by broadly similar flora and fauna. On land, biomes are separated primarily by latitude. Terrestrial biomes lying within the Arctic and Antarctic Circles are relatively barren of plant and animal life, while most of the more populous biomes lie near the equator. Terrestrial organisms in temperate and Arctic biomes have relatively small amounts of total biomass, smaller energy budgets, and display prominent adaptations to cold, including world-spanning migrations, social adaptations, homeothermy, estivation and multiple layers of insulation.

Biosphere 2 : Biosphere 2 is a 3.15-acre (12,700 m^2) structure originally built to be a man-made, materially-closed ecological system in Oracle, Arizona (USA) by Space Biosphere Ventures, a joint venture whose principal officers were John P. Allen,

inventor and Executive Director, and Margret Augustine, CEO. Constructed between 1987 and 1991, it was used to explore the complex web of interactions within life systems in a structure that included five areas based on natural biomes and an agricultural area and human living/working space to study the interactions between humans, farming and technology with the rest of nature. It also explored the possible use of closed biospheres in space colonization, and allowed the study and manipulation of a biosphere without harming Earth's. The name comes from Earth's biosphere, Biosphere 1, Earth's life system and the only biosphere currently known. Funding for the project came primarily from the joint venture's financial partner, Edward Bass' Decisions Investment, and cost $200 million from 1985 to 2007, including land, support research greenhouses, test module and staff facilities.

Biotechnology : Biotechnology is technology based on biology, especially when used in agriculture, food science, and medicine. United Nations Convention on Biological Diversity defines biotechnology as : Any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use.

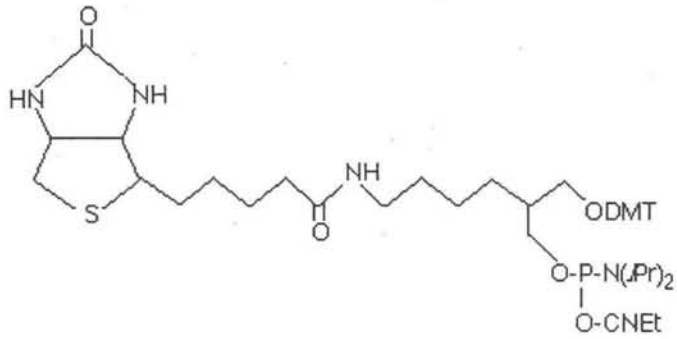
Biotechnology is often used to refer to genetic engineering technology of the 21st century, however the term encompasses a wider range and history of procedures for modifying biological organisms according to the needs of humanity, going back to the initial modifications of native plants into improved food crops through artificial selection and hybridization. Bioengineering is the science upon which all biotechnological applications are based. With the development of new approaches and modern techniques, traditional biotechnology industries are also acquiring new horizons enabling them to improve the quality of their products and increase the productivity of their systems.

Before 1971, the term, biotechnology, was primarily used in the food processing and agriculture industries. Since the 1970s, it began to be used by the Western scientific establishment to refer to laboratory-based techniques being developed in biological research, such as recombinant DNA or tissue culture-based processes, or horizontal gene transfer in living plants, using vectors such as the Agrobacterium bacteria to transfer DNA into a host organism. In fact, the term should be used in a much broader sense to describe the whole range of methods, both ancient and modern, used to manipulate organic materials to reach the demands of food production. So the term could be defined as, "The application of indigenous and/or scientific knowledge to the management of (parts of) microorganisms, or of cells and tissues of higher organisms, so that these supply goods and services of use to the food industry and its consumers.

Biotechnology combines disciplines like genetics, molecular biology, biochemistry, embryology and cell biology, which are in turn linked to practical disciplines like

chemical engineering, information technology, and biorobotics. Patho-biotechnology describes the exploitation of pathogens or pathogen derived compounds for beneficial effect.

Biotin : Also known as vitamin H or B_7, has the chemical formula $C_{10}H_{16}N_2O_3S$ (Biotin; Coenzyme R, Biopeiderm), is a water-soluble B-complex vitamin which is composed of an ureido (tetrahydroimidizalone) ring fused with a tetrahydrothiophene ring. A valeric acid substituent is attached to one of the carbon atoms of the tetrahydrothiophene ring. Biotin is a cofactor in the metabolism of fatty acids and leucine, and in gluconeogenesis.



Biotin : Molecular structure

Biotin is necessary for cell growth, the production of fatty acids, and the metabolism of fats and amino acids. It plays a role in the Citric acid cycle, which is the process by which biochemical energy is generated during aerobic respiration. Biotin not only assists in various metabolic reactions, but also helps to transfer carbon dioxide. Biotin is also helpful in maintaining a steady blood sugar level. Biotin is often recommended for strengthening hair and nails. Consequently, it is found in many cosmetic and health products for the hair and skin.

Deficiency is extremely rare, as intestinal bacteria generally produce an excess of the body's daily requirement. For that reason, statutory agencies in many countries (e.g., the Australian Department of Health and Aging) do not prescribe a recommended daily intake.

Brewing : Brewing is the production of alcoholic beverages and alcohol fuel through fermentation. The term is used for the production of beer, although the word "brewing" is also used to describe the fermentation process used to create wine

and mead. It can also refer to the process of producing sake and soy sauce. "Brewing" is also sometimes used to refer to any chemical mixing process.

Brewing specifically refers to the process of steeping, such as with tea and water, and extraction, usually through heat. Wine and cider technically aren't brewed, rather vinted, as the entire fruit is pressed, and then the liquid extracted. Mead isn't technically brewed, as heating often isn't used in the mixing process, and the honey is used entirely, as opposed to being heated with water, and then discarded, as are hops and barley in beer, and or tea leaves for tea, and coffee beans for coffee. Spices could technically be brewed into a mead though.

Brewing has a very long history, and archeological evidence suggests that this technique was used in ancient Egypt. Descriptions of various beer recipes can be found in Sumerian writings, some of the oldest known writing of any sort.

Bubonic plague : It is the best known manifestation of the bacterial disease plague, caused by the bacterium *Yersinia pestis* (formerly known as *Pasteurella pestis*). The term "bubonic plague" was often used synonymously for plague, but it does in fact refer specifically to an infection that enters through the skin and travels through the lymphatics, as is often seen in flea-borne infections. Bubonic plague kills about 50% of infected patients in 3–7 days without treatment, and is believed by many to be the Black Death that swept through Europe in the 1340s, killing millions.

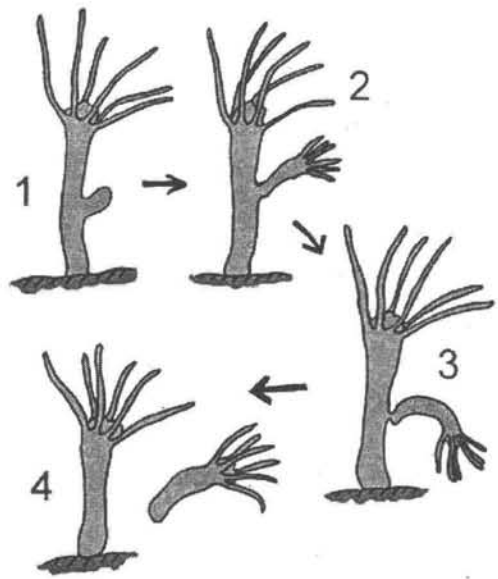
The bubonic plague is an infection of the lymphatic system, usually resulting from the bite of an infected flea. The fleas are often found on rodents, such as rats and mice, and seek out other prey when their rodent hosts die. Once established, bacteria rapidly spread to the lymph nodes and multiply. Yersinia pestis *Bacilli* can resist phagocytosis and even reproduce inside phagocytes and kill them. As the disease progresses, the lymph nodes can hemorrhage and become swollen and necrotic. Bubonic plague can progress to lethal septicemic plague in some cases. The plague is also known to spread to the lungs and become the disease known as the pneumonic plague.

The most famous symptom of bubonic plague is swollen lymph glands, called buboes. These are commonly found in the armpits, groin or neck. The bubonic plague was the first step of the ongoing plague. Two other forms of the plague, pneumonic and septicemic, resulted after a patient with the bubonic plague developed pneumonia or blood poisoning.

Other symptoms include spots on the skin that are red at first and then turn black, heavy breathing, continuous blood vomiting, aching limbs, coughing and terrible pain. The pain is usually caused by the actual decaying, or decomposing of the skin while the infected person is still alive.

In modern times, several classes of antibiotics are effective in treating bubonic plague. These include the aminoglycosides streptomycin and gentamicin, the tetracyclines tetracycline and doxycycline and the fluoroquinolone ciprofloxacin. Patients with plague in the modern era usually recover completely with prompt diagnosis and treatment

Budding : A form of asexual reproduction. The new organism is naturally genetically identical to the primary one (a clone). When yeast buds, one cell becomes two cells. When a sponge buds, a part of the parent sponge falls off and starts to grow into a new sponge. These are examples of asexual reproduction.



Budding in Hydra

Budding is the process by which enveloped viruses acquire their external envelope, often as fragment of the host cell membrane, which bulges outwards and takes the virion inside. Some viruses hijack the host cell proteins normally involved in endocytosis to facilitate this process.

C

Cancer : A class of diseases in which a group of cells display *uncontrolled growth* (division beyond the normal limits), *invasion* (intrusion on and destruction of adjacent tissues), and sometimes *metastasis* (spread to other locations in the body via lymph or blood). These three malignant properties of cancers differentiate them from benign tumors, which are self-limited, and do not invade or metastasize. Most cancers form a tumor but some, like leukemia, do not. The branch of medicine concerned with the study, diagnosis, treatment, and prevention of cancer is oncology.

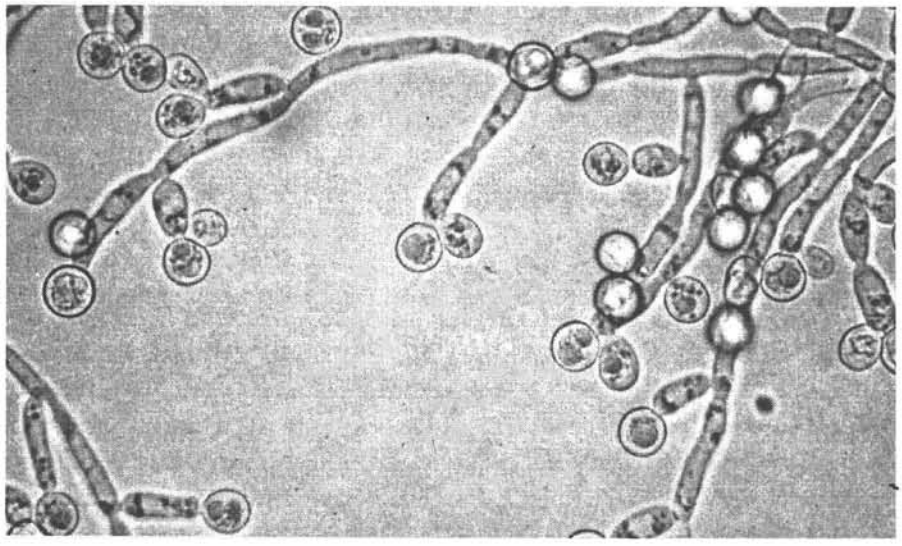
Cancer may affect people at all ages, even fetuses, but the risk for most varieties increases with age. Cancer causes about 13% of all human deaths. According to the American Cancer Society, 7.6 million people died from cancer in the world during 2007. Cancers can affect all animals. Nearly all cancers are caused by abnormalities in the genetic material of the transformed cells. These abnormalities may be due to the effects of carcinogens, such as tobacco smoke, radiation, chemicals, or infectious agents. Other cancer-promoting genetic abnormalities may be randomly acquired through errors in DNA replication, or are inherited, and thus present in all cells from birth. The heritability of cancers are usually affected by complex interactions between carcinogens and the host's genome. New aspects of the genetics of cancer pathogenesis, such as DNA methylation, and microRNAs are increasingly recognized as important.

Cancer immunotherapy : Is the use of the immune system to reject cancer. The main premise is stimulating the patient's immune system to attack the malignant tumor cells that are responsible for the disease. This can be either through immunization of the patient, in which case the patient's own immune system is trained to recognize tumor cells as targets to be destroyed, or through the administration of therapeutic antibodies as drugs, in which case the patient's immune system is recruited to destroy tumor cells by the therapeutic antibodies.

Since the immune system responds to the environmental factors it encounters on the basis of discrimination between self and non-self, many kinds of tumor cells

that arise as a result of the onset of cancer are more or less tolerated by the patient's own immune system since the tumor cells are essentially the patient's own cells that are growing, dividing and spreading without proper regulatory control. In spite of this fact, however, many kinds of tumor cells display unusual antigens that are either inappropriate for the cell type and/or its environment, or are only normally present during the organisms' development (e.g. fetal antigens). Examples of such antigens include the glycosphingolipid GD_2, a disialoganglioside that is normally only expressed at a significant level on the outer surface membranes of neuronal cells, where its exposure to the immune system is limited by the blood-brain barrier. GD_2 is expressed on the surfaces of a wide range of tumor cells including neuroblastoma, medulloblastomas, astrocytomas, melanomas, small-cell lung cancer, osteosarcomas and other soft tissue sarcomas. GD_2 is thus a convenient tumor-specific target for immunotherapies.

Candida albicans : Is a diploid fungus (a form of yeast), which is capable of sexual reproduction but not of meiosis, and a causal agent of opportunistic oral and genital infections in humans. Systemic fungal infections (fungemias) have emerged as important causes of morbidity and mortality in immunocompromised patients (e.g., AIDS, cancer chemotherapy, organ or bone marrow transplantation). In addition, hospital-related infections in patients not previously considered at risk (e.g. patients in an intensive care unit) have become a cause of major health concern.



Candida albicans

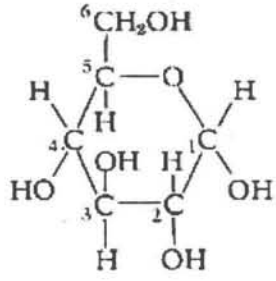
C. albicans is commensal and is among the gut flora, the many organisms which live in the human mouth and gastrointestinal tract. Under normal circumstances, *C. albicans* lives in 80% of the human population with no harmful effects, although overgrowth results in candidiasis. Candidiasis is often observed in immunocompromised individuals such as HIV-positive patients. Candidiasis also may occur in the blood and in the genital tract. Candidiasis, also known as "thrush", is a common condition which is usually easily cured in people who are not immunocompromised. To infect host tissue, the usual unicellular yeast-like form of *C. albicans* reacts to environmental cues and switches into an invasive, multicellular filamentous forms.

Candidiasis : Commonly called yeast infection or thrush, also known as "Candidosis," "Moniliasis," and "Oidiomycosis," is a fungal infection (mycosis) of any of the Candida species, of which Candida albicans is the most common. Candidiasis encompasses infections that range from superficial, such as oral thrush and vaginitis, to systemic and potentially life-threatening diseases. Candida infections of the latter category are also referred to as candidemia and are usually confined to severely immunocompromised persons, such as cancer, transplant, and AIDS patients. Superficial infections of skin and mucosal membranes by Candida causing local inflammation and discomfort are however common in many human populations. While clearly attributable to the presence of the opportunistic pathogens of the genus Candida, candidiasis describes a number of different disease syndromes that often differ in their causes and outcomes.

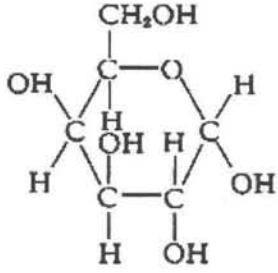
Most candidial infections are treatable and result in minimal complications such as redness, itching and discomfort, though complication may be severe or fatal if left untreated in certain populations. In immunocompetent persons, candidiasis is usually a very localized infection of the skin or mucosal membranes, including the oral cavity (thrush), the pharynx or esophagus, the gastrointestinal tract, the urinary bladder, or the genitalia (vagina, penis). Candidiasis is a very common cause of vaginal irritation, or vaginitis, and can also occur on the male genitals. In immunocompromised patients, Candida infections can affect the esophagus with the potential of becoming systemic, causing a much more serious condition, a fungemia called candidemia. Children, mostly between the ages of three and nine years of age, can be affected by chronic mouth yeast infections, normally seen around the mouth as white patches. However, this is not a common condition.

Carbohydrates : Carbohydrates are the most abundant of the four major classes of biomolecules. They fill numerous roles in living things, such as the storage and transport of energy (eg : starch, glycogen) and structural components (eg : cellulose in plants and chitin). Additionally, carbohydrates and their derivatives play major roles in the working process of the immune system, fertilization, pathogenesis, blood clotting, and development.

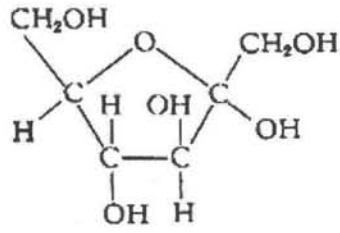
Chemically, carbohydrates are simple organic compounds that are aldehydes or ketones with many hydroxyl groups added, usually one on each carbon atom that is not part of the aldehyde or ketone functional group. The basic carbohydrate units are called monosaccharides, such as glucose, galactose, and fructose. The general stoichiometric formula of an unmodified monosaccharide is $(C{\cdot}H_2O)n$, where n is any number of three or greater; however, not all carbohydrates conform to this precise stoichiometric definition, nor are all chemicals that do conform to this definition automatically classified as carbohydrates.



glucose



galactose



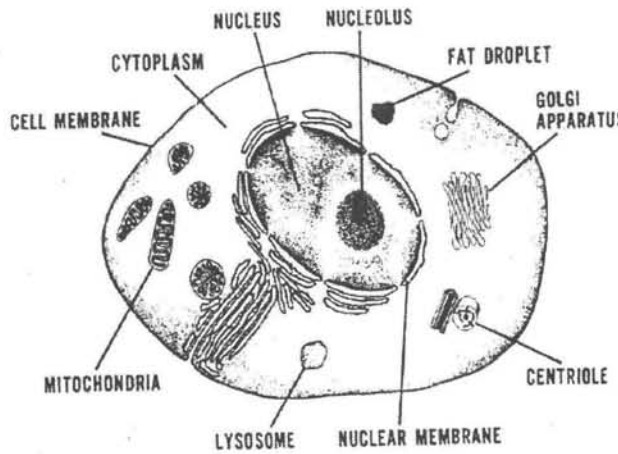
fructose

Monosaccharides can be linked together into what are called polysaccharides (or oligosaccharides) in almost limitless ways. Many carbohydrates contain one or more modified monosaccharide units that have had one or more groups replaced or removed. For example, deoxyribose, a component of DNA, is a modified version of ribose; chitin is composed of repeating units of N-acetylglucosamine, a nitrogen-containing form of glucose.

Carl Richard Woese : Is an American microbiologist and physicist. Woese is famous for defining the Archaea (a new domain or kingdom of life) in 1977 by phylogenetic taxonomy of 16S ribosomal RNA, a technique pioneered by Woese

and which is now standard practice. He was also the originator of the RNA world hypothesis in 1967, although not by that name. He currently holds the Stanley O. Ikenberry Chair and is professor of microbiology at the University of Illinois at Urbana-Champaign. Having defined Archaea as a new domain, Woese redrew the taxonomic tree. His three-domain system, based upon genetic relationships rather than obvious morphological similarities, divided life into 23 main divisions, all incorporated within three domains : Bacteria, Archaea, and Eucarya. Archaea are neither Bacteria nor Eukaryotes. Looked at another way, they are Prokaryotes that are not Bacteria. The tree of life elucidated by Woese is noteworthy for its demonstration of the overwhelming diversity of microbial lineages; single-celled organisms represent the vast majority of the biosphere's genetic, metabolic, and ecosystem niche diversity. This is surprising to some, given our familiarity with the macrobiological world.

Cell : The cell is the structural and functional unit of all known living organisms. It is the smallest unit of an organism that is classified as living, and is often called the building brick of life. Some organisms, such as most bacteria, are unicellular (consist of a single cell). Other organisms, such as humans, are multicellular. (Humans have an estimated 100 trillion or 1014 cells; a typical cell size is 10 μm; a typical cell mass is 1 nanogram.) The largest known cell is an unfertilized ostrich egg cell.



Cell structure

In 1835 before the final cell theory was developed, a Czech Jan Evangelista Purkyne observed small "granules" while looking at the plant tissue through a microscope.

The cell theory, first developed in 1839 by Matthias Jakob Schleiden and Theodor Schwann, states that all organisms are composed of one or more cells. All cells come from preexisting cells. Vital functions of an organism occur within cells, and all cells contain the hereditary information necessary for regulating cell functions and for transmitting information to the next generation of cells.

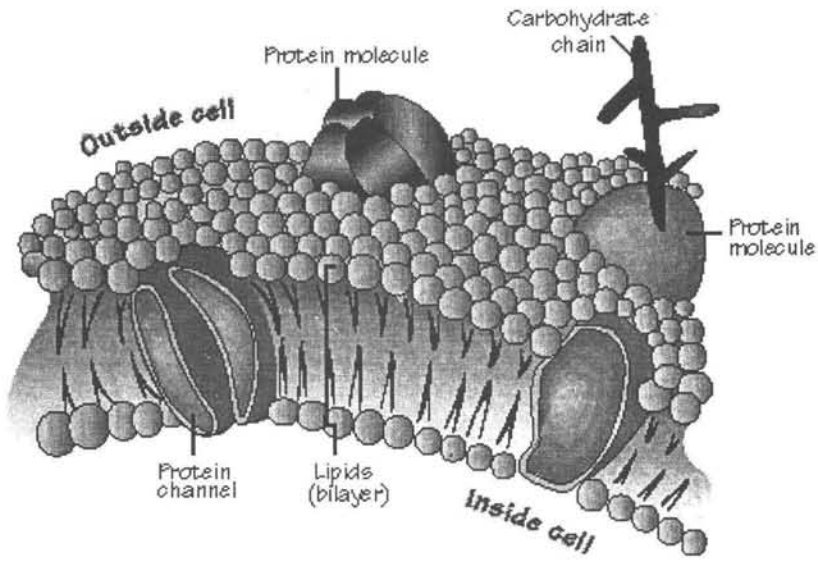
The word cell comes from the Latin cellula, meaning, a small room. The descriptive name for the smallest living biological structure was chosen by Robert Hooke in a book he published in 1665 when he compared the cork cells he saw through his microscope to the small rooms monks lived in.

Cell culture : Cell culture is the process by which prokaryotic or eukaryotic cells are grown under controlled conditions. In practice the term "cell culture" has come to refer to the culturing of cells derived from multicellular eukaryotes, especially animal cells. The historical development and methods of cell culture are closely interrelated to those of tissue culture and organ culture. Animal cell culture became a common laboratory technique in the mid-1900s, but the concept of maintaining live cell lines separated from their original tissue source was discovered in the 19th century

The 19th-century English physiologist Sydney Ringer developed salt solutions containing the chlorides of sodium, potassium, calcium and magnesium suitable for maintaining the beating of an isolated animal heart outside of the body. In 1885 Wilhelm Roux removed a portion of the medullary plate of an embryonic chicken and maintained it in a warm saline solution for several days, establishing the principle of tissue culture. Ross Granville Harrison, working at Johns Hopkins Medical School and then at Yale University, published results of his experiments from 1907-1910, establishing the methodology of tissue culture.

Cell culture techniques were advanced significantly in the 1940s and 1950s to support research in virology. Growing viruses in cell cultures allowed preparation of purified viruses for the manufacture of vaccines. The Salk polio vaccine was one of the first products mass-produced using cell culture techniques. This vaccine was made possible by the cell culture research of John Franklin Enders, Thomas Huckle Weller, and Frederick Chapman Robbins, who were awarded a Nobel Prize for their discovery of a method of growing the virus in monkey kidney cell cultures.

Cell membrane : The cell membrane is the biological membrane separating the interior of a cell from the outside environment. It is a semipermeable lipid bilayer found in all cells. It contains a wide variety of biological molecules, primarily proteins and lipids, which are involved in a vast array of cellular processes such as cell adhesion, ion channel conductance and cell signaling. The plasma membrane also serves as the attachment point for both the intracellular cytoskeleton and, if present, the extracellular cell wall.

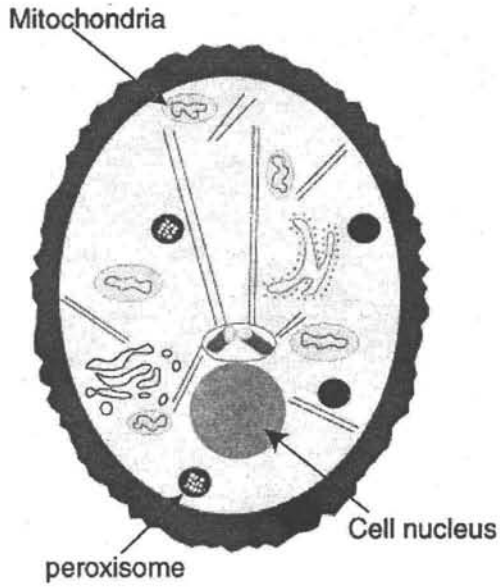


Cell membrane

The cell membrane surrounds the cytoplasm of a cell and, in animal cells, physically separates the intracellular components from the extracellular environment, thereby serving a function similar to that of skin. In fungi, some bacteria, and plants, an additional cell wall forms the outermost boundary; however, the cell wall plays mostly a mechanical support role rather than a role as a selective boundary. The cell membrane also plays a role in anchoring the cytoskeleton to provide shape to the cell, and in attaching to the extracellular matrix to help group cells together in the formation of tissues. The barrier is selectively permeable and able to regulate what enters and exits the cell, thus facilitating the transport of materials needed for survival.

The movement of substances across the membrane can be either passive, occurring without the input of cellular energy, or active, requiring the cell to expend energy in moving it. The membrane also maintains the cell potential. Specific proteins embedded in the cell membrane can act as molecular signals that allow cells to communicate with each other. Protein receptors are found ubiquitously and function to receive signals from both the environment and other cells. These signals are transduced and passed in a different form into the cell. For example, a hormone binding to a receptor could open an ion channel in the receptor and allow calcium ions to flow into the cell. Other proteins on the surface of the cell membrane serve as "markers" that identify a cell to other cells. The interaction of these markers with their respective receptors forms the basis of cell-cell interaction in the immune system.

Cell nucleus : The cell nucleus (pl. nuclei; from Latin nucleus or nuculeus, or kernel), also sometimes referred to as the "control center", is a membrane-enclosed organelle found in eukaryotic cells. It contains most of the cell's genetic material, organized as multiple long linear DNA molecules in complex with a large variety of proteins, such as histones, to form chromosomes. The genes within these chromosomes are the cell's nuclear genome. The function of the nucleus is to maintain the integrity of these genes and to control the activities of the cell by regulating gene expression—the nucleus is therefore the control center of the cell.



Cell nucleus

The main structures making up the nucleus are the nuclear envelope, a double membrane that encloses the entire organelle and separates its contents from the cellular cytoplasm, and the nuclear lamina, a meshwork within the nucleus that adds mechanical support, much like the cytoskeleton supports the cell as a whole. Because the nuclear membrane is impermeable to most molecules, nuclear pores are required to allow movement of molecules across the envelope. These pores cross both of the membranes, providing a channel that allows free movement of small molecules and ions. The movement of larger molecules such as proteins is carefully controlled, and requires active transport regulated by carrier proteins. Nuclear transport is crucial to cell function, as movement through the pores is required for both gene expression and chromosomal maintenance.

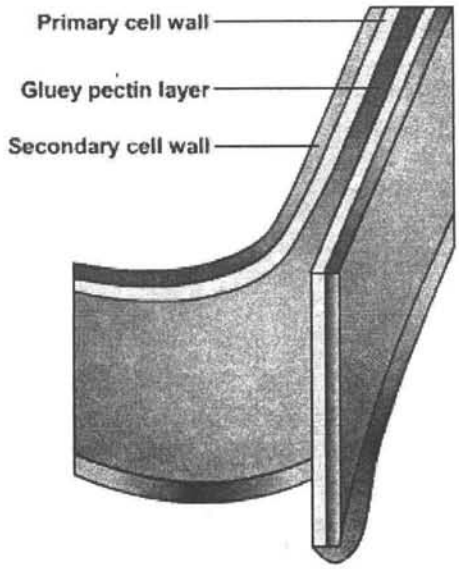
Although the interior of the nucleus does not contain any membrane-bound subcompartments, its contents are not uniform, and a number of subnuclear bodies exist, made up of unique proteins, RNA molecules, and particular parts of the chromosomes. The best known of these is the nucleolus, which is mainly involved in the assembly of ribosomes. After being produced in the nucleolus, ribosomes are exported to the cytoplasm where they translate mRNA.

The nucleus was the first organelle to be discovered, and was first described by Franz Bauer in 1804. It was later described in more detail by Scottish botanist Robert Brown in 1831 in a talk at the Linnean Society of London. Brown was studying orchids microscopically when he observed an opaque area, which he called the areola or nucleus, in the cells of the flower's outer layer. He did not suggest a potential function. In 1838 Matthias Schleiden proposed that the nucleus plays a role in generating cells, thus he introduced the name "Cytoblast" (cell builder). He believed that he had observed new cells assembling around "cytoblasts". Franz Meyen was a strong opponent of this view having already described cells multiplying by division and believing that many cells would have no nuclei. The idea that cells can be generated de novo, by the "cytoblast" or otherwise, contradicted work by Robert Remak (1852) and Rudolf Virchow (1855) who decisively propagated the new paradigm that cells are generated solely by cells ("Omnis cellula e cellula"). The function of the nucleus remained unclear.

Between 1876 and 1878 Oscar Hertwig published several studies on the fertilization of sea urchin eggs, showing that the nucleus of the sperm enters the oocyte and fuses with its nucleus. This was the first time it was suggested that an individual develops from a (single) nucleated cell. This was in contradiction to Ernst Haeckel's theory that the complete phylogeny of a species would be repeated during embryonic development, including generation of the first nucleated cell from a "Monerula", a structureless mass of primordial mucus ("Urschleim"). Therefore, the necessity of the sperm nucleus for fertilization was discussed for quite some time. However, Hertwig confirmed his observation in other animal groups, e.g. amphibians and molluscs. Eduard Strasburger produced the same results for plants (1884). This paved the way to assign the nucleus an important role in heredity. In 1873 August Weismann postulated the equivalence of the maternal and paternal germ cells for heredity. The function of the nucleus as carrier of genetic information became clear only later, after mitosis was discovered and the Mendelian rules were rediscovered at the beginning of the 20th century; the chromosome theory of heredity was developed.

Cell wall : A cell wall is a tough, flexible and sometimes fairly rigid layer that surrounds some types of cells. It is located outside the cell membrane and provides these cells with structural support and protection, and also acts as a filtering mechanism. A major function of the cell wall is to act as a pressure vessel, preventing over-

expansion when water enters the cell. They are found in plants, bacteria, fungi, algae, and some archaea. Animals and protozoa do not have cell walls.



Structure of cell wall

The materials in a cell wall vary between species, and in plants and fungi also differ between cell types and developmental stages. In plants, the strongest component of the complex cell wall is a carbohydrate called cellulose, which is a polymer of glucose. In bacteria, peptidoglycan forms the cell wall. \rchaean cell walls have various compositions, and may be formed of glycoprotein S-layers, pseudopeptidoglycan, or polysaccharides. Fungi possess cell walls made of the glucosamine polymer chitin, and algae typically possess walls made of glycoproteins and polysaccharides. Unusually, diatoms have a cell wall composed of silicic acid. Often, other accessory molecules are found anchored to the cell wall.

The cell wall serves a similar purpose in those organisms that possess them. The wall gives cells rigidity and strength, offering protection against mechanical stress. In multicellular organisms, it permits the organism to build and hold its shape (morphogenesis). The cell wall also limits the entry of large molecules that may be toxic to the cell. It further permits the creation of a stable osmotic environment by preventing osmotic lysis and helping to retain water. The composition, properties, and form of the cell wall may change during the cell cycle and depend on growth conditions.

Cell-mediated immunity : Is an immune response that does not involve antibodies or complement but rather involves the activation of macrophages, natural killer cells (NK), antigen-specific cytotoxic T-lymphocytes, and the release of various cytokines in response to an antigen. Historically, the immune system was separated into two branches : humoral immunity, for which the protective function of immunization could be found in the humor (cell-free bodily fluid or serum) and cellular immunity, for which the protective function of immunization was associated with cells. CD_4 cells or helper T cells provide protection against different pathogens.

Cellular immunity protects the body by :

- Activating antigen-specific cytotoxic T-lymphocytes that are able to induce apoptosis in body cells displaying epitopes of foreign antigen on their surface, such as virus-infected cells, cells with intracellular bacteria, and cancer cells displaying tumor antigens;
- Activating macrophages and natural killer cells, enabling them to destroy intracellular pathogens; and
- Stimulating cells to secrete a variety of cytokines that influence the function of other cells involved in adaptive immune responses and innate immune responses.

Cell-mediated immunity is directed primarily at microbes that survive in phagocytes and microbes that infect non-phagocytic cells. It is most effective in removing virus-infected cells, but also participates in defending against fungi, protozoans, cancers, and intracellular bacteria. It also plays a major role in transplant rejection.

Cellular microbiology : It is a subfield of biology. It is a discipline that bridges microbiology and cell biology. The term "cellular microbiology" was coined in 1996 in a *Science* article. Cooperation and mutual dependency between microbiology and cell biology had been increasing in the years before that, and the emergence of a new discipline had been suggested and discussed in several scientific conferences.

Cellular microbiology attempts to use pathogenic microbes as tools for cell-biology research, and to employ cell-biology methods to understand the pathogenicity of microbes. Toxins and virulence factors from microbes have been used for decades to influence processes in eukaryotic cells and to study them. It has increasingly appeared that applying a purified toxin on a cell does not always provide the complete picture, and that understanding the role of the toxin in pathogenicity, the way the toxin promotes the microbe, the way the toxin is produced and the co-evolution of the toxin and its host-cell counterparts, is crucial.

Numerous eukaryotic cellular processes have been clarified using microbial "tools". A major subject in this category is the cytoskeleton. Many microbes modify and influence the synthesis or degradation of the host-cell cytoskeleton, in particular the actin network. Intracellular microbes, such as the bacteria *Salmonella* and *Shigella*, elicit actin polymerization in host cells that otherwise do not internalize microbes (non-phagocytes). This causes the formation of projections that eventually engulf the bacteria. Bacteria such as *Yersinia* inhibit actin polymerization in phagocytes, thereby preventing their uptake. Cellular microbiology tries to understand these processes and how they promote infection. Other eukaryotic processes that microbes influence and that are researched using microbes are signal transduction, metabolism, vesicle trafficking, cell cycle and transcriptional regulation, to name but a few.

Cellulosic ethanol : Cellulosic ethanol is a biofuel produced from wood, grasses, or the non-edible parts of plants. It is a type of biofuel produced from lignocellulose, a structural material that comprises much of the mass of plants. Lignocellulose is composed mainly of cellulose, hemicellulose and lignin. Corn stover, switchgrass, miscanthus, woodchips and the byproducts of lawn and tree maintenance are some of the more popular cellulosic materials for ethanol production. Production of ethanol from lignocellulose has the advantage of abundant and diverse raw material compared to sources like corn and cane sugars, but requires a greater amount of processing to make the sugar monomers available to the microorganisms that are typically used to produce ethanol by fermentation.

Switchgrass and Miscanthus are the major biomass materials being studied today, due to their high productivity per acre. Cellulose, however, is contained in nearly every natural, free-growing plant, tree, and bush, in meadows, forests, and fields all over the world without agricultural effort or cost needed to make it grow.

According to U.S. Department of Energy studies conducted by the Argonne Laboratories of the University of Chicago, one of the benefits of cellulosic ethanol is that it reduces greenhouse gas emissions (GHG) by 85% over reformulated gasoline. By contrast, starch ethanol (e.g., from corn), which most frequently uses natural gas to provide energy for the process, may not reduce GHG emissions at all depending on how the starch-based feedstock is produced. A study by Nobel Prize winner Paul Crutzen found ethanol produced from corn, and sugarcane had a "net climate warming" effect when compared to oil.

Charales : Charales is an order of pondweeds, freshwater algae in the division Charophyta. They are green plants believed to be the closest relatives of the green land plants. Linnaeus established the genus (Chara) in 1753. The Charales, have large, macroscopic, thalli growing up to 120cm long, they are branched, multicellular, and use chlorophyll to photosynthesize. They grow in fresh water.

They may be called stoneworts, because the plants can become encrusted in lime (calcium carbonate) after some time. The "stem" is actually a central stalk consisting of giant, multinucleated cells. They are unique in having a whorl of small branchlets at each node in the stipe, this gives them a superficial resemblance to the genus Equisetum. In these whorls it is possible to see the phenomenon of cytoplasmic streaming. In fact the streaming in Chara is the fastest recorded of any cell. Cytoplasmic streaming is caused by the microfilaments found inside the cell, as proven by the use of cytochalasin B to stop streaming.There are about 400 species world-wide, with 33 in Britain and Ireland according to Groves and Bullock-Webster), however (Stewart and Church (1992) reduce this to 21.

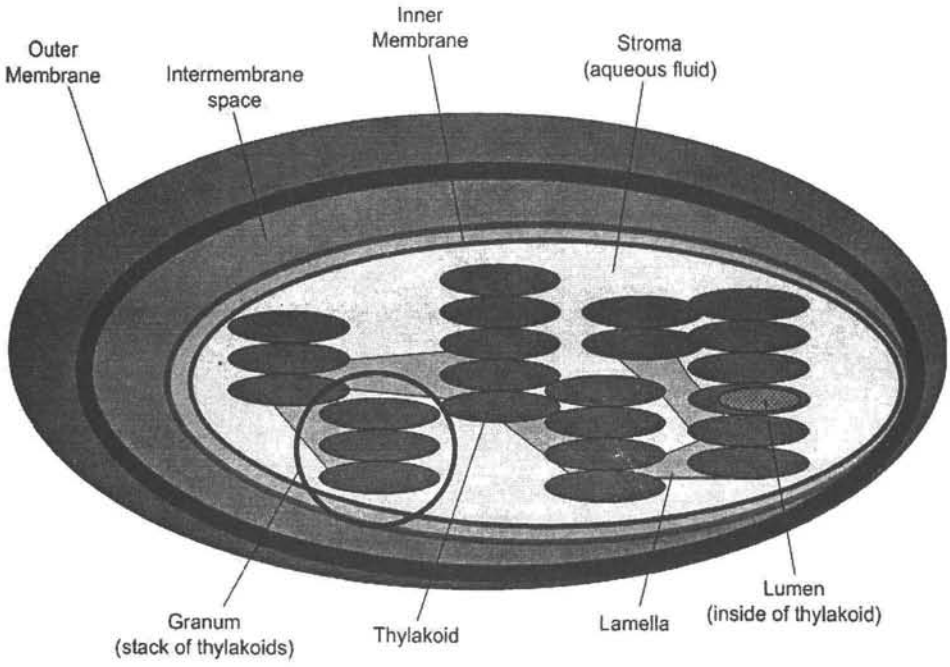
Charophyta : The Charophyta are a division of green algae, including the closest relatives of the embryophyte plants. In some groups, such as conjugating green algae, flagellate cells do not occur. The latter group does engage in sexual reproduction, and motility does not involve flagella, since they are totally lacking. Flagellate cells in the form of sperm are found in stoneworts (Charales) and Coleochaetales.Because they exclude the embryophytes, the Charophyta make a paraphyletic group (although the division Charophyta is occasionally restricted to simply the Charales or stoneworts, which are monophyletic). The Charophyta plus the embryophytes make up the Streptophyta, which is a monophyletic group.

Charophyta

Chemotrophs : Chemotrophs are organisms that obtain energy by the oxidation of electron donating molecules in their environments. These molecules can be organic (organotrophs) or inorganic (lithotrophs). The chemotroph designation is in contrast to phototrophs which utilize solar energy. Chemotrophs can be either autotrophic or heterotrophic.

Chemoautotrophs : Chemoautotrophs generally only use inorganic energy sources. Most are bacteria or archaea that live in hostile environments such as deep sea vents and are the primary producers in such ecosystems. Evolutionary scientists believe that the first organisms to inhabit Earth were chemoautotrophs that produced oxygen as a by-product and later evolved into both aerobic, animal-like organisms and photosynthetic, plant-like organisms. Chemoautotrophs generally fall into several groups : methanogens, halophiles, sulfur reducers, nitrifiers, anammoxbacteria and thermoacidophiles.

Chloroplasts : Chloroplasts are organelles found in plant cells and other eukaryotic organisms that conduct photosynthesis. Chloroplasts capture light energy to conserve free energy in the form of ATP and reduce NADP to NADPH through a complex set of processes called photosynthesis.



Chloroplast

The word chloroplast is derived from the Greek words chloros which means green and plast which means form or entity. Chloroplasts are members of a class of organelles known as plastids.

Chloroplasts are observable morphologically as flat discs usually 2 to 10 micrometer in diameter and 1 micrometer thick. In land plants they are generally 5 μm in diameter and 2.3 μm thick. The chloroplast is contained by an envelope that consists of an inner and an outer phospholipid membrane. Between these two layers is the intermembrane space. A typical parenchyma cell contains about 10 to 100 chloroplasts.

The material within the chloroplast is called the stroma, corresponding to the cytosol of the original bacterium, and contains one or more molecules of small circular DNA. It also contains ribosomes, although most of its proteins are encoded by genes contained in the host cell nucleus, with the protein products transported to the chloroplast

Cholera toxin : Cholera toxin (CTX) is a protein complex secreted by the bacterium Vibrio cholerae. CTX is responsible for the harmful effects of cholera infection. The cholera toxin is an oligomeric complex made up of six protein subunits : a single copy of the A subunit (part A), and five copies of the B subunit (part B). The two parts are connected by a disulfide bond. The three-dimensional structure of the toxin was determined using X-ray crystallography by Zhang et al. in 1995.

The five B subunits—each weighing 12 kDa, and all coloured blue in the accompanying figure—form a five-membered ring. The A subunit has two important segments. The A1 portion of the chain (CTA1, red) is a globular enzyme payload that ADP-ribosylates G proteins, while the A2 chain (CTA2, orange) forms an extended alpha helix which seats snugly in the central pore of the B subunit ring. This structure is similar in shape, mechanism, and sequence to the heat-labile enterotoxin secreted by some strains of the Escherichia coli bacterium.

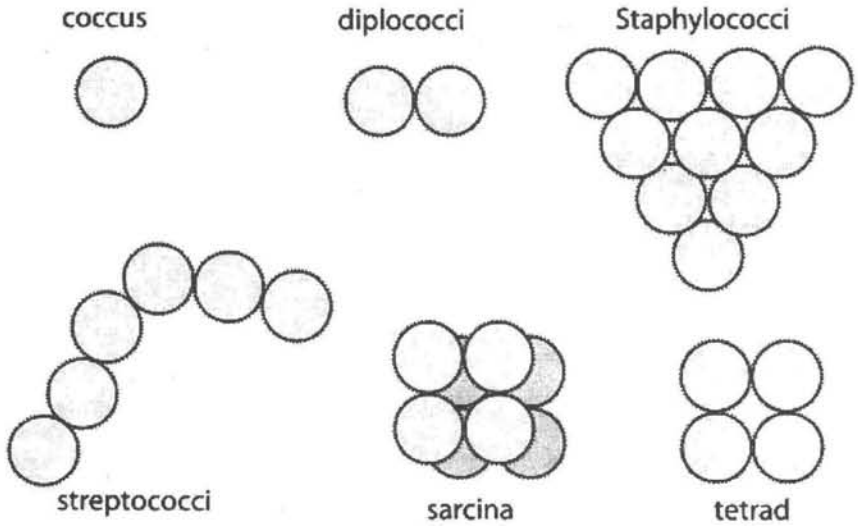
Chronic granulomatous disease (CGD) : It is a diverse group of hereditary diseases in which certain cells of the immune system have difficulty forming the reactive oxygen compounds (most importantly, the superoxide radical) used to kill certain ingested pathogens. This leads to the formation of granulomata in many organs. CGD affects about 1 in 200,000 people in the United States, with about 20 new cases diagnosed each year. This condition was first described in 1957 as "a fatal granulomatosus of childhood". The underlying cellular mechanism that causes chronic granulomatous disease was discovered in 1967, and research since that time has further elucidated the molecular mechanisms underlying the disease.

Clinical pathology : It is a medical specialty that is concerned with the diagnosis of disease based on the laboratory analysis of bodily fluids such as blood and urine,

and tissues using the tools of chemistry, microbiology, hematology and molecular pathology. Clinical pathologists work in close collaboration with medical technologists hospital administrations and referring physicians to insure the accuracy and optimal utilization of laboratory testing. Clinical pathology is one of the two major divisions of pathology, the other being anatomical pathology. Often, pathologists practice both anatomical and clinical pathology, a combination sometimes known as general pathology. Similar specialties exist in veterinary pathology.

Clinical pathology is itself divided in to subspecialties, the main ones being clinical chemistry, clinical hematology/blood banking, hematopathology and clinical microbiology and emerging subspecialities such as molecular diagnostics and proteomics. Many areas of clinical pathology overlap with anatomic pathology. Both can serve as medical directors of CLIA certified laboratories. This overlap includes imunoassays, flow cytometry, microbiology and cytogenetics and any assay done on tissue. Overlap between anatomic and clinical pathology is expanding to molecular diagnostics and proteomics as we move towards making the best use of new technologies for personalized medicine.

Cocci : Cocci are any microorganism (usually bacteria) whose overall shape is spherical or nearly spherical. Describing a bacterium as a coccus, or sphere, distinguishes it from bacillus, or rod. This is the first of many taxonomic traits for identifying and classifying a bacterium according to binomial nomenclature.

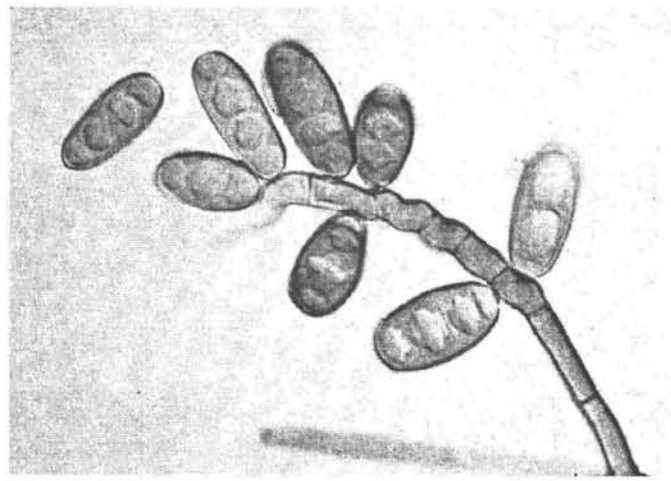


Cocci

Important human pathogens caused by coccoid bacteria include staphylococci infections, some types of food poisoning, some urinary tract infections, toxic shock syndrome, gonorrhea, as well as some forms of meningitis, throat infections, pneumonias, and sinusitis.

Coliform index : It is a rating of the purity of water based on a count of fecal bacteria. Coliform bacteria are microorganisms that primarily originate in the intestines of warm-blooded animals. By testing for coliforms, especially the well known *E.Coli*, which is a thermo tolerant coliform, one can determine if the water has probably been exposed to fecal contamination; that is, whether it has come in contact with human or animal feces. It is important to know this because many disease-causing organisms are transferred from human and animal feces to water, from where they can be ingested by people and infect them. Water that has been contaminated by feces usually contains pathogenic bacteria, which can cause disease. Some types of coliforms cause disease, but the coliform index is primarily used to judge if other types of pathogenic bacteria are likely to be present in the water. The coliform index is used because it is difficult to test for pathogenic bacteria directly. There are many different types of disease-causing bacteria, and they are usually present in low numbers which do not always show up in tests. Thermotolerant coliforms are present in higher numbers than individual types of pathogenic bacteria and they can be tested for relatively easily.

Conidia : Sometimes termed conidiospores, are asexual, non-motile spores of a fungus; they are also called mitospores due to the way they are generated through the cellular process of mitosis. They are haploid cells genetically identical to the haploid parent, can develop into a new organism if conditions are favorable, and serve in biological dispersal.



Conidia and conidiophore

Asexual reproduction in Ascomycetes (the Phylum Ascomycota) is by the formation of conidia, which are borne on specialized stalks called conidiophores. The morphology of these specialized conidiophores is often distinctive of a specific species and can therefore be used in identification of the species.

There are two main types of conidium development :

- *blastic* conidiogenesis, where the spore is already evident before it separates from the conidiogenic hypha which is giving rise to it, and
- *thallic* conidiogenesis, where first a cross-wall appears and then the thus created cell develops into a spore.

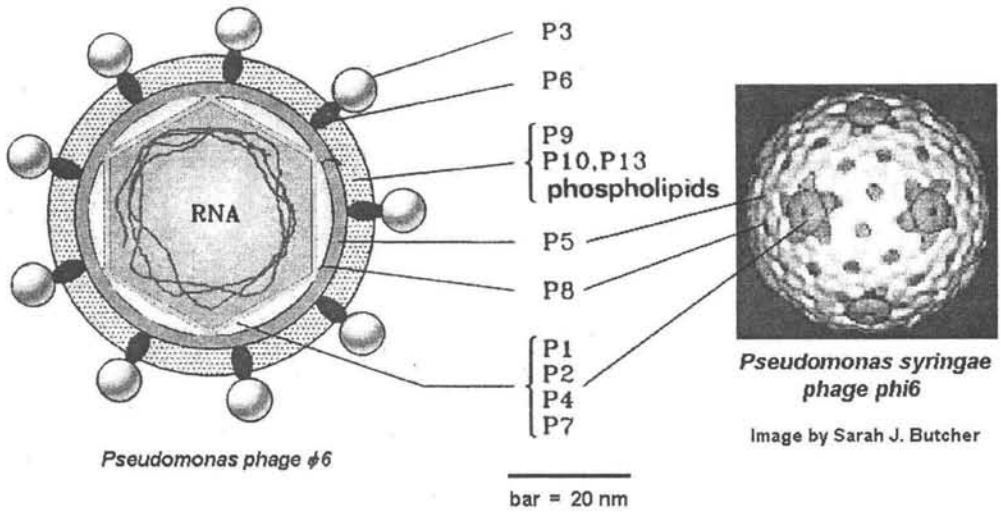
A conidium may form germ tubes (germination tubes) and conidial anastomosis tubes (CATs) in specific conditions. These two are some of the specialized hyphae that are formed by fungal conidia. Conidial anastomosis tubes are morphologically and physiologically distinct from germ tubes and are under separate genetic control.

Crenarchaeota : The Crenarchaeota, also known as Crenarchaea or eocytes, are a phylum of the Archaea. Initially, the Crenarchaeota were thought to be extremophiles but recent studies have identified them as the most abundant archaea in the marine environment. Originally, they were separated from the other archaea based on rRNA sequences; since then physiological features, such as lack of histones have supported this division. However, some crenarchaea were found to have histones. Until recently all cultured Crenarchaea had been thermophilic or hyperthermophilic organisms, some of which have the ability to grow at up to 113°C. These organisms stain gram negative and are morphologically diverse having rod, cocci, filamentous and oddly shaped cells.

One of the best characterized members of the Crenarcheota is *Sulfolobus solfataricus*. This organism was originally isolated from geothermally-heated sulfuric springs in Italy, and grows at 80°C and pH of 2-4. Since its initial characterization by Wolfram Zillig, a pioneer in thermophile and archaeon research, similar species in the same genus have been found around the world. Unlike the vast majority of cultured thermophiles, *Sulfolobus* grows aerobically and chemoorganotrophically (gaining its energy from organic sources such as sugars). These factors allow a much easier growth than anaerobic organisms and have led to Sulfolobus becoming a model organism for the study of hyperthermophiles and a large group of diverse viruses that replicate within them.

Cystovirus : *Cystovirus* is a genus of dsRNA virus, which infect certain Gram negative bacteria. All cystoviruses are distinguished by their three strands (analogous to chromosomes) of dsRNA, totalling ~14 kb in length and their protein and lipid outer layer. No other bacteriophage have any lipid in their outer coat, though the

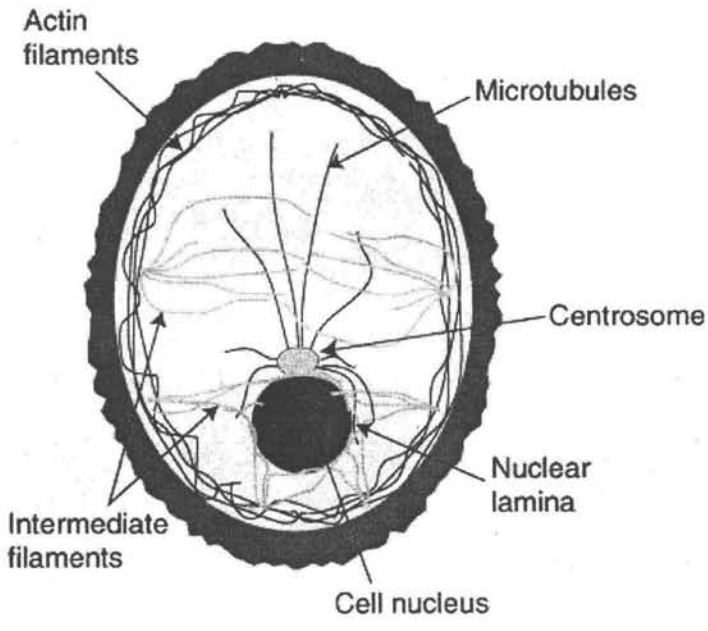
Tectiviridae and the *Corticoviridae* have lipids within their capsids. Most identified cystoviruses infect *Pseudomonas* species, but this is likely biased due to the method of screening and enrichment . The type species is *Pseudomonas phage F6*, but there are many other members of this family. F7, F8, F9, F10, F11, F12 and F13 have been identified and named , but other cystoviruses have also been isolated.



Structure of Cystovirus

Members of the *Cystoviridae* appear to be most closely related to the *Reoviridae*, but also share homology with the *Totiviridae*. Cystoviruses are the only bacteriophage that are more closely related to viruses of eukaryotes than to other phage.

Cytoskeleton (CSK) : It is a cellular "scaffolding" or "skeleton" contained within the cytoplasm. The cytoskeleton is present in all cells; it was once thought this structure was unique to eukaryotes, but recent research has identified the prokaryotic cytoskeleton. It is a dynamic structure that maintains cell shape, protects the cell, enables cellular motion (using structures such as flagella, cilia and lamellipodia), and plays important roles in both intracellular transport (the movement of vesicles and organelles, for example) and cellular division. The concept and the term (*cytosquelette*, in French) was first introduced by French embryologist Paul Wintrebert in 1931.



Cytoskeleton

Cytotoxic T cell (Killer T Cell) : It belongs to a sub-group of T lymphocytes (a type of white blood cell) that are capable of inducing the death of infected somatic or tumor cells; they kill cells that are infected with viruses (or other pathogens), or are otherwise damaged or dysfunctional.

Most cytotoxic T cells express T-cell receptors (TCRs) that can recognize a specific antigenic peptide bound to Class I MHC molecules, present on all nucleated cells, and a glycoprotein called CD8, which is attracted to non-variable portions of the Class I MHC molecule. The affinity between CD8 and the MHC molecule keeps the TC cell and the target cell bound closely together during antigen-specific activation. CD8+ T cells are recognized as TC cells once they become activated and are generally classified as having a pre-defined cytotoxic role within the immune system.

D

Decomposers : Decomposers (or saprotrophs) are organisms that consume dead or decaying organisms, and, in doing so, carry out the natural process of decomposition. Like herbivores and predators, decomposers are heterotrophic, meaning that they use organic substrates to get their energy, carbon and nutrients for growth and development. Decomposers use deceased organisms and non-living organic compounds as their food source. The primary decomposers are bacteria and fungi.

Bacteria are the primary decomposers of dead animals (carrion) and are the primary decomposers of dead plant matter (litter) in some ecosystems. In soils, active fungal hyphae and bacteria are much more important in the recycling of nutrients. Bacteria can also be very important in agricultural fields, because tillage usually increases the abundance of bacteria relative to fungi.

Fungi are the primary decomposers of litter in many ecosystems. Unlike bacteria, which are unicellular, most saprotrophic fungi grow as a branching network of hyphae. While bacteria are restricted to growing and feeding on the exposed surfaces of organic matter, fungi can use their hyphae to penetrate larger pieces of organic matter. Additionally, only fungi have evolved the enzymes necessary to decompose lignin, a chemically complex substance found in wood. These two factors make fungi the primary decomposers in forests, where litter has high concentrations of lignin and often occurs in large pieces.

Some animals, like millipedes, woodlice, and various worms are commonly called decomposers, because such animals consume dead organic matter and contribute to the process of decomposition. Scientists, however, refer to such organisms as detritivores. This distinction is made because bacteria and fungi are capable of digesting many complex chemical molecules that animals are incapable of digesting. Additionally, bacteria and fungi digest and decompose organic matter more fully than detritivores, reducing it to inorganic material. For these reasons, bacteria and fungi play a more fundamental role in the processes of decomposition and nutrient recycling than animals.

Decomposition : Decomposition refers to the process by which tissues of dead organisms break down into simpler forms of matter. Such a breakdown of dead organisms is essential for new growth and development of living organisms because it recycles the finite chemical constituents and frees up the limited physical space in the biome. Bodies of living organisms begin to decompose shortly after death. It is a cascade of processes that go through distinct phases. It may be categorized in two stages by the types of end products. The first stage is limited to the production of vapors. The second stage is characterized by the formation of liquid materials; flesh or plant matter begin to decompose. The science which studies such decomposition generally is called *taphonomy* from the Greek word *taphos*—which means grave. Besides the two stages mentioned above, historically the progression of decomposition of the flesh of dead organisms has been viewed also as four phases : (1) fresh (autolysis), (2) bloat (putrefaction), (3) decay (putrefaction and carnivores) and (4) dry (diagenesis).

Densovirus : Densovirus belongs to the Densovirinae subfamily which belongs to the Parvoviridae family. The viruses of this genus are single-stranded DNA viruses (and are thus group II viruses under the Baltimore classification). The viruses of this genus are invertebrate viruses, only known to infect insects. Examples of species classified into this genus include Aedes albopictus densovirus, Galleria mellonella densovirus, and Junonia coenia densovirus. These virions consist of non-enveloped capsids that have a round appearance and display icosahedral symmetry. The virions each have an isometric (and therefore spherical) nucleocapsid with a diameter of either 18-22 nm or 20-26 nm. Sixty *capsomers* are present in a capsid. The structure of each capsomer is described as "a quadrilateral 'kite-shaped' wedge"; the surface is said to have a rough appearance with small projections. The centre of capsids are sometimes visualised as appearing dark due to stain penetration in preparations where only a single species is retrieved. The virions do not appear to contain lipids. The buoyant density (in CsCl) of the virions is 1.4-1.44 g cm^{-3}.

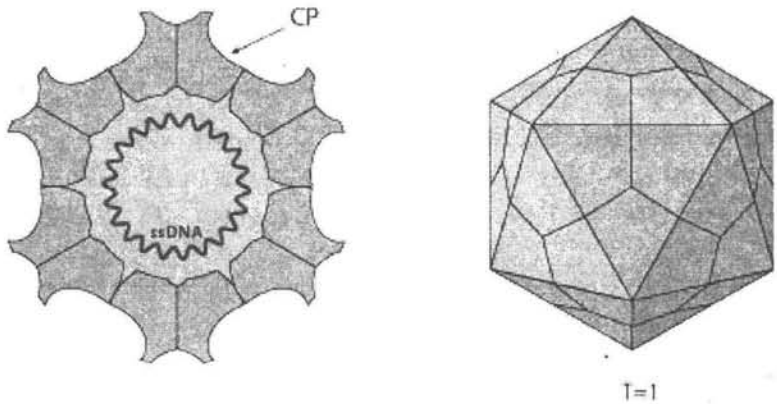
Deoxyribonucleic acid (DNA) : DNA is a nucleic acid that contains the genetic instructions used in the development and functioning of all known living organisms and some viruses. The main role of DNA molecules is the long-term storage of information. DNA is often compared to a set of blueprints or a recipe, or a code, since it contains the instructions needed to construct other components of cells, such as proteins and RNA molecules. The DNA segments that carry this genetic information are called genes, but other DNA sequences have structural purposes, or are involved in regulating the use of this genetic information.

Chemically, DNA consists of two long polymers of simple units called nucleotides, with backbones made of sugars and phosphate groups joined by ester bonds.

These two strands run in opposite directions to each other and are therefore anti-parallel. Attached to each sugar is one of four types of molecules called bases. It is the sequence of these four bases along the backbone that encodes information. This information is read using the genetic code, which specifies the sequence of the amino acids within proteins. The code is read by copying stretches of DNA into the related nucleic acid RNA, in a process called transcription.

Within cells, DNA is organized into structures called chromosomes. These chromosomes are duplicated before cells divide, in a process called DNA replication. Eukaryotic organisms (animals, plants, fungi, and protists) store most of their DNA inside the cell nucleus and some of their DNA in the mitochondria. Prokaryotes (bacteria and archaea) however, store their DNA in the cell's cytoplasm. Within the chromosomes, chromatin proteins such as histones compact and organize DNA. These compact structures guide the interactions between DNA and other proteins, helping control which parts of the DNA are transcribed.

Dianthovirus : Dianthovirus belong to the family Tombusviridae. Dianthoviruses are plant viruses. Examples of species of this genus include Carnation ringspot virus, Red clover necrotic mosaic virus and Sweet clover necrotic mosaic virus. The virus probably has a worldwide distribution. The viruses can be (and have been) transmitted via nematodes, by mechanical inoculation, by grafting of plants and by contact between infected hosts with previously uninfected host.



Structure of Dianthovirus

Viruses of this genus have round, non-enveloped capsids with icosahedral symmetry and a "hexagonal" appearance. The capsid is 31-35 nm in diameter. The buoyant density in CsCl of virions is between 1.363-1.366 g cm^{-3}. They have a

sedimentation coefficient of 126-132-135 S20w (1). The pH of their isoelectric point is 4.5. The virions become inactive from about 80-90°C and are inactive above those temperatures. They are viable in vitro for about 50-70 days. Treatment with ether either decreases or does not alter their infectivity. No lipids have so far been reported.

Diphtheria : Diphtheria is an upper respiratory tract illness characterized by sore throat, low fever, and an adherent membrane (a *pseudomembrane*) on the tonsils, pharynx, and/or nasal cavity. A milder form of diphtheria can be restricted to the skin. It is caused by *Corynebacterium diphtheriae,* an aerobic Gram-positive bacterium.

Diphtheria causes the progressive deterioration of myelin sheaths in the central and peripheral nervous system leading to degenerating motor control and loss of sensation. Diphtheria is a contagious disease spread by direct physical contact or breathing the aerosolized secretions of infected individuals. Historically quite common, diphtheria has largely been eradicated in industrialized nations through widespread vaccination. In the United States for example, there were 52 reported cases of diphtheria between 1980 and 2000; between 2000 and 2007 there were only five cases as the DPT (*Diphtheria–Pertussis–Tetanus*) vaccine is given to all school children. Boosters of the vaccine are recommended for adults since the benefits of the vaccine decrease with age without constant re-exposure; they are particularly recommended for those traveling to areas where the disease has not been eradicated.

Disease : Disease or medical condition is an abnormal condition of an organism that impairs bodily functions, associated with specific symptoms and signs. It may be caused by external factors, such as invading organisms, or it may be caused by internal dysfunctions, such as autoimmune diseases.

In human beings, "disease" is often used more broadly to refer to any condition that causes extreme pain, dysfunction, distress, social problems, and/or death to the person afflicted, or similar problems for those in contact with the person. In this broader sense, it sometimes includes injuries, disabilities, disorders, syndromes, infections, isolated symptoms, deviant behaviors, and atypical variations of structure and function, while in other contexts and for other purposes these may be considered distinguishable categories.

Some diseases such as influenza are contagious and infectious. The micro-organisms that cause these diseases are known as pathogens and include varieties of bacteria, viruses, protozoa and fungi. Infectious diseases can be transmitted by as, by hand to mouth contact with infectious material on surfaces, by bites of insects or other carriers of the disease, and from contaminated water or food (often via faecal contamination), etc. In addition, there are sexually transmitted diseases.

In some cases, micro-organisms that are not readily spread from person to person play a role, while other diseases can be prevented or ameliorated with appropriate nutrition or other lifestyle changes. Some diseases such as cancer, heart disease and mental disorders are in most cases, not considered to be caused by infection, although there are important exceptions. Many diseases (including some cancers, heart disease and mental disorders) have a partially or completely genetic basis and may thus be transmitted from one generation to another.

Dust mite : The house dust mite (sometimes referred to by allergists as HDM), is a cosmopolitan guest in human habitation. Dust mites feed on organic detritus such as flakes of shed human skin and flourish in the stable environment of dwellings. House dust mites are a common cause of asthma and allergic symptoms worldwide. Some of the gut enzymes (notably proteases) produced by the house mite persist in their fecal matter, and can be strongly allergenic. The European house dust mite (*Dermatophagoides pteronyssinus*) and the American house dust mite (*Dermatophagoides farinae*) are two different species, but are not necessarily confined to Europe or North America; a third species *Euroglyphus maynei* also occurs widely.

Dust mite

The body of a house dust mite is just visible against a dark background in normal light. A typical house dust mite measures 420 micrometers in length and 250 to 320 micrometers in width. Both male and female adult house dust mites are creamy blue and have a rectangular shape. The body of the house dust mite also contains a striated cuticle. Like all acari, house dust mites have eight legs (except 3 pairs in the first instar). Dust mites can be transported airborne by minor air currents generated from normal household activities.

The average life cycle for a male house dust mite is 10 to 19 days. A mated female house dust mite can live for 70 days, laying 60 to 100 eggs in the last 5 weeks of her life. In a 10 week life span, a house dust mite will produce approximately 2000 fecal particles and an even larger number of partially digested enzyme-covered dust particles. A simple washing will remove most of the waste matter. Both being exposed to temperatures of over 60 degrees Celsius (140 degrees Fahrenheit) for a period of one hour, freezing, or exposure to temperatures below 20°C (68°F], will typically prove fatal to house dust mites; a relative humidity less than 50 may also be fatal. Ten minutes in a household clothes dryer at lethal temperatures has been shown to be sufficient to kill all the dust mites in bedding. House dust mites reproduce quickly enough that their effect on human health can be significant.

E

Eagle phenomenon : Eagle phenomenon refers to an observation of an increase in survivors, seen when testing the activity of an antimicrobial agent. Initially when an antibiotic agent is added to a culture media, the number of bacteria that survive drops, as you would expect. But after increasing the concentration beyond a certain point, the number of bacteria that survive, paradoxically, increases.

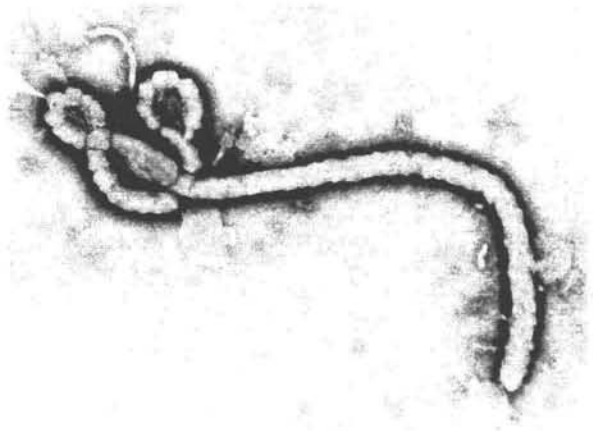
One of the explanations could be that as the concentration is too high, the agent might be self-antagonising the receptor with which it binds. (Penicillin binding proteins, for example, in the case of a penicillin.) This self antagonism, is only a possible explanation for the phenomenon. Another explanation could be that the antimicrobial agent precipitates out of solution, so activity is either not seen, or that the colorimeter is detecting crystals of antimicrobial.

Another example is in the area of drugs and reactions or effects totally contrary to the expected result. For example, there are serious complications occurring in conjunction with the use of sedatives creating a series of effects in some people, that create the total opposite effects as those expected. Malcolm Lader at the Institute of Psychiatry in London estimates the incidence of these adverse reactions at about 5%, even in short-term use of the drugs. The paradoxical reactions may consist of depression, with or without suicidal tendencies, phobias, aggressiveness, violent behavior and symptoms sometimes misdiagnosed as psychosis.

Ebola : Ebola is the common term for a group of viruses belonging to genus *Ebolavirus* (EBOV), which is a part of the family *Filoviridae*, and for the disease that they cause, Ebola hemorrhagic fever. The virus is named after the Ebola River, where the first recognized outbreak of Ebola hemorrhagic fever occurred. The viruses are characterized by long filaments, and have a shape similar to that of the Marburg virus, also in the family *Filoviridae*, and possessing similar disease symptoms.

There are a number of species within the ebolavirus genus, which in turn have a number of specific strains or serotypes. The *Zaïre virus* is the type species, which is also the first discovered and the most lethal. Ebola is transmitted primarily

through bodily fluids and to a limited extent through skin and mucous membrane contact. The virus interferes with the endothelial cells lining the interior surface of blood vessels and platelet cells. As the blood vessel walls become damaged and the platelets are unable to coagulate, patients succumb to hypovolemic shock.



Ebola

Ebola first emerged in 1976 in Zaire. It remained largely obscure until 1989 with the outbreak in Reston, Virginia.

Embryophytes : The embryophytes are the most familiar group of plants. They include trees, flowers, ferns, mosses, and various other green land plants. All are complex multicellular eukaryotes with specialized reproductive organs. With very few exceptions, embryophytes obtain their energy through photosynthesis (that is, by absorbing light); and they synthesize their food from carbon dioxide. Embryophyta may be distinguished from chlorophyll-using multicellular algae by having sterile tissue within the reproductive organs. Furthermore, embryophytes are primarily adapted for life on land, although some are secondarily aquatic. Accordingly, they are often called land plants or terrestrial plants.

Embryophytes developed from complex green algae (Chlorophyta) during the Paleozoic era. The Charales or stoneworts appear to be the best living illustration of that developmental step. These alga-like plants undergo an alternation between haploid and diploid generations (respectively called gametophytes and sporophytes). In the first embryophytes, however, the sporophytes became very different in structure and function, remaining small and dependent on the parent for their entire brief life. Such plants are informally called 'bryophytes'.

Embryophytes

On a microscopic level, embryophyte cells remain very similar to those of green algae. They are eukaryotic, with a cell wall composed of cellulose and plastids surrounded by two membranes. These usually take the form of chloroplasts, which conduct photosynthesis and store food in the form of starch, and characteristically are pigmented with chlorophylls *a* and *b*, generally giving them a bright green color. Embryophytes also generally have an enlarged central vacuole or tonoplast, which maintains cell turgor and keeps the plant rigid. They lack flagella and centrioles except in certain gametes.

Emergent virus : It is a virus that has adapted and emerged as a new disease/pathogenic strain, with attributes facilitating pathogenicity in a field not normally associated with that virus. This includes viruses that are the cause of a disease which has notably increased in incidence; this is often a result of a wide variety of causes from both the influence of man and nature. Most emergent viruses can be categorized as zoonotic (an animal disease that can be transmitted to humans), this has the advantage of possibly having several natural reservoirs for the disease.

The most important factor in the development of an emergent disease, to humans, is the ability to pass from animal host to humans. There is little to no occurrence

of spontaneous new virus species development, although the possible exception commonly cited is Ebola virus. Most often the virus, due to selection pressure for an animal version of the strain of disease to mutate and therefore adapt to the infection of human hosts.

Endolith : Endolith is an organism (archaeum, bacterium, fungus, lichen, alga or amoeba) that lives inside rock, coral, animal shells, or in the pores between mineral grains of a rock. Many are extremophiles; living in places previously thought inhospitable to life. They are of particular interest to astrobiologists, who theorize that endolithic environments on Mars and other planets constitute potential refugia for extraterrestrial microbial communities.

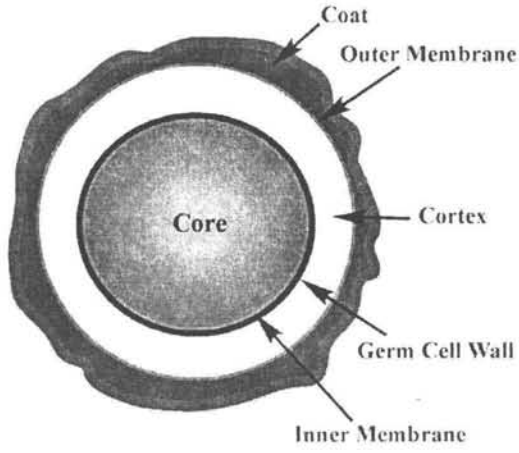
Endoliths have been found in rock down to a depth of 3 km (9,600 feet), though it is unknown if that is their limit (due to the cost involved in digging so deeply). The main threat to their survival seems not to result from the pressure at such depth, but from the increased temperature. Judging from hyperthermophile organisms, the temperature limit is at about 120°C (the recently-discovered Strain 121 can reproduce at 121°C), which limits the possible depth to 4-4.5 km below the continental crust, and 7 or 7.5 km below the ocean floor. Endolithic organisms have also been found in surface rocks in regions of low humidity (hypolith) and low temperature (psychrophile), including the Dry Valleys and permafrost of Antarctica.

Endophyte : It is an endosymbiont, often a bacterium or fungus, that lives within a plant for at least part of its life without causing apparent disease. Endophytes are ubiquitous and have been found in all the species of plants studied to date; however, most of these endophyte/plant relationships are not well understood. Many economically important forage and turfgrasses (e.g., *Festuca* spp., *Lolium* spp.) are infected with fungal endophytes (*Neotyphodium* spp.) which may improve the ability of these grasses to tolerate abiotic stresses such as drought, as well as improve their resistance to insect and mammalian herbivores.

Endophytes may be transmitted either vertically (directly from parent to offspring) or horizontally (from individual to unrelated individual). Vertically transmitted fungal endophytes are asexual and transmit via fungal hyphae penetrating the host's seeds (e.g. *Neotyphodium*). Since their reproductive fitness is intimately tied to that of their host plant, these fungi are often mutualistic. Conversely, horizontally transmitted fungal endophytes are sexual and transmit via spores that can be spread by wind and/or insect vectors. Since they spread in a similar way to pathogens, horizontally transmitted endophytes are often closely related to pathogenic fungi, though they are not pathogenic themselves.

Endospore : An endospore is a dormant, tough, and non-reproductive structure produced by bacteria from the Firmicute phylum which forms when a bacterium

produces a thick internal wall that encloses its DNA and part of its cytoplasm. Examples include *Bacillus* and *Clostridium*. The primary function of most endospores is to ensure the survival of a bacterium through periods of environmental stress. They are therefore resistant to ultraviolet and gamma radiation, desiccation, lysozyme, temperature, starvation, and chemical disinfectants. Endospores are commonly found in soil and water, where they may survive for long periods of time. Some bacteria produce exospores or cysts instead.



Structure of endospore

In contrast to eukaryotic spores, which are produced by many eukaryotes for reproductive purposes, bacteria will produce a single endospore internally. The spore is often surrounded by a thin covering known as the *exosporium*, which overlies the *spore coat*. The spore coat is impermeable to many toxic molecules and may also contain enzymes that are involved in germination. The *cortex* lies beneath the spore coat and consists of peptidoglycan. The *core wall* lies beneath the cortex and surrounds the protoplast or *core* of the endospore. The core has normal cell structures, such as DNA and ribosomes, but is metabolically inactive. Up to 15% of the dry weight of the endospore consists of calcium dipicolinate within the core, which is thought to stabilize the DNA. Dipicolinic acid could be responsible for the heat resistance of the spore, and calcium may aid in resistance to heat and oxidizing agents. However, mutants resistant to heat but lacking dipicolinic acid have been isolated, suggesting other mechanisms contributing to heat resistance are at work.

Endosymbiont : It is any organism that lives within the body or cells of another organism, i.e. forming an endosymbiosis. Examples are nitrogen-fixing bacteria

(called rhizobia) which live in root nodules on legume roots, single-celled algae inside reef-building corals, and bacterial endosymbionts that provide essential nutrients to about 10%–15% of insects. Many instances of endosymbiosis are obligate, that is either the endosymbiont or the host cannot survive without the other, such as the gutless marine worms of the genus *Riftia*, which get nutrition from their endosymbiotic bacteria. The most common examples of obligate endosymbiosis are mitochondria and chloroplasts. However, not all endosymbioses are obligate. Also, some endosymbioses can be harmful to either of the organisms involved.

Enrichment culture : It is a medium with specific and known qualities that favors the growth of a particular microorganism. The enrichment culture's environment will support the growth of a selected microorganism, while inhibiting the growth of others. Lourens Bass-Becking succinctly summarized enrichment cultures' abilities when he said "everything is everywhere; the environment selects." The botanist Martinus Beijerinck is credited with developing the first enrichment cultures. Sergei Winogradsky also experimented on bacteria using different cultures.

Enterotoxin : It is a protein toxin released by a microorganism in the intestine. Enterotoxins are chromosomally encoded exotoxins that are produced and secreted from several bacterial organisms. They are often heat stable, of low molecular weight and are water-soluble. Enterotoxins are frequently cytotoxic and kill cells by altering the apical membrane permeability of the mucosal (epithelial) cells of the intestinal wall. They are mostly pore forming toxins (mostly chloride pores), secreted by bacteria, that assemble to form pores in cell membranes. This causes the cells to die.

The action of enterotoxins leads to increased chloride ion permeability of the apical membrane of intestinal mucosal cells. These membrane pores are activated by either increased cAMP or by increased calcium ion concentration intracellularly. The pore formation has a direct effect on the osmolarity of the luminal contents of the intestines. Increased chloride permeability leads to leakage into the lumen followed by sodium and water movement. This leads to a secretory diarrhea within a few hours of ingesting enterotoxin. Several microbial organisms contain the necessary enterotoxin to create such an effect, such as Staphylococcus aureus or E. coli.

Enterotube II : The Enterotube II is an example of a rapid, multi test system used in identification of unknown oxidase- negative, gram- negative, rod shaped bacteria of the family *Enterobacteriaceae*. It consists of a tube with a flat side and contains 12 compartments for different biochemical tests. Although the manufacturer is continuously improving the accuracy of this system, it is worth noting that this system may sometimes yield false results. The Enterotube II is used by first

removing the caps from both ends to expose the inoculation wire. The wire is sterile and need not be flamed. The Enterotube II is inoculated by touching the wire to a well isolated colony from a Petri plate. The wire is pulled and rotated from the other end to inoculate all the compartments and pushed all the way back in to reinoculate the compartments. The wire is then pulled until it reaches the indole compartment and is broken off using a pair of pliers. The perforation on the aerobic compartments must be punctured using a flamed inoculation needle or a similar device. The tube is finally recapped and incubated at 37 degrees Celsius for 24 hours.

Epidemic : An epidemic occurs when new cases of a certain disease occur in a given human population, during a given period, substantially exceed what is "expected," based on recent experience (the number of new cases in the population during a specified period of time is called the "incidence rate"). (An epizootic is the analogous circumstance within an animal population.) In recent usages, the disease is not required to be communicable; examples include cancer or heart disease.

Defining an epidemic can be subjective, depending in part on what is "expected". An epidemic may be restricted to one locale (an outbreak), more general (an "epidemic") or even global (pandemic). Because it is based on what is "expected" or thought normal, a few cases of a very rare disease may be classified as an "epidemic," while many cases of a common disease (such as the common cold) would not.

Common diseases that occur at a constant but relatively low rate in the population are said to be "endemic." An example of an endemic disease is malaria in some parts of Africa (for example, Liberia) in which a large portion of the population is expected to get malaria at some point in their lifetime.

The term "epidemic" is often used in a sense to refer to widespread and growing societal problems, for example, in discussions of obesity or drug addiction. It can also be used metaphorically to relate a type of problem like those mentioned above.

Epsilonproteobacteria : Epsilonproteobacteria is a class of Proteobacteria. The *Epsilonproteobacteria* consist few known genera, mainly the curved to spirilloid *Wolinella* spp., *Helicobacter* spp., and *Campylobacter* spp. Most of the known species inhabit the digestive tract of animals and serve as symbionts (*Wolinella* spp. in cows) or pathogens (*Helicobacter* spp. in the stomach, *Campylobacter* spp. in the duodenum). There have also been numerous environmental sequences of *Epsilonproteobacteria* recovered from hydrothermal vents and cold seep habitats.

Error threshold : It is a concept in the study of evolutionary biology and population genetics and is concerned with the origins of life, in particular of very early life, before the advent of DNA. The first self-replicating molecules were probably small

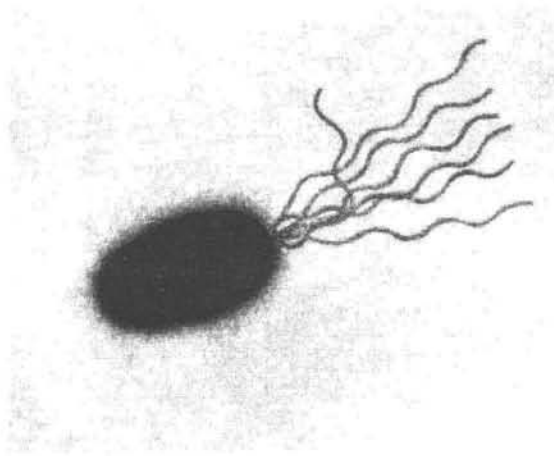
ribozyme-like RNA molecules. These molecules consist of strings of base pairs or "digits", and their order is a code that directs how the molecule interacts with its environment. All replication is subject to mutation error. During the replication process, each digit has a certain probability of being replaced by some other digit, which changes the way the molecule interacts with its environment, and may increase or decrease its fitness, or ability to reproduce, in that environment.

It was noted by Manfred Eigen in his 1971 paper (Eigen 1971) that this mutation process places a limit on the number of digits a molecule may have. If a molecule exceeds this critical size, the effect of the mutations become overwhelming and a runaway mutation process will destroy the information in subsequent generations of the molecule. The error threshold is also controlled by the fitness landscape for the molecules. Molecules which differ only by a few mutations may be thought of as "close" to each other, while those which differ by many mutations are distant from each other. Molecules which are very fit, and likely to reproduce, have a "high" fitness, those less fit have "low" fitness. These ideas of proximity and height form the intuitive concept of the "fitness landscape". If a particular sequence and its neighbors have a high fitness, they will form a quasispecies and will be able to support longer sequence lengths than a fit sequence with few fit neighbors, or a less fit neighborhood of sequences.

Escherichia coli (E. coli) : It is a Gram negative bacterium that is commonly found in the lower intestine of warm-blooded organisms (endotherms). Most *E. coli* strains are harmless, but some, such as serotype O_{157} :H_7, can cause serious food poisoning in humans, and are occasionally responsible for costly product recalls. The harmless strains are part of the normal flora of the gut, and can benefit their hosts by producing vitamin K_2, or by preventing the establishment of pathogenic bacteria within the intestine.

E. coli are not always confined to the intestine, and their ability to survive for brief periods outside the body makes them an ideal indicator organism to test environmental samples for fecal contamination. The bacteria can also be grown easily and its genetics are comparatively simple and easily-manipulated or duplicated through a process of metagenics, making it one of the best-studied prokaryotic model organisms, and an important species in biotechnology and microbiology. *E. coli* was discovered by German pediatrician and bacteriologist Theodor Escherich in 1885, and is now classified as part of the Enterobacteriaceae family of gamma-proteobacteria. A strain of *E. coli* is a sub-group within the species that has unique characteristics that distinguish it from other *E. coli* strains. These differences are often detectable only on the molecular level; however, they may result in changes to the physiology or lifecycle of the bacterium. For example, a strain may gain pathogenic capacity, the ability to use a unique carbon source, the ability to inhabit a particular ecological niche or the ability to resist

antimicrobial agents. Different strains of *E. coli* are often host-specific, making it possible to determine the source of fecal contamination in environmental samples. For example, knowing which *E. coli* strains are present in a water sample allows to make assumptions about whether the contamination originated from a human, another mammal or a bird.



E. coli

New strains of *E. coli* evolve through the natural biological process of mutation, and some strains develop traits that can be harmful to a host animal. Although virulent strains typically cause no more than a bout of diarrhea in healthy adult humans, particularly virulent strains, such as O_{157} :H_7 or O_{111} :B_4

E-test : The Epsilometer test is a laboratory test used by microbiologists to determine whether or not a specific strain of bacterium or fungus is susceptible to the action of a specific antibiotic. This is most commonly used in the setting of medicine, where a particular organism has been found to infect a patient, and the doctor treating the patient is seeking guidance on what antibiotic is suitable. The Etest is basically an agar diffusion method. It utilises a rectangular strip that has been impregnated with the drug to be studied. A lawn of bacteria is inoculated onto the surface an agar plate and the Etest strip is laid on top; the drug diffuses out into the agar, producing an exponential gradient of the drug to be tested. There is an exponential scale printed on the strip. After 24 hours of incubation, an elliptical zone of inhibition is produced and point at which the ellipse meets the strip gives a reading for the minimum inhibitory concentration (MIC) of the drug.

Ethanol fermentation : It is the biological process by which sugars such as glucose, fructose, and sucrose are converted into cellular energy and thereby produce

ethanol and carbon dioxide as metabolic waste products. Yeasts carry out ethanol fermentation on sugars in the absence of oxygen. Because the process does not require oxygen, ethanol fermentation is classified as anaerobic. Ethanol fermentation is responsible for the rising of bread dough, the production of ethanol in alcoholic beverages, and for much of the production of ethanol for use as fuel.

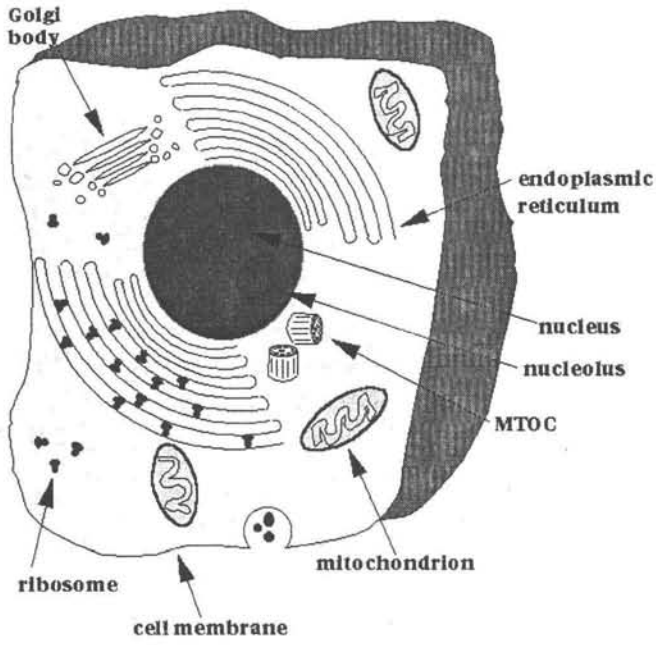
Ethanol fermentation is responsible for the rising of bread dough. Yeast organisms consume sugars in the dough and produce ethanol and carbon dioxide as waste products. The carbon dioxide forms bubbles in the dough, expanding it into something of a foam. Nearly all the ethanol evaporates from the dough when the bread is baked.

The production of all alcoholic beverages, except those produced by carbonic maceration, employs ethanol fermentation by yeast. Wines and brandies are produced by fermentation of the natural sugars present in fruits, especially grapes. Beers, ales, and whiskeys employ fermentation of grain starches that have been converted to sugar by the application of the enzyme, amylase, which is present in grain kernels that have been germinated. Amylase-treated grain or amylase-treated potatoes are fermented for the production of vodka. Fermentation of cane sugar is the first step in producing rum. In all cases, the fermentation must take place in a vessel that is arranged to allow carbon dioxide to escape, but that prevents outside air from coming in, as exposure to oxygen would prevent the formation of ethanol.

Eukaryote : A eukaryote is an organism whose cells are organized into complex structures enclosed within membranes. Most living organisms, including all animals, plants, fungi, and protists, are eukaryotes. The defining membrane-bound structure that differentiates eukaryotic cells from prokaryotic cells is the nucleus. Cell division in eukaryotes is different from organisms without a nucleus (prokaryotes). It involves separating the duplicated chromosomes, through movements directed by microtubules. There are two types of division processes. In mitosis, one cell divides to produce two genetically identical cells. In meiosis, which is required in sexual reproduction, one diploid cell (having two instances of each chromosome, one from each parent) undergoes recombination of each pair of parental chromosomes, and then two stages of cell division, resulting in four haploid cells (gametes). Each gamete has just one complement of chromosomes, each a unique mix of the corresponding pair of parental chromosomes.

Eukaryotes appear to be monophyletic, and so make up one of the three domains of life. The two other domains, bacteria and archaea, are prokaryotes, and have none of the above features. Eukaryotic cells are typically much larger than prokaryotes. They have a variety of internal membranes and structures, called organelles, and a cytoskeleton composed of microtubules, microfilaments, and intermediate filaments, which play an important role in defining the cell's

organization and shape. Eukaryotic DNA is divided into several linear bundles called chromosomes, which are separated by a microtubular spindle during nuclear division.



Eukaryotic cells

Eukaryotic cells include a variety of membrane-bound structures, collectively referred to as the endomembrane system. Simple compartments, called vesicles or vacuoles, can form by budding off other membranes. Many cells ingest food and other materials through a process of endocytosis, where the outer membrane invaginates and then pinches off to form a vesicle. It is probable that most other membrane-bound organelles are ultimately derived from such vesicles. The nucleus is surrounded by a double membrane (commonly referred to as a nuclear envelope), with pores that allow material to move in and out. Various tube- and sheet-like extensions of the nuclear membrane form what is called the endoplasmic reticulum or ER, which is involved in protein transport and maturation. It includes the rough ER where ribosomes are attached, and the proteins they synthesize enter the interior space or lumen. Subsequently, they generally enter vesicles, which bud off from the smooth ER. In most eukaryotes, these protein-carrying vesicles are released and further modified in stacks of flattened vesicles, called Golgi bodies or dictyosomes.

Exotoxin : An exotoxin is a toxin excreted by a microrganism, including bacteria, fungi, algae, and protozoa. An exotoxin can cause damage to the host by destroying cells or disrupting normal cellular metabolism. They are highly potent and can cause major damage to the host. Exotoxins may be secreted, or, similar to endotoxins, may be released during lysis of the cell.

Most exotoxins can be destroyed by heating. They may exert their effect locally or produce systemic effects. Well known exotoxins include the botulinum toxin produced by Clostridium botulinum, the Corynebacterium diphtheriae exotoxin which is produced during life threatening symptoms of diphtheria. Exotoxins are susceptible to antibodies produced by the immune system, but many exotoxins are so toxic that they may be fatal to the host before the immune system has a chance to mount defenses against it.

Extremophile : An extremophile is an organism that thrives in and even may require physically or geochemically extreme conditions that are detrimental to the majority of life on Earth. In contrast, organisms from moderate or neutral (often referring to pH) environments are termed neutrophiles. Most known extremophiles are microbes. The domain Archaea contains renowned examples, but extremophiles are present in numerous and diverse genetic lineages of both bacteria and archaeans. Furthermore, it is erroneous to use the term extremophile to encompass all archaeans, as some are mesophilic. Neither are all extremophiles unicellular; protostome animals found in similar environments include the Pompeii worm, the psychrophilic Grylloblattodea (insects), Antarctic krill (a crustacean), and the "water bear". There are many different classes of extremophiles, each corresponding to the way its environmental niche differs from mesophilic conditions. These classifications are not exclusive. Many extremophiles fall under multiple categories. For example, organisms living inside hot rocks deep under Earth's surface are both thermophilic and barophilic.

Eyespot apparatus : A photoreceptive organelle found in the flagellate (motile) cells of green algae and other unicellular photosynthetic organisms such as euglenids. It allows the cells to sense light direction and intensity and respond to it by swimming either towards the light (positive phototaxis) or away from the light (negative phototaxis). A related response ("photoshock" or photophobic response) occurs when cells are briefly exposed to high light intensity, causing the cell to stop, briefly swim backwards, then change swimming direction. Eyespot-mediated light perception helps the cells in finding an environment with optimal light conditions for photosynthesis. Eyespots are the simplest and most common "eyes" found in nature, composed of photoreceptors and areas of bright orange-red pigment granules. Signals relayed from the eyespot photoreceptors result in alteration the beating pattern of the flagella, generating a phototactic response.

F

Fecal coliforms : These are facultatively-anaerobic, rod-shaped, gram-negative, non-sporulating bacteria. They are capable of growth in the presence of bile salts or similar surface agents, oxidase negative, and produce acid and gas from lactose within 48 hours at 44 ± 0.5ºC. Fecal coliforms include the genera that originate in feces; *Escherichia* as well as genera that are not of fecal origin; *Enterobacter*, *Klebsiella*, and *Citrobacter*. The assay is intended to be an indicator of fecal contamination, or more specifically *E. coli* which is an indicator microorganism for other pathogens that may be present in feces. As recently as April 2006, many official websites including that of the Environmental Protection Agency failed to address the fact that presence of fecal coliforms does not necessarily indicate the presence of feces, as well as not being directly harmful.

Feline immunodeficiency virus (FIV) : It is a lentivirus that affects domesticated housecats worldwide and is the causative agent of feline AIDS. Approximately 11% of cats worldwide, and about 2.5% of cats in the USA, are infected with FIV. FIV differs taxonomically from two other feline retroviruses, feline leukemia virus (FeLV) and feline foamy virus (FFV) and is more closely related to human immunodeficiency virus HIV. Within FIV, five subtypes have been identified based on amino acid sequence differences coding for the viral envelope. FIV is the only non-primate lentivirus to cause an AIDS-like syndrome, but FIV is not always a death sentence for cats, as they can live relatively healthily as carriers and transmitters of the disease for many years. A vaccine is available although its efficacy remains uncertain, and cats will test positive for FIV antibodies after vaccination. FIV was first discovered in 1986 in a colony of cats that had a high prevalence of opportunistic infections and degenerative conditions, and has since been identified as an endemic disease in domestic cat populations worldwide .

Feline leukemia virus (FeLV) : It is a retrovirus that infects cats. As a retrovirus, the genetic information of FeLV is carried by RNA instead of DNA. FeLV is usually transmitted between infected cats when the transfer of saliva or nasal secretions is involved, for example when sharing a feeding dish. If not defeated by the

animal's immune system, the virus can be lethal. The disease is a virus, not a cancer. The name stems from the fact that the first disease associated with the virus was a form of leukemia. By the time it was discovered that the virus was not the same as leukemia, the misnomer had already found its way into the vocabulary of pet owners.

Ferdinand Julius Cohn : He was a German biologist. Cohn was born in Breslau (Wroclaw) in the Prussian Province of Silesia. At the age of 10 he suffered hearing impairment. He received a degree in botany in 1847 at the age of nineteen at the University of Berlin. He was a teacher and researcher at University of Breslau for his entire career. In the 1850s he mostly studied algae. In the 1860s he studied plant physiology in several different aspects. From 1870 onward he mostly studied bacteria. He published over 150 research reports during his lifetime. The University of Breslau became an innovative center for plant physiology and microbiology while he was there.

Ferdinand Julius Cohn

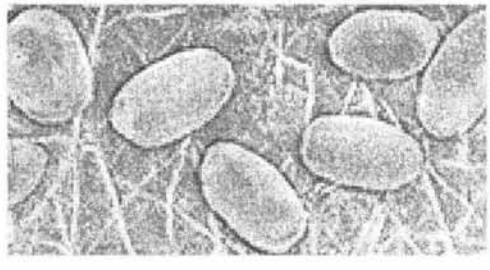
Cohn was the first to classify bacteria as plants, and to define what distinguishes them from green plants. His classification of bacteria into four groups based on shape (sphericals, short rods, threads, and spirals) is still used today. Among other things Cohn is remembered today for being the first to show (1876) that Bacillus can change from a vegetative state to an endospore state when subjected to an environment deleterious to the vegetative state.

Fermentation : Fermentation refers to the conversion of sugar to alcohol using yeast under anaerobic conditions. A more general definition of fermentation is the

chemical conversion of carbohydrates into alcohols or acids. When fermentation stops prior to complete conversion of sugar to alcohol, a stuck fermentation is said to have occurred. The science of fermentation is known as zymology. Fermentation usually implies that the action of the microorganisms is desirable, and the process is used to produce alcoholic beverages such as wine, beer, and cider. Fermentation is also employed in preservation to create lactic acid in sour foods such as pickled cucumbers, kimchi and yogurt.

Since fruits ferment naturally, fermentation precedes human history. Since prehistoric times, however, humans have been controlling the fermentation process. The earliest evidence of winemaking dates from eight thousand years ago, in Georgia, in the Caucasus area. Seven-thousand-year-old jars containing the remains of wine have been excavated in the Zagros Mountains in Iran, which are now on display at the University of Pennsylvania. There is strong evidence that people were fermenting beverages in Babylon circa 5000 BC, ancient Egypt circa 3150 BC, pre-Hispanic Mexico circa 2000 BC, and Sudan circa 1500 BC. There is also evidence of leavened bread in ancient Egypt circa 1500 BC and of milk fermentation in Babylon circa 3000 BC.

Firmicutes : These are a phylum of bacteria, most of which have Gram-positive cell wall structure. A few, the Mollicutes or mycoplasmas, lack cell walls altogether and so do not respond to Gram staining, but still lack the second membrane found in other Gram-negative forms. Others, such as Megasphaera, Pectinatus, Selenomonas, and Zymophilus, have a porous pseudo-outer-membrane that causes them to stain Gram-negative.



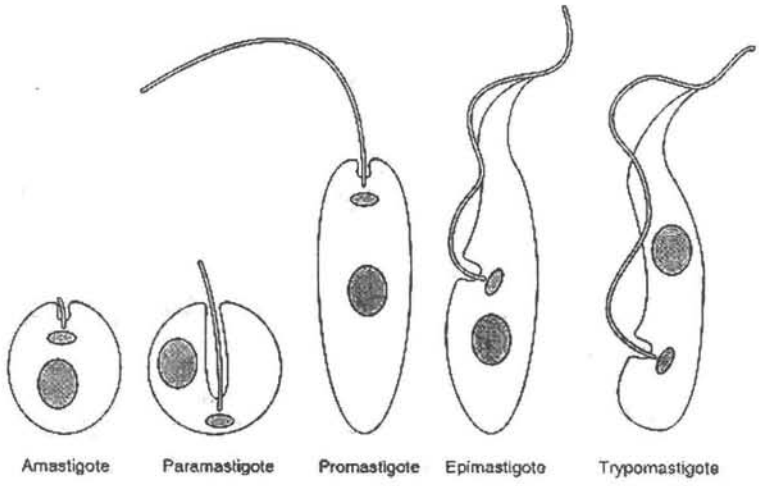
Firmicutes

Scientists once classified the Firmicutes to include all Gram-positive bacteria, but have recently defined them to be of a core group of related forms called the low-G+C group, in contrast to the Actinobacteria. They have round cells, called cocci (singular coccus), or rod-shaped forms. Many *Firmicutes* produce endospores, which are resistant to desiccation and can survive extreme conditions. They are found in various environments, and the group includes some notable pathogens.

Those in one family, the heliobacteria, produce energy through photosynthesis. Firmicutes play an important role in beer, wine, and cider spoilage.

Flagellates : Flagellates are cells with one or more whip-like organelles called flagella. Some cells in animals may be flagellate, for instance the spermatozoa of most phyla. Higher plants and fungi do not produce flagellate cells, but the closely related green algae and chytrids do. Many protists take the form of single-celled flagellates. It describes a means of motion, and does not provide specific classification. However, the term "flagellate" is included in other terms (such as "zooflagellate") which are more formally characterized. Another group is Dinoflagellate.

Eukaryotic flagella are supported by microtubules in a characteristic arrangement, with nine fused pairs surrounding two central singlets. These arise from a basal body or kinetosome, with microtubule roots that are an important part of the cell's brain. In some, for instance, they support a cytostome or mouth, where food is ingested. The flagella often support hairs, called mastigonemes, or contain rods. Their ultrastructure plays an important role in classifying eukaryotes.



Flagellated microscopic animals

In protists and microscopic animals, flagella are generally used for propulsion. They may also be used to create a current that brings in food. In most things, one or more flagella are located at or near the anterior of the cell eg Euglena. Often

there is one directed forwards and one trailing behind. Among animals, fungi, and Choanozoa, which make up a group called the opisthokonts, there is a single posterior flagellum. They are from the phylum Mastigophora. They can cause diseases and they can make their own food. For example, Trypanosome which causes the African sleeping sickness.

Flagellin : It is a protein that arranges itself in a hollow cylinder to form the filament in bacterial flagellum. It has a mass of about 30,000 to 60,000 daltons. Flagellin is the principal substituent of bacterial flagellum, and is present in large amounts on nearly all flagellated bacteria. The structure of flagellin is responsible for the helical shape of the flagellar filament, which is important for its proper function. The N- and C-termini of flagellin form the inner core of the flagellin protein, and is responsible for flagellin's ability to polymerize into a filament. The central portion of the protein makes up the outer surface of the flagellar filament. While the termini of the protein is quite similar between all bacterial flagellins, the central portion is wildly variable.

Flagellum : A flagellum is a tail-like structure that projects from the cell body of certain prokaryotic and eukaryotic cells, and functions in locomotion. There are some notable differences between prokaryotic and eukaryotic flagella, such as protein composition, structure, and mechanism of propulsion. An example of a flagellated bacterium is the ulcer-causing *Helicobacter pylori*, which uses multiple flagella to propel itself through the mucus lining to reach the stomach epithelium. An example of a eukaryotic flagellated cell is the sperm cell, which uses its flagellum to propel itself through the female reproductive tract. Eukaryotic flagella are structurally identical to eukaryotic cilia, although distinctions are sometimes made according to function and/or length.

The bacterial flagellum is made up of the protein flagellin. Its shape is a 20 nanometer-thick hollow tube. It is helical and has a sharp bend just outside the outer membrane; this "hook" allows the helix to point directly away from the cell. A shaft runs between the hook and the basal body, passing through protein rings in the cell's membrane that act as bearings. Gram-positive organisms have 2 of these basal body rings, one in the peptidoglycan layer and one in the plasma membrane. Gram-negative organisms have 4 such rings : the L ring associates with the lipopolysaccharides, the P ring associates with peptidoglycan layer, the M ring is embedded in the plasma membrane, and the S ring is directly attached to the plasma membrane. The filament ends with a capping protein.

The bacterial flagellum is driven by a rotary engine made up of protein (Mot complex), located at the flagellum's anchor point on the inner cell membrane. The engine is powered by proton motive force, i.e., by the flow of protons (hydrogen ions) across the bacterial cell membrane due to a concentration gradient set up

by the cell's metabolism in *Vibrio* species there are two kinds of flagella, lateral and polar, and some are driven by a sodium ion pump rather than a proton pump). The rotor transports protons across the membrane, and is turned in the process. The rotor alone can operate at 6,000 to 17,000 rpm, but with the flagellar filament attached usually only reaches 200 to 1000 rpm.

Flagella do not rotate at a constant speed but instead can increase or decrease their rotational speed in relation to the strength of the proton motive force. Flagellar rotation can move bacteria through liquid media at speeds of up to 60 cell lengths/second (sec). Although this is only about 0.00017 km/h (0.00011 mph), when comparing this speed with that of higher organisms in terms of number of lengths moved per second, it is extremely fast. By comparison, the cheetah, the fastest land animal, can sprint at 110 km/h (68 mph), which is approximately 25 body lengths/sec.

Folic acid and Folate : These are forms of the water-soluble Vitamin B9. Vitamin B9 (Folic acid and Folate inclusive) is essential to numerous bodily functions ranging from nucleotide synthesis to the remethylation of homocysteine. It is especially important during periods of rapid cell division and growth. Both children and adults require folic acid to produce healthy red blood cells and prevent anemia. Folate and Folic acid derive their names from the Latin word folium (leaf).

Leafy vegetables such as spinach, turnip greens, lettuces, dried/fresh beans and peas, fortified cereal products, sunflower seeds and certain other fruits and vegetables are rich sources of folate. Liver and liver products also contain high amounts of folate, as does baker's yeast. Some breakfast cereals (ready-to-eat and others) are fortified with 25% to 100% of the recommended dietary allowance (RDA) for folic acid. A table of selected food sources of folate and folic acid can be found at the USDA National Nutrient Database for Standard Reference. Folic acid is added to grain products in many countries, and in these countries fortified products make up a significant source of folate Because of the difference in bioavailability between supplemented folic acid and the different forms of folate found in food, the dietary folate equivalent (DFE) system was established. 1 DFE is defined as 1 μg of dietary folate, or 0.6 μg of folic acid supplement. This is reduced to 0.5 μg of folic acid if the supplement is taken on an empty stomach.

Fomite : It is any inanimate object or substance capable of carrying infectious organisms (such as germs or parasites) and hence transferring them from one individual to another. A fomite can be anything (such as a cloth or mop head), so when cleaning, it is important to remember that such items could aid the spread of pathogenic organisms. Skin cells, hair, clothing, and bedding are common hospital sources of contamination.

Fomites are associated particularly with hospital acquired infections (HAI), as they are possible routes to pass pathogens between patients. Stethoscopes and neckties are two such fomites associated with health care workers. Basic hospital equipment, such as IV drip tubes, catheters, and life support equipment can also be carriers, when the pathogens form biofilms on the surfaces. Careful sterilization of such objects must be undertaken to stop cross-infection.

Researchers discovered that smooth (non-porous) surfaces transmit bacteria and viruses better than porous materials; so one is more likely to pick-up a disease from a door knob than from paper money. The reason is that porous, especially fibrous, materials absorb and trap the contagion, making it harder to contract through simple touch.

Food microbiology : Food microbiology is the study of the microorganisms which inhabit, create or contaminate food. Of major importance is the study of microorganisms causing food spoilage. However "good" bacteria such as probiotics are becoming increasingly important in food science. In addition, microorganisms are essential for the production of foods such as cheese, yoghurt, other fermented foods, bread, beer and wine.

Food safety is a major focus of food microbiology. Pathogenic bacteria, viruses and toxins produced by microorganisms are all possible contaminants of food. However, microorganisms and their products can also be used to combat these pathogenic microbes. Probiotic bacteria, including those which produce bacteriocins can kill and inhibit pathogens. Alternatively, purified bacteriocins such as nisin can be added directly to food products. Finally, bacteriophage, viruses which only infect bacteria, can be used to kill bacterial pathogens. Thorough preparation of food, including proper cooking will eliminate most bacteria and viruses. However, toxins produced by contaminants may not be heat-labile, and some will not be eliminated by cooking.

Foodborne illness : Any illness resulting from the consumption of contaminated food.There are two types of food poisoning : food infection and food intoxication. Food infection refers to the presence of bacteria or other microbes which infect the body after consumption. Food intoxication refers to the ingestion of toxins contained within the food, including bacterially produced exotoxins, which can happen even when the microbe that produced the toxin is no longer present or able to cause infection. In spite of the common term food poisoning, most cases are caused by a variety of pathogenic bacteria, viruses, prions or parasites that contaminate food, rather than chemical or natural toxins.

Foot rot : A hoof infection that is commonly found in sheep, goat, and cattle. As the name suggests, it rots away the foot of the animal, more specifically the area between the two toes of the affected animal. It is extremely painful and contagious.

It can be treated with a series of medications but if not treated the whole herd can become infected. The cause of the infection in cattle is two anaerobic bacteria (bacteria that can grow without oxygen), *Fusobacterium necrophorum* and *Bacteroides melaninogenicus*. Both bacteria are common to the environment that cattle live in and *Fusobacterium* is present in the rumen and fecal matter of the cattle. Usually there is an injury to the skin between the hooves that allows the bacteria to infect the animal. Another cause of foot rot may be high temperatures or humidity causing the skin between the hooves to crack and let the bacteria infect the foot. This is one of the reasons that foot rot is such a major problem in the summer. Foot rot is easily identifiable by its appearance and foul odor. Treatment is usually with

Frederick William Twort : He was an English bacteriologist. He was born in Camberley, Surrey. He was the original discoverer in 1915 of bacteriophages (viruses that infect bacteria). He studied medicine at St Thomas's Hospital, London, was superintendent of the Brown Institute for Animals (a pathology research centre), and he was also professor of bacteriology at the University of London. He researched into Johne's disease, a chronic intestinal infection of cattle, and also discovered that vitamin K is needed by growing leprosy bacteria.

Frederick William Twort

Twort had one scientific idea which he pursued all of his life. His theory was that pathogenic bacteria required an "Essential Substance" for their growth and vitality. Each organism (bacteria) required a specific and unique nutrient substance that was provided by its host.

In 1914, Twort set out to identify the elusive "Essential Substance" that would allow vaccinia virus to grow in vitro. At the time, smallpox vaccines had to be made

in the skin of calves and was almost always contaminated with the bacteria Staphylococcus. Twort speculated that the contaminating bacteria might be the source of the "essential substance" needed by vaccinia to survive. He plated some of the smallpox vaccines on nutrient agar slants and obtained large bacterial colonies of several colours. Upon closer examination of the colonies with a magnifying glass, he found minute glassy areas that would not grow when subcultured. He quickly realized that these glassy areas were the result of the destruction of the bacterial cells and was able to pick from some of these areas and transmit this from one staph colony to another.

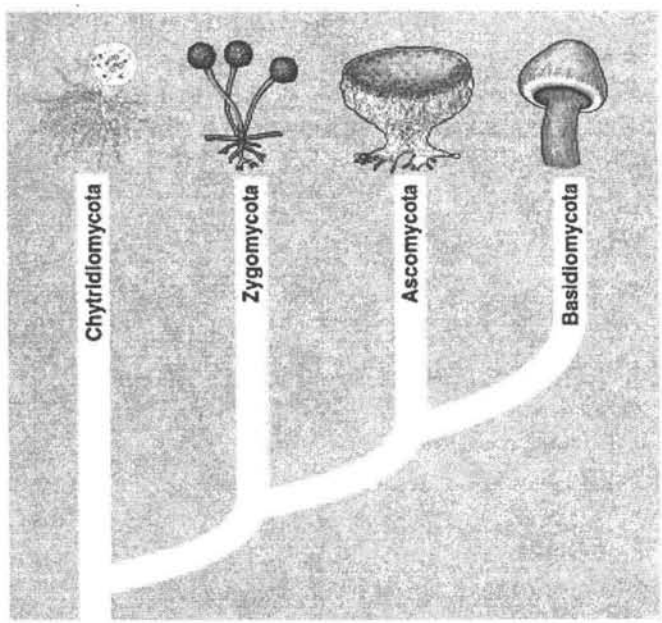
Fuel cell : A fuel cell is an electrochemical conversion device. It produces electricity from fuel (on the anode side) and an oxidant (on the cathode side), which react in the presence of an electrolyte. The reactants flow into the cell, and the reaction products flow out of it, while the electrolyte remains within it. Fuel cells can operate virtually continuously as long as the necessary flows are maintained.

Fuel cells are different from electrochemical cell batteries in that they consume reactant from an external source, which must be replenished—a thermodynamically open system. By contrast batteries store electrical energy chemically and hence represent a thermodynamically closed system. Many combinations of fuel and oxidant are possible. A hydrogen cell uses hydrogen as fuel and oxygen (usually from air) as oxidant. Other fuels include hydrocarbons and alcohols. Other oxidants include chlorine and chlorine dioxide.

Fungus : A fungus is a eukaryotic organism that is a member of the kingdom Fungi. The fungi are a monophyletic group, also called the *Eumycota* (*true fungi* or *Eumycetes*), that is phylogenetically distinct from the morphologically similar slime molds (myxomycetes) and water molds (oomycetes).

The fungi are heterotrophic organisms possessing a chitinous cell wall, with most species growing as multicellular filaments called hyphae forming a mycelium; some species also grow as single cells. Sexual and asexual reproduction of the fungi is commonly via spores, often produced on specialized structures or in fruiting bodies. Some have lost the ability to form reproductive structures, and propagate solely by vegetative growth. Yeasts, molds, and mushrooms are examples of fungi. Although they are more closely related to animals than plants, the discipline of biology devoted to the study of fungi, known as mycology, is often regarded as a branch of botany. Occurring worldwide, most fungi are largely invisible to the naked eye, living for the most part in soil, dead matter, and as symbionts of plants, animals, or other fungi. They perform an essential role in ecosystems in decomposing organic matter and are indispensable in nutrient cycling and exchange. Fungi may become noticeable when fruiting, either as mushrooms or molds. They have long been used as a direct source of food, such as mushrooms and truffles, and in fermentation of various food products, such as wine, beer, and

soy sauce. More recently, fungi are being used as sources for antibiotics used in medicine and various enzymes, such as cellulases, pectinases, and proteases, important for industrial use or as active ingredients of detergents.



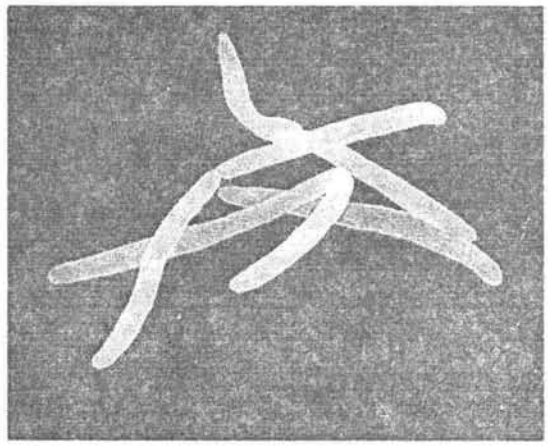
Fungi

Many species produce bioactive compounds called mycotoxins, such as alkaloids and polyketides that are toxic to animals including humans. Fruiting structures of a few species are used recreationally or in traditional ceremonies as a source of psychotropic compounds. Fungi are significant pathogens of humans and other animals, and losses due to diseases of crops (e.g., rice blast disease) or food spoilage can have a large impact on human food supply and local economies.

Fungi have a worldwide distribution, and grow in a wide range of habitats, including deserts, hypersaline environments, the deep sea, on rocks, and in extremely low and high temperatures. They are able to survive the intense UV and cosmic radiation encountered during space travel. Most grow in terrestrial environments, but several species live partly or solely in aquatic habitats. For example, the chytrid fungus *Batrachochytrium dendrobatidis*—responsible for a worldwide decline in amphibian populations—spends part of its life cycle as motile zoospore, enabling it to propel itself through water and penetrate the skin of an

amphibian host. Fungi, along with bacteria, are the primary decomposers of organic matter in most if not all terrestrial ecosystems worldwide. Based on observations of the ratio of the number of fungal species to the number of plant species in select environments, the fungal kingdom has been estimated to contain about 1.5 million species. Around 70,000 species have been formally described by taxonomists, but the true dimension of fungal diversity is still unknown. Until recently, fungal species were described based mainly on morphological characteristics, such as the size and shape of spores or fruiting structures, and biological species concepts. The application of molecular tools, such as DNA sequencing and phylogenetic analysis, to study diversity has greatly enhanced the resolution and added robustness to estimates of genetic diversity within various taxonomic groups.

Fusobacterium : Fusobacterium is a genus of filamentous, anaerobic, Gram-negative bacteria, similar to *Bacteroides*. *Fusobacterium* contribute to several human diseases, including periodontal diseases, Lemierre's syndrome, and topical skin ulcers. Although older resources have stated that *Fusobacterium* is a common occurrence in the human oropharynx, the current consensus is that *Fusobacterium* should always be treated as a pathogen.



Fusobacterium necrophorum

Fusobacterium necrophorum is the species of *Fusobacterium* that is responsible for Lemierre's syndrome, and appears to be responsible for 10% of all acute sore throats and 21% of all recurring sore throats, with the remainder being caused by Group A streptococci or viruses. Other complications from *F. necrophorum* include meningitis, complicated by thrombosis of the cerebral veins, and infection of the urogenital and the gastrointestinal tracts.

F. necrophorum infection usually responds to treatment with penicillin or metronidazole, but penicillin treatment for persistent pharyngitis appears anecdotally to have a higher relapse rate, although the reasons for that are unclear. This bacterium is also considered the cause of the foot disease thrush in horses. Although this infection is rare, researchers agree that this diagnosis should be considered in a septicaemic patient with thrombosis in an unusual site, and underlying malignancy should be excluded in cases of confirmed *F. necrophorum* occurring at sites caudal to the head.

F. necrophorum is also a cause for lameness in sheep. Its infection is commonly called scald. It can last for several years on land used by either sheep or cattle and is found on most land of this type throughout the world. Due to its survival length in these areas it is unrealistic to try to remove it. Sheep most often get scald due to breakage or weakness of the skin surrounding the hoof. This can occur due to strong footbaths, sandy soils, mild frost bite or prolongened waterlogging of a field which results in denaturing of the skin between the cleats.

G

Gammaproteobacteria : It is a class of several medically and scientifically important groups of bacteria, such as the Enterobacteriaceae (*Escherichia coli*), Vibrionaceae and Pseudomonadaceae. An exceeding number of important pathogens belongs to this class, e.g. *Salmonella* (enteritis and typhoid fever), *Yersinia* (plague), *Vibrio* (cholera), *Pseudomonas aeruginosa* (lung infections in hospitalised or cystic fibrosis patients). The *Gammaproteobacteria* comprise several medically and scientifically important groups of bacteria, such as the *Enterobacteriaceae, Vibrionaceae* and *Pseudomonadaceae*. A number of important pathogens belongs to this class, e.g. Salmonella spp. (enteritis and typhoid fever), *Yersinia pestis* (plague), *Vibrio cholerae* (cholera), *Pseudomonas aeruginosa* (lung infections in hospitalized or cystic fibrosis patients), and *Escherichia coli* (food poisoning). Members of Chromatium are photosynthetic and oxidize Hydrogen Sulfide instead of water producing sulfer as excrement. Some Gammaproteobacteria are methane oxidizers and many of them are in symbiosis with geothermic ocean vent dwelling animals.

Gardnerella : It is a genus of gram-positive (although may stain gram-negative) aerobic bacteria of which Gardnerella vaginalis is the only species. Once classified as a species of *Haemophilus, G. vaginalis* grows as small, circular, convex, gray colonies on chocolate agar; it will also grow on HBT agar. A selective medium for *G. vaginalis* is colistin-oxolinic acid blood agar.

Gardnerella vaginalis can cause bacterial vaginosis in some women. While typically isolated in genital cultures, it may also be detected from other sources, such as blood, urine and pharynx. Although a chief cause of bacterial vaginosis, it may be isolated from women without any signs or symptoms of infection.

It has a gram-positive cell wall, but because the cell wall is so thin it can appear either gram-positive or gram-negative under the microscope. It is associated microscopically with clue cells, which are epithelial cells covered in bacteria. *G. vaginalis* produces a pore-forming toxin, vaginolysin, which affects only human cells. Infections with *G. vaginalis* go along with proteolysis, giving nitrous products such as cadaverines and putrescines, which can cause a bad smell and loss of water.

Genetic engineering : Genetic engineering, recombinant DNA technology, genetic modification/manipulation (GM) and gene splicing are terms that apply to the direct manipulation of an organism's genes. Genetic engineering is different from traditional breeding, where the organism's genes are manipulated indirectly. Genetic engineering uses the techniques of molecular cloning and transformation to alter the structure and characteristics of genes directly. Genetic engineering techniques have found some successes in numerous applications. Some examples are in improving crop technology, the manufacture of synthetic human insulin through the use of modified bacteria, the manufacture of erythropoietin in hamster ovary cells, and the production of new types of experimental mice such as the oncomouse (cancer mouse) for research.

The term "genetic engineering" was coined in Jack Williamson's science fiction novel *Dragon's Island,* published in 1951, two years before James Watson and Francis Crick showed that DNA could be the medium of transmission of genetic information. Although there has been a revolution in the biological sciences in the past twenty years, there is still a great deal that remains to be discovered. The completion of the sequencing of the human genome, as well as the genomes of most agriculturally and scientifically important animals and plants, has increased the possibilities of genetic research immeasurably. Expedient and inexpensive access to comprehensive genetic data has become a reality with billions of sequenced nucleotides already online and annotated.

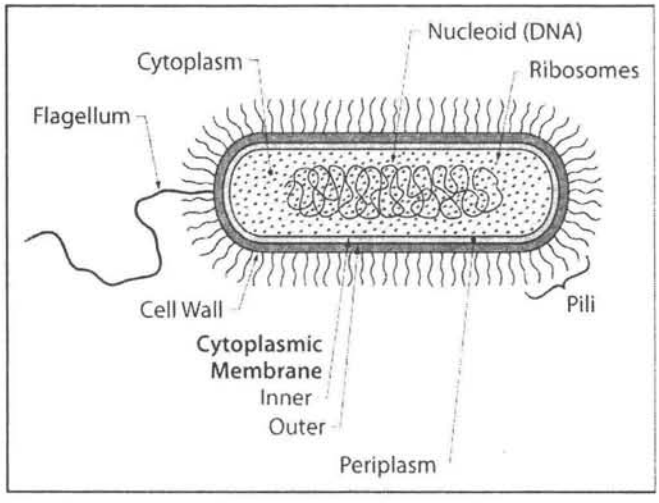
Genomics : Genomics is the study of the genomes of organisms. The field includes intensive efforts to determine the entire DNA sequence of organisms and fine-scale genetic mapping efforts. The field also includes studies of intragenomic phenomena such as heterosis, epistasis, pleiotropy and other interactions between loci and alleles within the genome. In contrast, the investigation of the roles and functions of single genes is a primary focus of molecular biology and is a common topic of modern medical and biological research. Research of single genes does not fall into the definition of genomics unless the aim of this genetic, pathway, and functional information analysis is to elucidate its effect on, place in, and response to the entire genome's networks.

For the United States Environmental Protection Agency, "the term "genomics" encompasses a broader scope of scientific inquiry associated technologies than when genomics was initially considered. A genome is the sum total of all an individual organism's genes. Thus, genomics is the study of all the genes of a cell, or tissue, at the DNA (genotype), mRNA (transcriptome), or protein (proteome) levels."

Geobacter : Geobacter is a genus of proteobacteria. *Geobacter* are an anaerobic respiration bacterial species which have capabilities that may make them useful

in bioremediation. The geobacter was found to be the first organism with the ability to oxidize organic compounds and metals, including iron, radioactive metals and petroleum compounds into environmentally benign carbon dioxide while using iron oxide or other available metals as electron acceptor. *Geobacter metallireducens* was first isolated by Derek Lovley in 1987 in sand sediment from the Potomac River in Washington D.C.

The first strain was deemed strain GS-15. Geobacter have been found in anaerobic conditions in soils and aquatic sediment.Research on the potential of the Geobacter is underway and on-going. The Geobacter's ability to consume oil-based pollutants and radioactive material with carbon dioxide as waste by-product has already been used in environmental clean-up for underground petroleum spills and for the precipitation of uranium out of groundwater. The Geobacter metabolizes the material by creating "pili," columns the width of a 3-5 nanometers that act as conduits to pass electrons between the food material and the Geobacter. This manner of consumption has also led scientists to theorize that the Geobacter could act as a natural battery.



Geobacter

This natural battery could use renewable biomass such as compost materials, or be used to convert human and animal solid waste into electricity.

Geomicrobiology : Geomicrobiology is a subset of the scientific discipline microbiology. The field of geomicrobiology concerns the role of microbe and microbial processes in geological and geochemical processes. The field is especially important when

dealing with microorganisms in aquifers and public drinking water supplies. Another area of investigation in geomicrobiology is the study of extremophile organisms, the microorganisms that thrive in environments normally considered hostile. Such environments may include extremely hot (hot springs or mid-ocean ridge black smoker) environments, extremely saline environments, or even space environments such as Martian soil or comets.

Recent observations and research in hyper-saline lagoon environments in Brazil and Australia have shown that anaerobic sulfate-reducing bacteria may be directly involved in the formation of dolomite. This suggests the alteration and replacement of limestone sediments by dolomitization in ancient rocks was possibly aided by ancestors to these anaerobic bacteria. Some bacteria use metal ions as their energy source. They convert (or chemically reduce) the dissolved metal ions from one electrical state to another. This reduction releases energy for the bacteria's use, and, as a side product, serves to concentrate the metals into what ultimately become *ore deposits*. Certain iron, uranium and even gold ores are thought to have formed as the result of microbe action. Microbes are being studied and used to degrade organic and even nuclear waste pollution and assist in environmental cleanup.

Germ theory : The germ theory, also called the pathogenic theory of medicine, is a theory that proposes that microorganisms are the cause of many diseases. Although highly controversial when first proposed, it is now a cornerstone of modern medicine and clinical microbiology, leading to such important innovations as antibiotics and hygienic practices.The ancient historical view was that disease was spontaneously generated instead of being created by microorganisms which grow by reproduction. The Atharvaveda, a sacred text of Hinduism, is the first ancient text dealing with medicine. It identifies the causes of disease as living causative agents such as the yatudhanya, the kimidi. The atharvans seek to kill them with a variety of drugs in order to counter the disease.

GIANTmicrobes : GIANTmicrobes is a toy company based in Stamford, CT. GIANTmicrobes manufactures plush toys resembling microbes, including a number of clinically important human pathogens. The toys, also referred to as GIANTmicrobes, are available via Internet and are also typically found at medical facilities, Toy stores, pharmacies and other health-related locations. Many are on display at MoMA. The toys were developed primarily for educational, if not in some cases ironic, value. They are found around the world and the tagging explaining the illness, pathogen or organism has been translated into over 8 languages for use in public awareness in North America and Europe.

The appearance of each 5-7 inch long toy is based on electron micrographs of the real microbe, thus the toys represent an approximate million-fold magnification of the actual organisms in many cases. In order to appeal to the general public

and present an air of lovability, some license is taken in the design of the toys in that they are brightly colored and furry. To further anthropomorphize them, they typically feature two eyes and in some cases other facial features that are in line with some aspect of the disease they represent.

Despite this license, the toys typically maintain the salient features of their biological cousins, such as the presence of surface glycoproteins, cilia, flagella, and overall morphology. To emphasize the basic faithfulness to the actual microbes, the toys possess a tag showing the micrograph upon which their appearance is based, the scientific nomenclature of the microbe, and some general clinical facts related to the disease it causes.

Glycocalyx : Glycocalyx is a general term referring to extracellular polymeric material (glycoprotein) produced by some bacteria, epithelia and other cells. The slime on the outside of a fish is considered a glycocalyx. The term was initially applied to the polysaccharide matrix excreted by epithelial cells forming a coating on the surface of epithelial tissue. A glycocalyx, literally "sugar coat", is a network of polysaccharides that project from cellular surfaces, e.g. those of bacteria. It serves to protect the bacterium by creating capsules, or allows the bacterium to attach itself to inert surfaces (like teeth or rocks; e.g. *Streptococcus pneumoniae* attaches itself to lung cells), eukaryotes, or other bacteria (their glycocalyxes can fuse to envelop the colony).

The glycocalyx can be found just outside the cell wall of a bacterium. A distinct, gelatinous glycocalyx is called a Bacterial capsule, while an irregular, diffuse layer is called a slime layer. Glycocalyx can help protect bacteria from phagocytes. It also helps in the formation of biofilms such as a coating on inert surfaces such as teeth or rocks. The glycocalyx is also the name given to a specific structure of a mature platelet. The glycocalyx is unique among the cellular components of the blood. It is similar to the bacterial glycocalyx above in that it is made up of glycoproteins and allows the platelet to adhere to surfaces such as collagen of damaged vessels. The glycocalyx appears as a fluffy coat to the outer membrane of platelets and contains many of the receptor proteins that allow cell adhesion. Glycocalyx also appears on the cells lining blood vessels (endothelial cells). Among its established roles are reducing friction to the flow of blood and serving as a barrier for loss of fluid through the vessel wall. In times of inflammation, the endothelial cell glycocalyx is sheared off, to permit attachment of leukocytes and movement of water from microvessels.

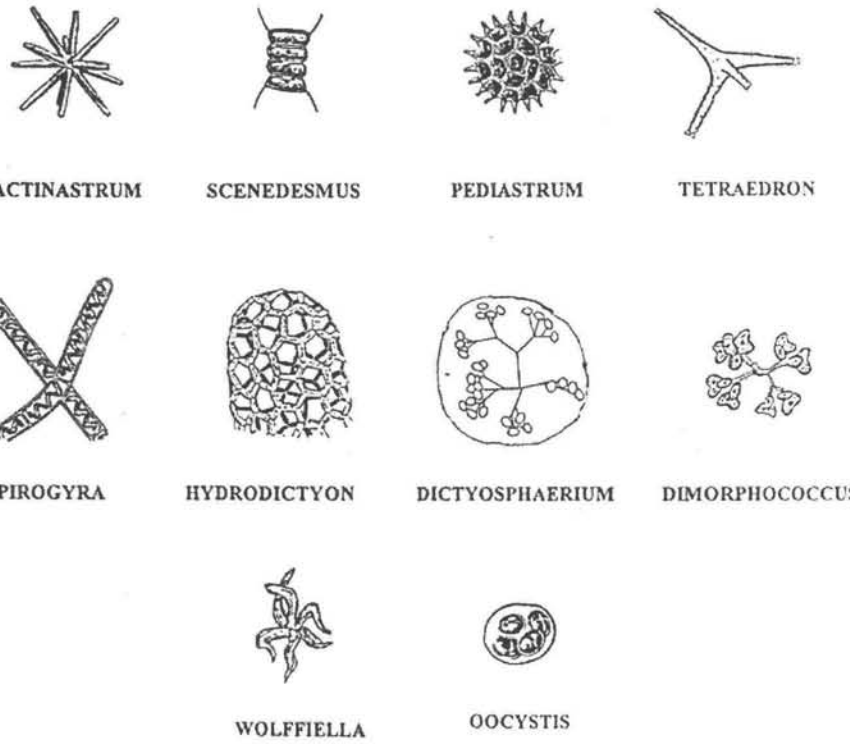
Gram staining : An empirical method of differentiating bacterial species into two large groups (Gram-positive and Gram-negative) based on the chemical and physical properties of their cell walls. While Gram staining is a valuable diagnostic tool in both clinical and research settings, not all bacteria can be definitively classified by

this technique, thus forming *Gram variable* and *Gram indeterminant* groups as well.The method is named after its inventor, the Danish scientist Hans Christian Gram (1853—1938), who developed the technique in 1884 to discriminate between two types of bacteria with similar clinical symptoms : *Streptococcus pneumoniae* (also known as the *pneumococcus*) and *Klebsiella pneumoniae* bacteria. Gram staining is used to differentiate bacterial species into two large groups (Gram-positive and Gram-negative) based on the chemical and physical properties of their cell walls. Gram staining is not used to classify archaea, since these microorganisms yield widely varying responses that do not follow their phylogenetic groups.

Gram-negative bacteria : These are bacteria that do not retain crystal violet dye in the Gram staining protocol. In a Gram stain test, a counterstain (commonly safranin) is added after the crystal violet, coloring all Gram-negative bacteria with a red or pink color. The test itself is useful in classifying two distinct types of bacteria based on the structural differences of their cell walls. On the other hand, Gram-positive bacteria will retain the crystal violet dye when washed in a decolorizing solution. Many species of Gram-negative bacteria are pathogenic, meaning that they can cause disease in a host organism. This pathogenic capability is usually associated with certain components of Gram-negative cell walls, in particular the lipopolysaccharide (also known as LPS or endotoxin) layer. In humans, LPS triggers an innate immune response characterized by cytokine production and immune system activation. Inflammation is a common result of cytokine (from the Greek cyto=cell, kinesis=movement) production, which can also produce host toxicity.

Gram-positive bacteria : These are bacteria that are stained dark blue or violet by Gram staining. This is in contrast to Gram-negative bacteria, which cannot retain the crystal violet stain, instead taking up the counterstain (safranin or fuchsin) and appearing red or pink. Gram-positive organisms are able to retain the crystal violet stain because of the high amount of peptidoglycan in the cell wall. Gram-positive cell walls typically lack the outer membrane found in Gram-negative bacteria. When treated as a clade, the term "Posibacteria" is sometimes used.

Green algae : The green algae are the large group of algae from which the embryophytes (higher plants) emerged. As such, they form a paraphyletic group, although the group including both green algae and embryophytes is monophyletic (and often just known as kingdom Plantae). The green algae include unicellular and colonial flagellates, usually but not always with two flagella per cell, as well as various colonial, coccoid, and filamentous forms. In the Charales, the closest relatives of higher plants, full differentiation of tissues occurs. There are about 6000 species of green algae. Many species live most of their lives as single cells, while other species form colonies or long filaments.



Green algae

A few other organisms rely on green algae to conduct photosynthesis for them. The chloroplasts in euglenids and chlorarachniophytes were acquired from ingested green algae, and in the latter retain a vestigial nucleus (nucleomorph). Some species of green algae, particularly of genera Trebouxia and Pseudotrebouxia (Trebouxiophyceae), can be found in symbiotic associations with fungi to form lichens. In general the fungal species that partner in lichens cannot live on their own, while the algal species is often found living in nature without the fungus. Almost all forms have chloroplasts. These contain chlorophylls a and b, giving them a bright green colour (as well as the accessory pigments beta carotene and xanthophylls), and have stacked thylakoids.

All green algae have mitochondria with flat cristae. When present, flagella are typically anchored by a cross-shaped system of microtubules, but these are absent among the higher plants and charophytes. Flagella are used to move the organism. Green algae usually have cell walls containing cellulose, and undergo open mitosis without centrioles.The chloroplasts of green algae are bound by a double membrane, so presumably they were acquired by direct endosymbiosis of cyanobacteria. A number of cyanobacteria show similar pigmentation, but this

appears to have arisen more than once, and the chloroplasts of green algae are no longer considered closely related to such forms. Instead, the green algae probably share a common origin with the red algae. A growth of the green seaweed, Enteromorpha on rock substratum at the ocean shore. Some green seaweeds, such as Enteromorpha and Ulva, are quick to utilize inorganic nutrients from land runoff, and thus can be indicators of nutrient pollution. Green algae are often classified with their embryophyte descendants in the green plant clade Viridiplantae (or Chlorobionta). Viridiplantae, together with red algae and glaucophyte algae, form the supergroup Primoplantae, also known as Archaeplastida or Plantae sensu lato.

Green sulfur bacteria : These are a family of obligately anaerobic photoautotrophic bacteria. Most closely related to the distant Bacteroidetes, they are accordingly assigned their own phylum.

Green sulfur bacteria

Green sulfur bacteria are non-motile (except *Chloroherpeton thalassium*, which may glide) and come in spheres, rods, and spirals. Photosynthesis is achieved using bacteriochlorophyll (BChl) *c*, *d*, or *e*, in addition to BChl *a* and chlorophyll *a*, in chlorosomes attached to the membrane. They use sulfide ions, hydrogen or ferrous iron as an electron donor and the process is mediated by the type I reaction centre and Fenna-Matthews-Olson complex. Elemental sulfur deposited outside the cell may be further oxidized. By contrast, the photosynthesis in plants uses water as electron donor and produces oxygen.

Chlorobium tepidum has emerged as a model organism for the group, and although only ten genomes have been sequenced, these are quite comprehensive of the family's biodiversity. Their 2-3 Mb genomes encode 1750-2800 genes, 1400-1500 of which are common to all strains. The apparent absence of two-component histidine-kinases and response regulators suggest limited phenotypic plasticity.

Their small dependence on organic molecule transporters and transcription factors also indicate that these organisms are adapted to a narrow range of energy-limited conditions, an ecology shared with the simpler cyanobacteria, *Prochlorococcus* and *Synechococcus*. A species of green sulfur bacteria has been found living near a black smoker off the coast of Mexico at a depth of 2,500 meters beneath the surface of the Pacific Ocean. At this depth, the bacterium, designated GSB1, lives off the dim glow of the thermal vent since no sunlight can penetrate to that depth.

Griffith's experiment : The experiment conducted in 1928 by Frederick Griffith, was one of the first experiments suggesting that bacteria are capable of transferring genetic information through a process known as transformation. Griffith used two strains of *Pneumococcus* (which infects mice), a type III-S (smooth) and type II-R (rough) strain. The III-S strain covers itself with a polysaccharide capsule that protects it from the host's immune system, resulting in the death of the host, while the II-R strain doesn't have that protective capsule and is defeated by the host's immune system. A German bacteriologist, Fred Neufeld, had discovered the three pneumococcal types (Types I, II, and III) and discovered the Quellung reaction to identify them in vitro. Until Griffith's experiment, bacteriologists believed that the types were fixed and unchangeable, from one generation to another.

In this experiment, bacteria from the III-S strain were killed by heat, and their remains were added to II-R strain bacteria. While neither alone harmed the mice, the combination was able to kill its host. Griffith was also able to isolate both live II-R and live III-S strains of *pneumococcus* from the blood of these dead mice. Griffith concluded that the type II-R had been "transformed" into the lethal III-S strain by a "transforming principle" that was somehow part of the dead III-S strain bacteria.

Growth Medium : A growth medium or a culture medium is a liquid or gel designed to support the growth of microorganisms or cells , or small plants like the moss *Physcomitrella patens* . There are different types of media for growing different types of cells. There are two major types of growth media : those used for cell culture, which use specific cell types derived from plants or animals, and microbiological culture, which are used for growing microorganisms, such as bacteria or yeast. The most common growth media for microorganisms are *nutrient broths* and agar plates; specialized media are sometimes required for microorganism and cell culture growth. Some organisms, termed *fastidious organisms*, require specialized environments due to complex nutritional requirements. Viruses, for example, are obligatory intracellular parasites and require a growth medium composed of living cells.

The most common growth media for microorganisms are *nutrient broths* (liquid nutrient medium) or *Luria Bertani medium* (LB medium or *Lysogeny Broth*). Liquid

media are often mixed with agar and poured into petri dishes to solidify. These agar plates provide a solid medium on which microbes may be cultured. They remain solid, as very few bacteria are able to decompose agar. Bacteria grown in liquid cultures often form colloidal suspensions.

The differences between growth media used for cell culture and those used for microbiological culture are because cells derived from whole organisms and grown in culture often cannot grow without the addition of, for instance, hormones or growth factors which usually occur *in vivo*. In the case of animal cells, this difficulty is often addressed by the addition of blood serum to the medium. In the case of microorganisms, there are no such limitations, as they are often unicellular organisms. One other major difference is that animal cells in culture are often grown on a flat surface to which they attach, and the medium is provided in a liquid form, which covers the cells. In contrast, bacteria such as *Escherichia coli* may be grown on solid media or in liquid media.

An important distinction between growth media types is that of *defined* versus *undefined* media. A defined medium will have known quantities of all ingredients. For microorganisms, they consist of providing trace elements and vitamins required by the microbe and especially a defined carbon source and nitrogen source. Glucose or glycerol are often used as carbon sources, and ammonium salts or nitrates as inorganic nitrogen sources). An undefined medium has some complex ingredients, such as yeast extract or casein hydrolysate, which consist of a mixture of many, many chemical species in unknown proportions. Undefined media are sometimes chosen based on price and sometimes by necessity—some microorganisms have never been cultured on defined media.

A good example of a growth medium is the wort used to make beer. The wort contains all the nutrients required for yeast growth, and under anaerobic conditions, alcohol is produced. When the fermentation process is complete, the combination of medium and dormant microbes, now beer, is ready for consumption.

H

Habitat : A habitat (which is Latin for "it inhabits") is an ecological or environmental area that is inhabited by a particular animal or plant species. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a species population.

The term "species population" is preferred to "organism" because, while it is possible to describe the habitat of a single black bear, we may not find any particular or individual bear but the grouping of bears that comprise a breeding population and occupy a certain biogeographical area. Further, this habitat could be somewhat different from the habitat of another group or population of black bears living elsewhere. Thus it is neither the species nor the individual for which the term habitat is typically used.

A microhabitat is a physical location that is home to very small creatures, such as woodlice. Microenvironment is the immediate surroundings and other physical factors of an individual plant or animal within its habitat.

Haloarchaea : Haloarchaea are microrganisms member of the halophile community, in that they require high salt concentrations to grow. They are a distinct evolutionary branch of the Archaea, and are generally considered extremophiles, although not all members of this group can be considered as such.

Haloarchaea require salt concentrations in excess of 2 M (or about 10%) to grow, and optimal growth usually occurs at much higher concentrations, typically 20–25%. However, Haloarchaea can grow up to saturation (about 37% salts).

Haloarchaea are found mainly in hypersaline lakes and solar salterns. Their high densities in the water often lead to pink or red colourations of the water (the cells possessing high levels of carotenoid pigments, presumably for UV protection).

Haloarchaea are often considered pleomorphic, or able to take on a range of shapes—even within the one species. This makes identification by microscopic means difficult, and it is now more common to use gene sequencing techniques for identification instead.

One of the more unusually shaped Haloarchaea is the "Square Haloarchaeon of Walsby." Was classified in 2004 using a very low nutrition solution to allow growth along with a high salt concentration, square in shape and extremely thin (like a postage stamp). This shape is probably only permitted by the high osmolarity of the water, permitting cell shapes that would be difficult, if not impossible, under other conditions.

Hantaviruses : Hantaviruses belong to the *Bunyaviridae* family of viruses. The *Bunyaviridae* family is divided into 5 genera : *Orthobunyavirus, Nairovirus, Phlebovirus, Tospovirus,* and *Hantavirus*. Like all members of this family, hantaviruses have genomes comprised of three negative-sense, single-stranded RNA segments, and so are classified as negative sense RNA viruses. Viruses in the genus *Hantavirus* are unique in that they are transmitted by aerosolized rodent excreta or rodent bites, whereas all other genera in the *Bunyaviridae* family are arthropod-borne viruses.

The name *hantavirus* is derived from the Hantan River, where the Hantaan virus (the etiologic agent of Korean hemorrhagic fever) was first isolated by Dr. Ho-Wang Lee and colleagues. The disease associated with Hantaan virus is called hemorrhagic fever with renal syndrome (HFRS), a term that is accepted by the World Health Organization. It was formerly called Korean hemorrhagic fever (a term that is no longer in use).

Hashimoto's thyroiditis : It is an autoimmune disease where the body's own T-cells attack the cells of the thyroid. It was the first disease to be recognised as an autoimmune disease. This disorder is believed to be the most common cause of primary hypothyroidism in North America. It occurs far more often in women than in men (10 :1 to 20 :1), and is most prevalent between 45 and 65 years of age. In European countries, an atrophic form of autoimmune thyroiditis (Ord's thyroiditis) is more common than Hashimoto's thyroiditis.

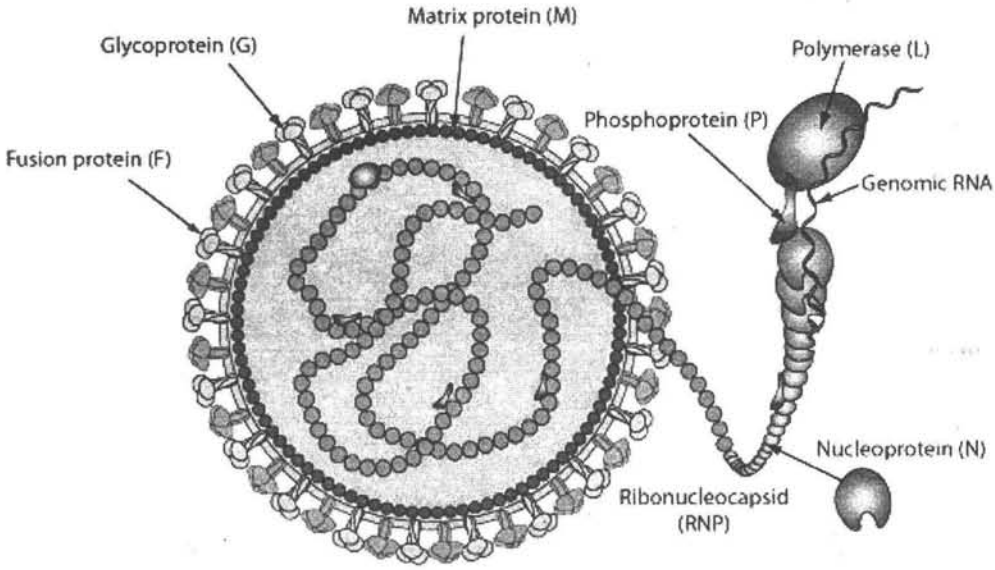
The family history of thyroid disorders is common, with the *HLA-DR5* gene most strongly implicated conferring a relative risk of 3 in the UK. In addition Hashimoto's thyroiditis may be associated with *CTLA-4* gene since the CTLA-4 antigen acts as an inhibitor to T-Cell activation. The genes implicated vary in different ethnic groups and the incidence is increased in patients with chromosomal disorders, including Turner, Down's, and Klinefelter's syndromes. The underlying specifics of the immune system destruction of thyroid cells is not clearly understood. Various autoantibodies may be present against thyroid peroxidase, thyroglobulin and TSH receptors, although a small percentage of patients may have none of these antibodies present. A percentage of the population may also have these antibodies without developing Hashimoto's thyroiditis.

Heinrich Hermann Robert Koch : He was a German physician. He became famous for isolating *Bacillus anthracis* (1877), the Tuberculosis bacillus (1882) and the Vibrio cholera (1883) and for his development of Koch's postulates He was awarded the Nobel Prize in Physiology or Medicine for his tuberculosis findings in 1905. He is considered one of the founders of microbiology—he inspired such major figures as Paul Ehrlich and Gerhard Domagk.

The Robert Koch Prize and Medal were created to honour Microbiologists who make groundbreaking discoveries or who contribute to global health in a unique way. The now-defunct Robert Koch Hospital at Koch, Missouri (south of St. Louis, Missouri), was also named in his honor. A hagiographic account of Koch's career can be found in the 1939 Nazi propaganda film *Robert Koch, der Bekämpfer des Todes* (The fighter against death), directed by Hans Steinhoff and starring Emil Jannings as Koch

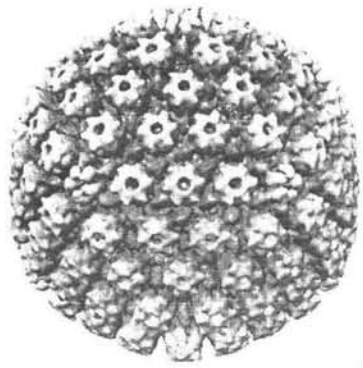
Henipavirus : It is a genus of the family *Paramyxoviridae*, order *Mononegavirales* containing two members, Hendravirus and Nipahvirus. The henipaviruses are naturally harboured by Pteropid fruit bats (flying foxes) and are characterised by a large genome, a wide host range and their recent emergence as zoonotic pathogens capable of causing illness and death in domestic animals and humans.

Henipaviruses are pleomorphic (variably shaped), ranging in size from 40 to 600 nm in diameter. They possess a lipid membrane overlying a shell of viral matrix protein. At the core is a single helical strand of genomic RNA tightly bound to N (nucleocapsid) protein and associated with the L (large) and P (phosphoprotein) proteins which provide RNA polymerase activity during replication.



Embedded within the lipid membrane are spikes of F (fusion) protein trimers and G (attachment) protein tetramers. The function of the G protein is to attach the virus to the surface of a host cell via ephrin B2, a highly conserved protein present in many mammals. The F protein fuses the viral membrane with the host cell membrane, releasing the virion contents into the cell. It also causes infected cells to fuse with neighbouring cells to form large, multinucleated syncytia.

Herpes B virus : It is the endemic simplexvirus of macaque monkeys. B virus is an alphaherpesvirus, which consists of a subset of herpesviruses that travel within hosts using the peripheral nerves. As such, this neurotropic virus is not found in the blood.



Herpes B virus

In the natural host, the virus exhibits pathogenesis similar to that of herpes simplex virus (HSV) in humans. Conversely, when humans are zoonotically infected with B virus, patients can present with severe central nervous system disease, resulting in permanent neurological dysfunction or death. Severity of the disease increases for untreated patients, with a mortality rate of approximately 80%. Early diagnosis and subsequent treatment are the lynchpins of surviving the infection.

Linked with more than two dozen deaths since its discovery, B virus is the only identified nonhuman primate herpesvirus that displays severe pathogenicity in humans. The last identified case of human B virus infection occurred in 2008, with the last known fatality occurring when a worker at the Yerkes National Primate Research Center was infected in 1997 after an eye splash occurred. Proper personal protective equipment is essential when working with macaques, especially those who have tested positive for the virus. Bites, scratches and exposures to mucous membranes, including the eye, must be cleaned immediately.

Hershey-Chase experiments : These were a series of experiments conducted in 1952 by Alfred Hershey and Martha Chase, confirming that DNA was the genetic material, which had first been demonstrated in the 1944 Avery-MacLeod-McCarty experiment. While DNA had been well known to biologists since 1869, most assumed at the time that proteins carried the information for inheritance.

Hershey and Chase conducted their experiments on the T2 phage, a virus whose structure had recently been shown by electron microscopy. The phage consists only of a protein shell containing its genetic material. The phage infects a bacterium by attaching to its outer membrane and injecting its genetic material, causing the bacterium's genetic machinery to produce more viruses, leaving its empty shell attached to the bacterium.

In a first experiment, they labeled the DNA of phages with radioactive Phosphorus-32 (the element phosphorus is present in DNA but not present in any of the 20 amino acids from which proteins are made). They allowed the phages to infect *E. coli*, then removed the protein shells from the infected cells with a blender and a centrifuge. They found that the radioactive tracer was visible only in the bacterial cells and not in the protein shells. In a second experiment, they labeled the phages with radioactive Sulfur-35 (Sulfur is present in the amino acids Cysteine and Methionine, but not in DNA). After separation, the radioactive tracer then was found in the protein shells, but not in the infected bacteria, confirming that the genetic material which infects the bacteria is DNA.

Heterotroph : A heterotroph is an organism that uses organic substrates to get its chemical energy for its life cycle. This contrasts with autotrophs such as plants which are able to directly use sources of energy such as light to produce organic substrates from inorganic carbon dioxide. An example would be *Cyanobacteria*

synechocystis sp. PCC 6803. Heterotrophs are known as consumers in food chains and obtain organic carbon by eating other heterotrophs or autotrophs. All animals are heterotrophic, as well as fungi and many bacteria. Some animals, such as corals, form symbiotic relationships with autotrophs and obtain organic carbon in this way. Furthermore, some parasitic plants have also turned fully or partially heterotrophic, while so-called carnivorous plants consume animals to augment their nitrogen supply but are still autotrophic.

For a species to be termed a heterotroph, it must obtain its carbon from organic compounds. If it obtains nitrogen from organic compounds, but not energy, it will be deemed an autotroph. If a species obtains carbon from organic compounds then there are two possible subtypes of these heterotrophs :

- Photoheterotroph—obtains energy from light but must still obtain carbon in an organic form
- Chemoheterotroph—obtains energy from the consumption of organic or inorganic molecules, and utilizes an organic source of carbon

Hexylresorcinol : It is a chemical compound with anaesthetic, antiseptic and antihelmintic properties. It can be used topically on small skin infections, or as an ingredient in throat lozenges. In vivo studies conducted on Synovea HR Hexylresorcinol by Sytheon in January 2007 have shown that it has the same lightening effect as 2% hydroquinone over an 8 week period.

An ingredient in Strepsils Extra (but not Strepsils Original). A study published in Chemical Research in Toxicology in March 2009 shows that 4-hexylresorcinol used as a food additive (E-586) exhibits some estrogenic activity, i.e. resembles action of the female sex hormone estrogen.

HRF cell : An HRF cell is a bacterium with a conjugative plasmid (often the F-factor) integrated into its genomic DNA. Hfr is the abbreviation for *high frequency recombination,* which was first characterized by Luca Cavalli-Sforza. Unlike a normal F+ cell, hfr strains will, upon conjugation with a F- cell, attempt to transfer their *entire* DNA through the mating bridge, not to be confused with the pilus. This occurs because the F factor has integrated itself via an insertion point in the bacterial chromosome. Due to the F factor's inherent nature to transfer itself during conjugation, the rest of the bacterial genome is dragged along with it, thus making such cells very useful and interesting in terms of studying gene linkage and recombination. Because the genome's rate of transfer through the pilus is constant, molecular biologists and geneticists can use Hfr strain of bacteria (often *E. coli*) to study genetic linkage and map the chromosome. The procedure commonly used for this is called interrupted mating.

Highlands J (HJ) virus : It is a zoonotic alphavirus native to North and South America. It maintains a natural reservoir in the songbird population of freshwater swamps (generally scrub jays and blue jays) and is transmitted by the bite of the female Culiseta melanura mosquito.

Though nearly identical in structure and natural cycle to the Eastern equine encephalitis virus, it is considerably less virulent than its cousin, causing relatively mild symptoms in its primary avian reservoir and only nominally capable of zoonotic transmission to mammals. A 1995 study conducted in Florida swampland found that 15% of swamp-dwelling jays tested positive for HJ antibodies, all of which were asymptomatic and in apparent good health. Recorded bird deaths from HJ infection are uncommon but not rare, and include several domestic turkeys at a commercial facility and young broiler chickens in an experimental setting.

Transmission to equines or humans via mosquito is also possible, though even more rare. During the 1990-1991 St. Louis encephalitis outbreak in Missouri, 4 patients were found to be comorbidly infected with SLE and HJ, though no harmful effects were attributed to the HJ alone. A limited survey of swamp-dwelling rodents in Florida found one cotton mouse and one cotton rat with antibodies to HJ, both asymptomatic. The sole mammalian fatality attributed to HJ was a Florida horse originally diagnosed with Western equine encephalitis in 1964, which was later redetermined in 1989 to have been caused by HJ.

Histoplasmosis : It is a disease caused by the fungus Histoplasma capsulatum. Symptoms of this infection vary greatly, but the disease primarily affects the lungs. Occasionally, other organs are affected; this is called disseminated histoplasmosis, and it can be fatal if untreated. Histoplasmosis is common among AIDS patients because of their lowered immune system.

If symptoms of histoplasmosis infection occur, they will start within 3 to 17 days after exposure; the average is 12–14 days. Most affected individuals have clinically silent manifestations and show no apparent ill effects. The acute phase of histoplasmosis is characterized by non-specific respiratory symptoms, often cough or flu-like. Chest X-ray findings are normal in 40–70% of cases. Chronic histoplasmosis cases can resemble tuberculosis; disseminated histoplasmosis affects multiple organ systems and is fatal unless treated. While histoplasmosis is the most common cause of malaria mediastinitis, this remains a relatively rare disease. Severe infections can cause hepatosplenomegaly, lymphadenopathy, and adrenal enlargement. Lesions have a tendency to calcify as they heal. Ocular histoplasmosis damages the retina of the eyes. Scar tissue is left on the retina which can experience leakage, resulting in a loss of vision not unlike macular degeneration.

Hok/sok system : Host killing/suppressor of killing system, also known as hok/sok system, in molecular biology, is a postsegregational killing system of the plasmid R1 of *Escherichia coli*. Put simply, the system is controlled by two genes, *hok* and *sok*, which code what can be thought of as a long-lived poison, and a short-lived antidote, respectively. After cell division, daughter cells without a copy of the plasmid die because the poison from the parent cell is still active while the short-lived antidote is not. Only cells with a plasmid can produce more antidote and survive. For this reason, the killing system is "postsegregational", since cell death occurs after segregation of the plasmid.

The *hok* gene codes for a 52 amino acid toxic protein which causes cell death by depolarization of the cell membrane. The translation of *hok* mRNA is, however, inhibited by the transcript of the *sok* gene, which is an antisense regulator. This then binds to the *hok* mRNA forming a duplex which is recognized by the RNase III and degraded. The killing mechanism is obtained through differential decay rates of the *hok* and *sok* transcripts. While *hok* mRNA is quite stable, *sok*-RNA is rapidly degraded, which would allow *hok* to be expressed. However, the higher rate of transcription of *sok* compensates for this, leaving *hok* mRNA untranslated in plasmid-containing cells. The loss of plasmid causes the *hok* mRNA not to be inhibited by *sok* antisense, which leads to protein expression and cell death.

Hopanoids : Hopanoids are pentacyclic compounds similar to sterols, whose primary function is to improve plasma membrane fluidity in Bacteria. Cholesterol serves a similar function in eukaryotes (including humans). This relationship between biochemical structure and cellular function can be seen in the similarity of the basic structures of diploptene, a hopanoid compound found in some prokaryotic cell membranes, and cholesterol, a sterol compound found in eukaryotic membranes.

In many bacteria hopanoids may play important roles in the adjustment of cell membrane permeability and adaptation to extreme environmental conditions. They are formed in the aerial hyphae—spore bearing structures—of the prokaryotic soil bacteria *Streptomyces*, where they are thought to minimise water loss across the membrane to the air. This is a physiological adaptation not faced by most bacteria which mainly live in water, but similar adaptations are needed by eukaryotic fungi that produce aerial spore bearing hyphae. In the ethanol fermenting bacterium *Zymomonas mobilis* hopanoids may have a role in adaptation of cell membranes to ethanol accumulation and to temperature changes which influence membrane functions. In the actinomycete *Frankia*, the hopanoids in diazovesicle membranes likely restrict the entry of oxygen by making the lipid bilayer more tight and compact.

Horizontal gene transfer (HGT) : Any process in which an organism incorporates genetic material from another organism without being the offspring of that

organism. By contrast, *vertical transfer* occurs when an organism receives genetic material from its ancestor, e.g. its parent or a species from which it evolved. Most thinking in genetics has focused upon vertical transfer, but there is a growing awareness that horizontal gene transfer is a highly significant phenomenon, and amongst single-celled organisms perhaps the dominant form of genetic transfer. Artificial horizontal gene transfer is a form of genetic engineering.

Horizontal gene transfer was first described in Japan in a 1959 publication that demonstrated the transfer of antibiotic resistance between different species of bacteria. In the mid-1980s, Syvanen predicted that lateral gene transfer existed, had biological significance, and was involved in shaping evolutionary history from the beginning of life on earth.

Host : A host is an organism that harbors a virus or parasite, or a mutual or commensal symbiont, typically providing nourishment and shelter. In botany, a host plant is one that supplies food resources and substrate for certain insects or other fauna. Examples of such interactions include a cell being host to a virus, a legume plant hosting helpful nitrogen-fixing bacteria, and animals as hosts to parasitic worms, e.g. nematodes.

A host cell is a living cell in which a virus reproduces. A primary host or definitive host is a host in which the parasite reaches maturity and, if applicable, reproduces sexually. A secondary host or intermediate host is a host that harbors the parasite only for a short transition period, during which (usually) some developmental stage is completed. For trypanosomes, the cause of sleeping sickness, humans are the primary host, while the tsetse fly is the secondary host. Cestodes (tapeworms) and other parasitic flatworms have complex life-cycles, in which specific developmental stages are completed in a sequence of several different hosts.

As the life cycles of many parasites are not well understood, sometimes the "more important" organism is arbitrarily defined as definitive, and this designation may continue even after it is determined to be incorrect. For example, sludge worms are sometimes considered "intermediate hosts" for whirling disease, even though it is known that the parasite causing the disease reproduces sexually inside them.

In *Trichinella spiralis,* the roundworm that causes trichinosis, a host has both reproductive adults in its digestive tract and immature juveniles in its muscles, and is therefore considered both an intermediate host and a definitive host.

A paratenic host is similar to an intermediate host, only that it is not needed for the parasite's development cycle to progress. There are also reservoir hosts. A reservoir can harbor a pathogen indefinitely with no ill effects. A single reservoir host may be reinfected several times. The difference between a paratenic and reservoir host is that the latter is a primary host, whereas paratenic hosts serve

as "dumps" for non-mature stages of a parasite which they can accumulate in high numbers. A dead-end host is an intermediate host that does generally not allow transmission to the definite host, thereby preventing the parasite from completing its development. For example, humans are dead-end hosts for *Echinococcus* canine tapeworms. As infected humans are not usually eaten by dogs, foxes etc., the immature *Echinococcus*—although it causes serious disease in the dead-end host—is unable to infect the primary host and mature. Also called Incidental host. Host of Predilection is the host preffered by a parasite. Amplifying host is a host in which the level of pathogen can become high enough that a vector such as a mosquito that feeds on it will probably become infectious.

The host range or host specificity of a parasite is the collection of hosts that an organism can utilize as a partner. In the case of human parasites, the host range influences the epidemiology of the parasitism or disease. For instance, the production of antigenic shifts in Influenza A virus can result from pigs being infected with the virus from several different hosts (such as human and bird). This co-infection provides an opportunity for mixing of the viral genes between existing strains, thereby producing a new viral strain. An influenza vaccine produced against an existing viral strain might not be effective against this new strain, which then requires a new influenza vaccine to be prepared for the protection of the human population.

Host tropism : It is the name given a process of tropism that determines which cells can become infected by a given pathogen. Various factors determine the ability of a pathogen to infect a particular cell. Viruses, for example, must bind to specific cell surface receptors to enter a cell. If a cell does not express these receptors then the virus cannot normally infect it.

Viral tropism is determined by a combination of susceptibility and permissiveness: a host cell must be both permissive (allow viral entry) and susceptible (possess the receptor compliment needed for viral entry) for a virus to establish infection.

An example of this is the HIV virus, which exhibits tropism for CD4- related immune cells (eg T helper cells, macrophages or dendritic cells). These cells express a CD4 receptor, to which the HIV virus can bind, through the gp120 and gp41 proteins on its surface.

Human immunodeficiency virus (HIV) : It is a lentivirus (a member of the retrovirus family) that can lead to *acquired immunodeficiency syndrome* (AIDS), a condition in humans in which the immune system begins to fail, leading to life-threatening opportunistic infections. Previous names for the virus include human T-lymphotropic virus-III (HTLV-III), lymphadenopathy-associated virus (LAV), and AIDS-associated retrovirus (ARV).

Infection with HIV occurs by the transfer of blood, semen, vaginal fluid, pre-ejaculate, or breast milk. Within these bodily fluids, HIV is present as both free virus particles and virus within infected immune cells. The four major routes of transmission are unprotected sexual intercourse, contaminated needles, breast milk, and transmission from an infected mother to her baby at birth (Vertical transmission). Screening of blood products for HIV has largely eliminated transmission through blood transfusions or infected blood products in the developed world.

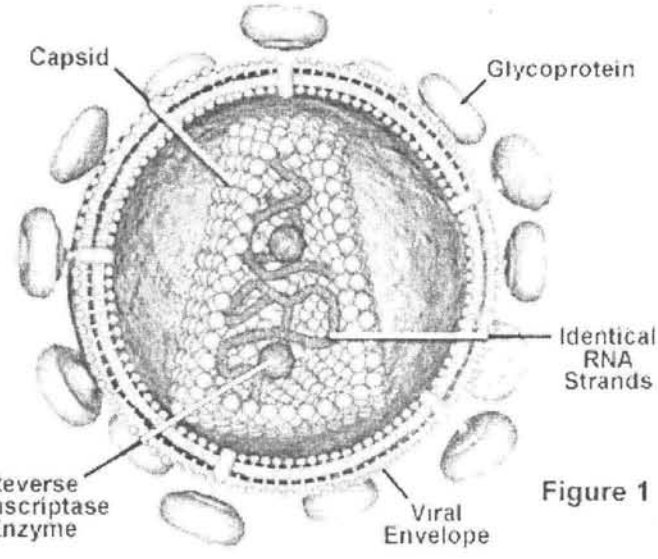


Figure 1

Human immunodeficiency virus

HIV infection in humans is now pandemic. As of January 2006, the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organization (WHO) estimate that AIDS has killed more than 25 million people since it was first recognized on December 1, 1981. It is estimated that about 0.6 percent of the world's population is infected with HIV. In 2005 alone, AIDS claimed an estimated 2.4–3.3 million lives, of which more than 570,000 were children. A third of these deaths are occurring in sub-Saharan Africa, retarding economic growth and increasing poverty. According to current estimates, HIV is set to infect 90 million people in Africa, resulting in a minimum estimate of 18 million orphans. Antiretroviral treatment reduces both the mortality and the morbidity of HIV infection, but routine access to antiretroviral medication is not available in all countries.

Human respiratory syncytial virus (RSV) : RSV causes respiratory tract infections. It is the major cause of lower respiratory tract infection and hospital visits during infancy and childhood. There is no vaccine, and the only treatment is oxygen. In temperate climates there is an annual epidemic during the winter months. In tropical climates, infection is most common during the rainy season.

In the United States, 60% of infants are infected during their first RSV season, and nearly all children will have been infected with the virus by 2-3 years of age. Natural infection with RSV does not induce protective immunity, and thus people can be infected multiple times. Sometimes an infant can become symptomatically infected more than once even within a single RSV season. Severe RSV infections have increasingly been found among elderly patients.

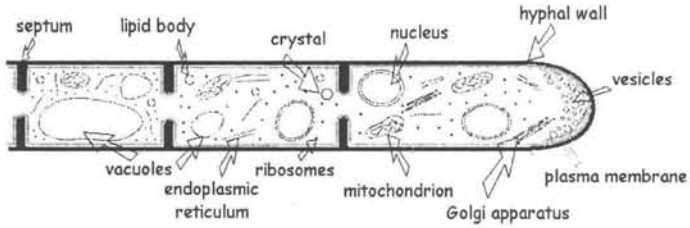
RSV is a negative-sense, single-stranded RNA virus of the family *Paramyxoviridae*, which includes common respiratory viruses such as those causing measles and mumps. RSV is a member of the paramyxovirus subfamily Pneumovirinae. Its name comes from the fact that F proteins on the surface of the virus cause the cell membranes on nearby cells to merge, forming syncytia.

Human T-lymphotropic virus Type I (HTLV-1) : It is a human RNA retrovirus that causes T-cell leukemia and T-cell lymphoma in adults and may also be involved in certain demyelinating diseases, including tropical spastic paraparesis. The HTLV-1 genome is composed of two copies of a single-stranded RNA virus whose genome is copied into a double-stranded DNA form that integrates into the host cell genome, at which point the virus is referred to as a provirus. Adult T-lymphotropic virus (ATLV) is a strain of this disease that affects primarily adults. A closely related virus is bovine leukemia virus BLV.

Hypha : A hypha (plural hyphae) is a long, branching filamentous cell of a fungus, and also of unrelated Actinobacteria. In fungi, hyphae are the main mode of vegetative growth, and are collectively called a mycelium. A hypha consists of one or more cells surrounded by a tubular cell wall. In most fungi, hyphae are divided into cells by internal cross-walls called septa (singular septum). Septa are usually perforated by pores large enough for ribosomes, mitochondria and sometimes nuclei to flow among cells. The structural polymer in fungal cell walls is typically chitin (in contrast plants have cellulosic cell walls, and animal cells lack walls). Some fungi however, have non-septate hypha, meaning their hypha are not separated by septa.

Hyphae grow at their tips. During tip growth, cell walls are extended by the external assembly and polymerization of cell wall components, and the internal production of new cell membrane. The spitzenkörper is an intracellular organelle associated with tip growth. It is composed of an aggregation of membrane-bound

vesicles containing cell wall components. The spitzenkörper is part of the endomembrane system of fungi, holding and releasing vesicles it receives from the Golgi apparatus, which then travel to the cell membrane via the cytoskeleton, and dump their contents outside the cell by the process of exocytosis, where it can then be transported to where it is needed. Vesicle membranes contribute to growth of the cell membrane while their contents form new cell wall. The spitzenkörper moves along the apex of the hyphal strand and generates apical growth and branching; the apical growth rate of the hyphal strand parallels and is regulated by the movement of the spitzenkörper.



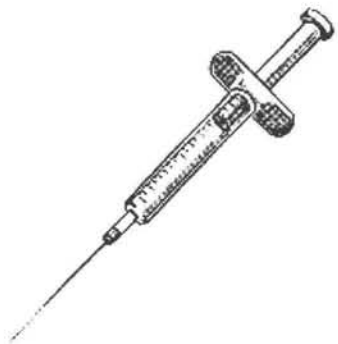
Structure of a hypha

As a hypha extends, septa may be formed behind the growing tip to partition each hypha into individual cells. Hyphae can branch through bifurcation of a growing tip, or by the emergence of a new tip from an established hypha.

Hypodermic needle : A hypodermic needle is a hollow needle commonly used with a syringe to inject substances into the body or extract liquids from the body. They may also be used to take liquid samples from the body, for example taking blood from a vein in venipuncture. A hypodermic needle is used for rapid delivery of a drug, or when the injected substance cannot be ingested, either because it would not be absorbed (as with insulin), or because it would harm the liver (as with testosterone). There are many possible routes for an injection.

Hypodermic needles are normally made from a stainless-steel tube drawn through progressively smaller dies to make the needle. The end is bevelled to create a sharp pointed tip. This lets the needle easily penetrate the skin. When a hypodermic needle is inserted, the bevel should be facing upwards. Hypodermic needles are usually used by medical professionals (physicians, nurses, paramedics), but they are sometimes used by patients themselves. This is most common with type one diabetics, who may require several insulin injections a day. It also occurs with

patients who have asthma or other severe allergies. Such patients may need to take desensitization injections; or they may need to carry injectable medicines to use for first aid in case of a severe allergic reaction. Such patients often carry a syringe loaded with epinephrine (e.g. EpiPen); some also carry syringes loaded with Benadryl and Decadron.



Hypodermic needle

The rapid injection of these drugs may stop a severe allergic reaction, prevent anaphylactic shock, and make an emergency room trip unnecessary, although it may be disconcerting to spectators. Hypodermic needles are also used in recreational intravenous drug use, and to limit the spreading of blood born diseases like Hepatitis and HIV through sharing of injection equipment, many countries now have Needle exchanges in most of their larger cities. Though the dispensing of hypodermic syringes used to be limited to those with a prescription in most countries, nowadays the large majority of countries allow the dispensing of hypodermic syringes without a prescription, and are often even government subsidised through Needle exchange programs.

I

Ice-minus bacteria : Is a nickname given to a variant of the common bacterium *Pseudomonas syringae* (*P. syringae*). This strain of *P. syringae* lacks the ability to produce a certain surface protein, usually found on wild-type "ice-plus" *P. syringae*. The "ice-plus" protein (Ina protein, "Ice nucleation-active" protein) found on the outer bacterial cell wall acts as the nucleating centers for ice crystals. This facilitates ice formation, hence the designation "ice-plus." The ice-minus variant of *P. syringae* is a mutant, lacking the gene responsible for ice-nucleating surface protein production. This lack of surface protein provides a less favorable environment for ice formation. Both strains of *P. syringae* occur naturally, but recombinant DNA technology has allowed for the synthetic removal or alteration of specific genes, enabling the creation of the ice-minus strain. Modifying *P. syringae* may have unexpected consequences for climate. A study has shown that its ice nucleating proteins may play an important part in causing ice crystals to form in clouds. If humans increase the frequency of bacteria lacking these proteins then it may affect rainfall.

Immune system : An immune system is a collection of biological processes within an organism that protects against disease by identifying and killing pathogens and tumour cells. It detects a wide variety of agents, from viruses to parasitic worms, and needs to distinguish them from the organism's own healthy cells and tissues in order to function properly. Detection is complicated as pathogens can evolve rapidly, producing adaptations that avoid the immune system and allow the pathogens to successfully infect their hosts.

To survive this challenge, multiple mechanisms evolved that recognize and neutralize pathogens. Even simple unicellular organisms such as bacteria possess enzyme systems that protect against viral infections. Other basic immune mechanisms evolved in ancient eukaryotes and remain in their modern descendants, such as plants, fish, reptiles, and insects. These mechanisms include antimicrobial peptides called defensins, phagocytosis, and the complement system. Vertebrates such as humans have even more sophisticated defense

mechanisms. The immune systems of vertebrates consist of many types of proteins, cells, organs, and tissues, which interact in an elaborate and dynamic network. As part of this more complex immune response, the human immune system adapts over time to recognise specific pathogens more efficiently. This adaptation process is referred to as "adaptive immunity" or "acquired immunity" and creates immunological memory. Immunological memory created from a primary response to a specific pathogen, provides an enhanced response to secondary encounters with that same, specific pathogen. This process of acquired immunity is the basis of vaccination.

Disorders in the immune system can result in disease. Immunodeficiency diseases occur when the immune system is less active than normal, resulting in recurring and life-threatening infections. Immunodeficiency can either be the result of a genetic disease, such as severe combined immunodeficiency, or be produced by pharmaceuticals or an infection, such as the acquired immune deficiency syndrome (AIDS) that is caused by the retrovirus HIV. In contrast, autoimmune diseases result from a hyperactive immune system attacking normal tissues as if they were foreign organisms. Common autoimmune diseases include Hashimoto's Thyroiditis, rheumatoid arthritis, diabetes mellitus type 1 and lupus erythematosus. Immunology covers the study of all aspects of the immune system which has significant relevance to human health and diseases. Further investigation in this field is expected to play a serious role in promotion of health and treatment of diseases.

Immunity : Immunity is a biological term that describes a state of having sufficient biological defenses to avoid infection, disease, or other unwanted biological invasion. Immunity involves both specific and non-specific components. The non-specific components act either as barriers or as eliminators of wide range of pathogens irrespective of antigenic specificity. Other components of the immune system adapt themselves to each new disease encountered and are able to generate pathogen-specific immunity.

Adaptive immunity is often sub-divided into two major types depending on how the immunity was introduced. Naturally acquired immunity occurs through contact with a disease causing agent, when the contact was not deliberate, where as artificially acquired immunity develops only through deliberate actions such as vaccination. Both naturally and artificially acquired immunity can be further subdivided depending on whether immunity is induced in the host or passively transferred from a immune host. Passive immunity is acquired through transfer of antibody or activated T-cells from an immune host, and is short lived, usually lasts only a few months, whereas active immunity is induced in the host itself by antigen, and lasts much longer, sometimes life-long.

Immunodeficiency : It is a state in which the immune system's ability to fight infectious disease is compromised or entirely absent. Most cases of immunodeficiency are acquired ("secondary") but some people are born with defects in the immune system, or primary immunodeficiency. Transplant patients take medications to suppress their immune system as an anti-rejection measure, as do some patients suffering from an over-active immune system. A person who has an immunodeficiency of any kind is said to be immunocompromised. An immunocompromised person may be particularly vulnerable to opportunistic infections, in addition to normal infections that could affect everyone.

Immunology : It is a broad branch of biomedical science that covers the study of all aspects of the immune system in all organisms. It deals with, among other things, the physiological functioning of the immune system in states of both health and disease; malfunctions of the immune system in immunological disorders (autoimmune diseases, hypersensitivities, immune deficiency, transplant rejection); the physical, chemical and physiological characteristics of the components of the immune system in vitro, in situ, and in vivo. Immunology has applications in several disciplines of science, and as such is further divided.

Even before the concept of immunity (from *immunis*, Latin for "exempt") was developed, numerous early physicians characterized organs that would later prove to be part of the immune system. The key primary lymphoid organs of the immune system are thymus and bone marrow, and secondary lymphatic tissues such as spleen, tonsils, lymph vessels, lymph nodes, adenoids, and skin. When health conditions warrant, immune system organs including the thymus, spleen, portions of bone marrow, lymph nodes and secondary lymphatic tissues can be surgically excised for examination while patients are still alive. Many components of the immune system are actually cellular in nature and not associated with any specific organ but rather are embedded or circulating in various tissues located throughout the body.

Immunosuppression : It involves an act that reduces the activation or efficacy of the immune system. Some portions of the immune system itself have immunosuppressive effects on other parts of the immune system, and immunosuppression may occur as an adverse reaction to treatment of other conditions. Deliberately induced immunosuppression is generally done to prevent the body from rejecting an organ transplant, treating graft-versus-host disease after a bone marrow transplant, or for the treatment of auto-immune diseases such as rheumatoid arthritis or Crohn's zdisease. This is typically done using drugs, but may involve surgery (splenectomy), plasmapharesis, or radiation.

A person who is undergoing immunosuppression, or whose immune system is weak for other reasons (for example, chemotherapy and HIV patients) is said to

be *immunocompromised*. When an organ is transplanted, the immune system of the recipient will most likely recognize it as foreign tissue and attack it. The destruction of the organ will, if untreated, end in the death of the recipient. In the past, radiation therapy was used to decrease the strength of the immune system, but now immunosuppressant drugs are used to inhibit the reaction of the immune system. The downside is that with such a deactivated immune system, the body is very vulnerable to opportunistic infections, even those usually considered harmless. Also, prolonged use of immunosuppressants increases the risk of cancer.

Cortisone was the first immunosuppressant identified, but its wide range of side effects limited its use. The more specific azathioprine was identified in 1959, but it was the discovery of cyclosporine in 1970 that allowed for significant expansion of kidney transplantation to less well-matched donor-recipient pairs as well as broad application of liver transplantation, lung transplantation, pancreas transplantation, and heart transplantation.

Dr. Joseph Murray of Harvard Medical School and chief plastic surgeon at Children's Hospital Boston from 1972-1985 was awarded the Nobel Prize in Physiology or Medicine in 1990 for his work on immunosuppression. Dr. Murray and his team are credited with first successful human kidney transplant at Peter Bent Brigham Hospital, Boston on 23 December 1954.

In vitro : In vitro (Latin for within the glass) refers to the technique of performing a given procedure in a controlled environment outside of a living organism. Some may argue that in vitro refers to a process that is created in a "test tube"; however, Robert Kail and John Cavanaugh on page 58 in the 4th edition of Human Development : A Life-Span View cite that in fact the process is contained in a petri dish. Many experiments in cellular biology are conducted outside of organisms or cells; because the test conditions may not correspond to the conditions inside of the organism, this may lead to results that do not correspond to the situation that arises in a living organism. Consequently, such experimental results are often annotated with in vitro, in contradistinction with in vivo.

This type of research aims at describing the effects of an experimental variable on a subset of an organism's constituent parts. It tends to focus on organs, tissues, cells, cellular components, proteins, and/or biomolecules. it is better suited for deducing the mechanisms of action. With fewer variables and perceptually amplified reactions to subtle causes, results are generally more discernible. The massive adoption of low-cost in vitro molecular biology techniques has caused a shift away from in vivo research which is more idiosyncratic and expensive in comparison to its molecular counterpart. Currently, in vitro research is both vital and highly productive.

In vivo : In vivo (Latin for "within the living") refers to experimentation using a whole, living organism as opposed to a partial or dead organism, or a in vitro controlled environment. Animal testing and clinical trials are two forms of in vivo research. In vivo testing is often employed over in vitro because it is better suited for observing the overall effects of an experiment on a living subject. In molecular biology in vivo is often used to refer to experimentation done in live isolated cells rather than in a whole organism, for example, cultured cells derived from biopsies. In this situation, the more specific term is ex vivo. Once cells are disrupted and individual parts are tested or analyzed, this is known as in vitro.

According to Christopher Lipinski and Andrew Hopkins, "Whether the aim is to discover drugs or to gain knowledge of biological systems, the nature and properties of a chemical tool cannot be considered independently of the system it is to be tested in. Compounds that bind to isolated recombinant proteins are one thing; chemical tools that can perturb cell function another; and pharmacological agents that can be tolerated by a live organism and perturb its systems are yet another. If it were simple to ascertain the properties required to develop a lead discovered in vitro to one that is active in vivo, drug discovery would be as reliable as drug manufacturing."

In the past, the guinea pig was such a commonly used in vivo experimental subject that they became part of idiomatic English : to be a guinea pig. However, they have largely been replaced by their smaller, cheaper, and faster breeding cousins, rats and mice.

Inclusion bodies : These are nuclear or cytoplasmic aggregates of stainable substances, usually proteins. They typically represent sites of viral multiplication in a bacterium or a eukaryotic cell and usually consist of viral capsid proteins. Protein inclusion bodies are classically thought to contain misfolded protein. However, this has recently been contested, as green fluorescent protein will sometimes fluoresce in inclusion bodies, which indicates some semblance of the native structure and researchers have recovered folded protein from inclusion bodies.

When genes from one organism are expressed in another the resulting protein sometimes forms inclusion bodies. This is often true when large evolutionary distances are crossed : a cDNA isolated from Eukarya for example, and expressed as a recombinant gene in a prokaryote risks the formation of the inactive aggregates of protein known as inclusion bodies. While the cDNA may properly code for a translatable mRNA, the protein that results will emerge in a foreign microenvironment. This often has fatal effects, especially if the intent of cloning is to produce a biologically active protein. For example, eukaryotic systems for carbohydrate modification and membrane transport are not found in prokaryotes. The internal microenvironment of a prokaryotic cell (pH, osmolarity) may differ

from that of the original source of the gene. Mechanisms for folding a protein may also be absent, and hydrophobic residues that normally would remain buried may be exposed and available for interaction with similar exposed sites on other ectopic proteins. Processing systems for the cleavage and removal of internal peptides would also be absent in bacteria. The initial attempts to clone insulin in a bacterium suffered all of these deficits. In addition, the fine controls that may keep the concentration of a protein low will also be missing in a prokaryotic cell, and overexpression can result in filling a cell with ectopic protein that, even if it were properly folded, would precipitate by saturating its environment.

Indicator bacteria : These are certain species of bacteria used by health authorities to detect contaminated water. Each gram of human feces contains approximately 12 billion bacteria, among them may include pathogenic bacteria, such as *Salmonella*, associated with gastroenteritis. In addition, feces may contain pathogenic viruses, protozoa and parasites. If ingested, these organisms would cause disease. When testing drinking water for contamination, the variety and often low concentrations of pathogens makes them difficult to test for individually. Health authorities therefore use the presence of other more abundant and more easily detected fecal bacteria as indicators of the presence of fecal contamination.

Indicator bacteria are not themselves dangerous to the health but are used to indicate the presence of a health risk.The most popularized known indicator bacteria are fecal coliforms, which are found in the intestinal tracts of warm blooded animals. Another less commonly used group of indicator organisms are hydrogen sulfide producing bacteria, which are also found in humans as well as the intestinal tracts of birds and reptiles—known carriers of Salmonella.

Industrial microbiology : Industrial microbiology encompasses the use of microorganisms in the manufacture of food or industrial products. The use of microorganisms for the production of food, either human or animal, is often considered a branch of food microbiology. The microorganisms used in industrial processes may be natural isolates, laboratory selected mutants or genetically engineered organisms.

Yogurt, cheese, chocolate, butter, pickles, sauerkraut, soya sauce, vitamins, amino acids, food thickeners (microbial polysaccharides), alcohol, sausages, and silage (animal food) are all produced by industrial microbiology processes. "Good" bacteria such as probiotics are becoming increasingly important in the food industry. A huge variety of biopolymers, such as polysaccharides, polyesters, and polyamides, are produced by microorganisms. These products range from viscous solutions to plastics. The genetic manipulation of microorganisms has permitted the biotechnological production of biopolymers with tailored material properties suitable for high-value medical application such as tissue engineering and drug

delivery. Industrial microbiology can be used for the biosynthesis of xanthan, alginate, cellulose, cyanophycin, poly(gamma-glutamic acid), levan, hyaluronic acid, organic acids, oligosaccharides and polysaccharides, and polyhydroxy-alkanoates.

Infectious disease : An infectious disease is a clinically evident disease resulting from the presence of pathogenic microbial agents, including pathogenic viruses, pathogenic bacteria, fungi, protozoa, multicellular parasites, and aberrant proteins known as prions. These pathogens are able to cause disease in animals and/or plants. Infectious pathologies are usually qualified as contagious diseases (also called communicable diseases) due to their potentiality of transmission from one person or species to another. Transmission of an infectious disease may occur through one or more of diverse pathways including physical contact with infected individuals. These infecting agents may also be transmitted through liquids, food, body fluids, contaminated objects, airborne inhalation, or through vector-borne spread.

The term infectivity describes the ability of an organism to enter, survive and multiply in the host, while the infectiousness of a disease indicates the comparative ease with which the disease is transmitted to other hosts. An infection however, is not synonymous with an infectious disease, as an infection may not cause important clinical symptoms or impair host function. Among the almost infinite varieties of microorganisms, relatively few cause disease in otherwise healthy individuals. Infectious disease results from the interplay between those few pathogens and the defenses of the hosts they infect. The appearance and severity of disease resulting from any pathogen depends upon the ability of that pathogen to damage the host as well as the ability of the host to resist the pathogen. Infectious microorganisms, or microbes, are therefore classified as either primary pathogens or as opportunistic pathogens according to the status of host defenses.

Primary pathogens cause disease as a result of their presence or activity within the normal, healthy host, and their intrinsic virulence (the severity of the disease they cause) is, in part, a necessary consequence of their need to reproduce and spread. Many of the most common primary pathogens of humans only infect humans, however many serious diseases are caused by organisms acquired from the environment or which infect non-human hosts.

Inflammation : It is the complex biological response of vascular tissues to harmful stimuli, such as pathogens, damaged cells, or irritants. It is a protective attempt by the organism to remove the injurious stimuli as well as initiate the healing process for the tissue. Inflammation is not a synonym for infection. Even in cases where inflammation is caused by infection, the two are not synonymous : infection is caused by an exogenous pathogen, while inflammation is the response of the

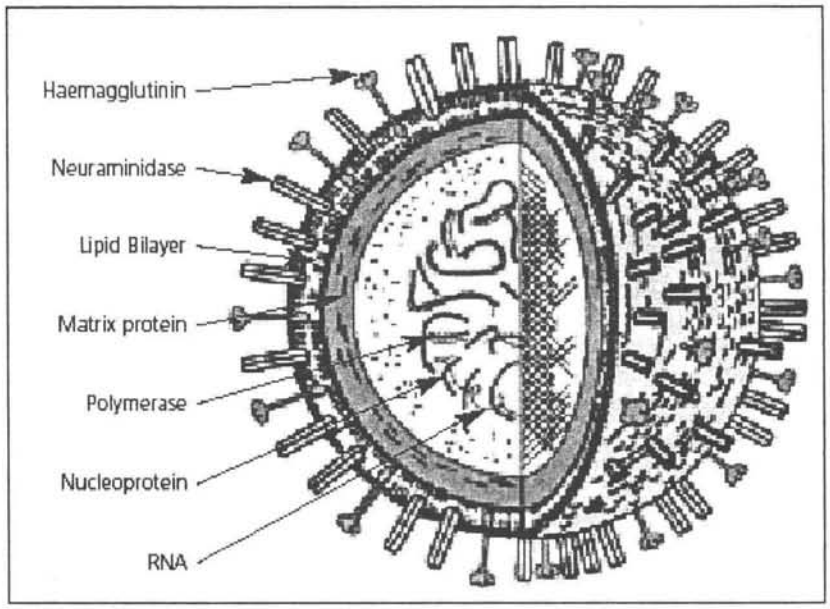
organism to the pathogen. In the absence of inflammation, wounds and infections would never heal and progressive destruction of the tissue would compromise the survival of the organism. However, an inflammation that runs unchecked can also lead to a host of diseases, such as hay fever, atherosclerosis, and rheumatoid arthritis. It is for that reason that inflammation is normally closely regulated by the body.

Inflammation can be classified as either *acute* or *chronic*. *Acute inflammation* is the initial response of the body to harmful stimuli and is achieved by the increased movement of plasma and leukocytes from the blood into the injured tissues. A cascade of biochemical events propagates and matures the inflammatory response, involving the local vascular system, the immune system, and various cells within the injured tissue. Prolonged inflammation, known as *chronic inflammation*, leads to a progressive shift in the type of cells which are present at the site of inflammation and is characterised by simultaneous destruction and healing of the tissue from the inflammatory process.

Influenza : Commonly referred to as the flu, is an infectious disease caused by RNA viruses of the family Orthomyxoviridae (the influenza viruses), that affects birds and mammals. The name *influenza* comes from the Italian *influenza*, meaning "influence" (Latin : *influentia*). The most common symptoms of the disease are chills, fever, sore throat, muscle pains, severe headache, coughing, weakness and general discomfort. Fever and coughs are the most frequent symptoms. In more serious cases, influenza causes pneumonia, which can be fatal, particularly for the young and the elderly. Although it is often confused with other influenza-like illnesses, especially the common cold, influenza is a much more severe disease than the common cold and is caused by a different type of virus. Influenza may produce nausea and vomiting, particularly in children, but these symptoms are more common in the unrelated gastroenteritis, which is sometimes called "stomach flu" or "24-hour flu".

Typically, influenza is transmitted through the air by coughs or sneezes, creating aerosols containing the virus. Influenza can also be transmitted by bird droppings, saliva, nasal secretions, feces and blood. Infections also occur through contact with these body fluids or with contaminated surfaces. Airborne aerosols have been thought to cause most infections, although which means of transmission is most important is not absolutely clear. Influenza viruses can be inactivated by sunlight, disinfectants and detergents. As the virus can be inactivated by soap, frequent hand washing reduces the risk of infection. Influenza spreads around the world in seasonal epidemics, resulting in the deaths of hundreds of thousands annually—millions in pandemic years. Three influenza pandemics occurred in the 20th century and killed tens of millions of people, with each of these pandemics being caused by the appearance of a new strain of the virus in humans. Often, these

new strains appear when an existing flu virus spreads to humans from other animal species, or when an existing human strain picks up new genes from an a virus that usually infects birds or pigs. An avian strain named H5N1 raised the concern of a new influenza pandemic, after it emerged in Asia in the 1990s, but it has not evolved to a form that spreads easily between people.



Influenza virion

Vaccinations against influenza are usually given to people in developed countries and to farmed poultry. The most common human vaccine is the trivalent influenza vaccine (TIV) that contains purified and inactivated material from three viral strains. Typically, this vaccine includes material from two influenza A virus subtypes and one influenza B virus strain. The TIV carries no risk of transmitting the disease, and it has very low reactivity. A vaccine formulated for one year may be ineffective in the following year, since the influenza virus evolves rapidly, and new strains quickly replace the older ones. Antiviral drugs can be used to treat influenza, with neuraminidase inhibitors being particularly effective.

Innate immune system : The innate immune system comprises the cells and mechanisms that defend the host from infection by other organisms, in a non-specific manner. This means that the cells of the innate system recognize and respond to pathogens in a generic way, but unlike the adaptive immune system, it does not confer long-lasting or protective immunity to the host. Innate immune systems provide immediate defense against infection, and are found in all classes of plant and animal life.

The innate system is thought to constitute an evolutionarily older defense strategy, and is the dominant immune system found in plants, fungi, insects, and in primitive multicellular organisms. The major functions of the vertebrate innate immune system include :

- Recruiting immune cells to sites of infection and inflammation, through the production of chemical factors, including specialized chemical mediators, called cytokines.
- Activation of the complement cascade to identify bacteria, activate cells and to promote clearance of dead cells or antibody complexes.
- The identification and removal of foreign substances present in organs, tissues, the blood and lymph, by specialized white blood cells.
- Activation of the adaptive immune system through a process known as antigen presentation.

Integron : An integron is a gene capture system found in plasmids, chromosomes and transposons. Pieces of DNA called gene cassettes can be incorporated, expressed, and disseminated. An integron with a large number of cassettes may be called a super-integron, as in Vibrio cholerae chromosome 2. A cassette may encode genes for antibiotic resistance, although most genes in integrons are uncharacterized. An integron contains an integrase (int1) related to those of a phage, followed by an *attI* site for integration of cassettes and recognition of the integrase , and a promoter to drive expression. An integron may appear in a plasmid or on the chromosome. An *attC* sequence is a repeat that flanks cassettes and enables cassettes to be integrated at the *attI* site, excised and undergo horizontal gene transfer.

Intrinsic immunity : Refers to a set of recently discovered cellular based anti-viral defense mechanisms, notably genetically encoded proteins which specifically target eukaryotic retroviruses. Unlike adaptive and innate immunity effectors, intrinsic immune proteins are usually expressed at a constant level, allowing a viral infection to be halted quickly. Eukaryotic organisms have been exposed to viral infections for millions of years. The development of the innate and adaptive immune system reflects the evolutionary importance of fighting infection. Some viruses, however, have proven to be so deadly or refractory to conventional immune mechanisms that specific, genetically encoded cellular defense mechanisms have evolved to combat them. Intrinsic immunity comprises cellular proteins which are always active and have evolved to block infection by specific viruses or viral taxa. The recognition of intrinsic immunity as a potent anti-viral defense mechanism is a recent discovery and is not yet discussed in most immunology courses or texts. Though the extent of protection intrinsic immunity affords is still unknown, it is possible that intrinsic immunity may eventually be considered a third branch of the traditionally bipartite immune system.

J

Jaagsiekte : Is a chronic and contagious disease of the lungs in sheep and goats first described in 1865. Its name derives from Afrikaans and means "Chasing Sickness" such that animals afflicted with the disease are in respiratory distress as if they are out of breath from being chased. It is also referred to as Ovine Pulmonary Adenocarcinoma (OPA). During end-stage disease, animals exude a foamy white fluid from the nose which is thought to be the mode of transmission between animals. Dissected lungs from afflicted sheep are interspersed with multifocal tumors. Some of these are small discrete nodules and others will involve the entire half of a lung lobule. The disease is caused by a retrovirus called the Jaagsiekte Sheep Retrovirus (JSRV) that acutely transforms the lung epithelia into cancerous cells. Specifically, Type-2 pneumocytes and Clara Cells of the lung are the likely target for JSRV transformation. The tumors formed there exhibit the overactive secretory functions which are a hallmark of OPA.

OPA is an infectious disease of sheep and recently has been used as an animal model for human lung cancer. It is common in the UK and in South Africa. The disease has a long incubation period and is not seen until sheep reach at least 2 years of age. Clinical symptoms include weight loss, loss of appetite, and respiratory difficulty which is associated with obvious movement of the abdomen and high pitched noises. Fluid accumulates in the respiratory tract and the disease ultimately causes death. The retroviral antigen levels of JSRV are very high in OPA tumors and can be detected in the lung secretions of infected sheep. A common field assessment for Jaagsiekte is the "wheelbarrow test" where one lifts the hind legs of the animal above the head to observe lung exudate flow out the nose and mouth. This fluid contains infectious JSRV. It is thought that infected animals secrete the virus before showing clinical symptoms and the virus is therefore easily spread within flocks. The disease is histologically similar to human bronchoalveolar carcinoma which accounts for approximately 25% of all diagnosed human lung cancers.

JC virus (John Cunningham virus (JCV) : It is a type of human polyomavirus (formerly known as papovavirus) and is genetically similar to BK virus and SV40. It was discovered in 1971 and named after the two initials of a patient with progressive multifocal leukoencephalopathy (PML). The virus causes PML and other diseases only in cases of immunodeficiency, as in AIDS or during treatment with drugs intended to induce a state of immunosuppression (e.g. organ transplant patients). The virus is very common in the general population, infecting 70 to 90 percent of humans; most people acquire JCV in childhood or adolescence. It is found in high concentrations in urban sewage worldwide, leading some researchers to suspect contaminated water as a typical route of infection. Minor genetic variations are found consistently in different geographic areas; thus, genetic analysis of JC virus samples has been useful in tracing the history of human migration.

K

Kauffman and White classification scheme : Is a classification system that permits serological varieties of the genus *Salmonella* to be differentiated from each other. This scheme differentiates isolates by determining which surface antigens are produced by the bacterium. First, the "O" antigen type is determined. "O" antigens are the polysaccharides associated with the lipopolysaccharide of the bacterial outer membrane. Having found the "O" antigen group, the "H" antigen is determined. The "H" antigens are proteins associated with the bacterial flagella (singular; flagellum). Salmonellas exist in two phases; a motile phase and a non-motile phase. These are also referred to as the specific and non-specific phases. Different "H" antigens are produced depending on the phase in which the salmonella is found. Non-motile isolates may be "switched" to the motile phase using a Cragie tube—bacteria are inoculated down the center of a hollow tube in a semi-solid nutrient agar. Those bacteria that become motile can then swim out of the bottom of the tube and are recovered from the agar outside of the tube. Pathogenic strains of *Salmonella typhi* carry an additional antigen, "Vi", so-called because of the enhanced virulence of strains that produce this antigen, which is associated with a bacterial capsule.

Killer yeasts : These are yeasts, such as *Saccharomyces cerevisiae,* which can carry a double-stranded RNA virus, causing them to secrete a number of toxic proteins which are lethal to receptive cells. These yeast cells are immune to the toxic effects of the protein due to an intrinsic immunity. Killer yeast strains can be a problem in commercial processing because they kill desirable strains.The virus, L-A, is an icosahedral virus of *S. cerevisiae* comprising a 4.6 kb genomic segment and several satellite double-stranded RNA sequences, which are called M dsRNAs. The genomic segment encodes for the viral coat protein and a protein which replicates the viral genomes. The M dsRNAs encode the toxin, of which there are at least three variants in *S. cerevisiae,* and many more variants across all species.

Knallgas-bacteria : Is a name sometimes used for bacteria which oxidize hydrogen. These bacteria include *Hydrogenobacter thermophilus, Hydrogenovibrio marinus,*

and *Helicobacter pylori*. There are both gram positive and negative knallgas bacteria.Most grow best under microaerophilic conditions. They do this because the hydrogenase enzyme used in hydrogen oxidation is inhibited by the presence of oxygen, but oxygen is still needed as a terminal electron acceptor. The word "*Knallgas*" is German for "bang-gas" and means a mixture of hydrogen and oxygen.

Kobuvirus : Is a viral genus belonging to the family *Picornaviridae*. The genus is comprised of two species, *Aichi virus* and *Bovine kobuvirus*, each possessing a single serotype. Aichi virus infects man , while bovine kobuvirus , as suggested by its name, infects cattle. The molecular mass of a typical virion particle of this genus is typically eight to nine million. The virions of the viruses in this genus consist of capsids that are 27 to 30 nm in diameter . The capsid is described as being round and displaying icosahedral symmetry. The capsid is believed to consist of 12 capsomers and the capsid shell structure of these virions has a monolayer composition . Using conventional electron microscopy, the structure of the capsid surface can be visualised . The virus particles contain a single species of ssRNA. These virions have a sedimentation coefficient of 140-165 S20w. The particles are described to be "relatively stable" in vitro (in comparison to other viruses) and stable in acidic conditions of pH 3.5 . They have also been found to be insensitive to treatment with some chemicals including chloroform, ether and non-ionic detergents .

Koch's postulates : These are four criteria designed to establish a causal relationship between a causative microbe and a disease. The postulates were formulated by Robert Koch and Friedrich Loeffler in 1884 and refined and published by Koch in 1890. Koch applied the postulates to establish the etiology of anthrax and tuberculosis, but they have been generalized to other diseases. Koch's postulates are :

- The microorganism must be found in abundance in all organisms suffering from the disease, but should not be found in healthy animals.
- The microorganism must be isolated from a diseased organism and grown in pure culture.
- The cultured microorganism should cause disease when introduced into a healthy organism.
- The microorganism must be reisolated from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent.

However, Koch abandoned the universalist requirement of the first postulate altogether when he discovered asymptomatic carriers of cholera and, later, of

typhoid fever. Asymptomatic or subclinical infection carriers are now known to be a common feature of many infectious diseases, especially viruses such as polio, herpes simplex, HIV and hepatitis C. As a specific example, all doctors and virologists agree that poliovirus causes paralysis in just a few infected subjects, and the success of the polio vaccine in preventing disease supports the conviction that the poliovirus is the causative agent.

The third postulate specifies "should", not "must", because as Koch himself proved in regard to both tuberculosis and cholera, not all organisms exposed to an infectious agent will acquire the infection. Noninfection may be due to : chance or to the host's immune system successfully repulsing the invading pathogen; acquired immunity, as from previous exposure or vaccination; or genetic immunity, as with the resistance to malaria conferred by possessing at least one sickle cell allele.

The second postulate may also be suspended for certain microorganisms which we cannot (at the present time) grow in pure culture, such as HIV-1, HBV and other similar viruses. For further information please look at the Limbic System.

Korarchaeota : These are a group of Archaea that have been found only in high temperature hydrothermal environments. Analysis of their 16S rRNA gene sequences suggests that they are a deeply-branching lineage that does not belong to the main archaeal groups, Crenarchaeota and Euryarchaeota. Analysis of the genome of one korarchaeote that was enriched from a mixed culture revealed a number of both Crenarchaeota- and Euryarchaeota-like features and supports the hypothesis of a deep-branching ancestry.

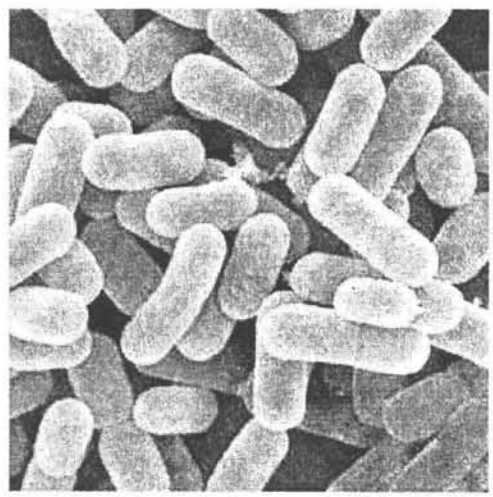
Kudoa thrysites : Is a myxosporean parasite of marine fishes. It has a worldwide distribution, and infects a wide range of host species. This parasite is responsible for causing economic losses to the fisheries sector, by causing post-mortem "myoliquefaction", a softening of the flesh to such an extent that the fish becomes unmarketable. It is not infective to humans. The spores of *K. thyrsites* are stellate in shape, with 4 valves and 4 polar capsules. Upon infection by the actinosporean stage the sporoplasm migrates to a muscle fibre where it forms a pseudocyst. Within these pseudocysts are the developing spore stages. Comparison of 18S rDNA sequences of *Kudoa* species and other myxozoan species to determine their relationships. They show that *Kudoa* species are distinct from other myxozoans analyzed (*Myxidium* sp., *Myxobolus* sp., and *Henneguya zschokkei*). *Kudoa thyrsites* is an interesting member of this group in that apparently has very broad host specificity, infecting many fish species around the world.

Members of the genus Kudoa primarily infect muscle tissue of marine fishes, where they form nodules or pseudocysts containing a great number of individual

spores. In lighter infections these pseudocysts are isolated from the fish's immune system within the muscle fibre. More intense infections can result in severe inflammation surrounding infected muscle fibres. Although apparently asymptomatic in all but heavy infections, they are associated with post-mortem degeneration of the tissue. This softening of flesh is most likely a result the release of proteolytic enzymes by the parasite. This causes losses to both aquaculture operations, for instance, where salmon are being reared in "sea-pens", and to capture fisheries. Losses are both direct, through the degradation of fish products, and indirectly, through the perception of the consumer that fish from a particular area are of a lower quality. The intensity of *K. thyrsites* infection is positively correlated with the severity of flesh softening in Atlantic salmon fillets. Softening of flesh always occurred with heavily infected fillets, while lightly infected fillets showed no softening. Prevention and/or control of *K. thyrsites* infections is problematic especially in open water netpens. Currently there are no available treatments. One approach to control may be to disrupt the life cycle in some way thereby minimizing the likelihood of infection.

L

Lactic acid bacteria (LAB) : Comprise a clade of Gram-positive, low-GC, acid-tolerant, generally non-sporulating, non-respiring rod or cocci that are associated by their common metabolic and physiological characteristics. These bacteria, usually found in decomposing plants and lactic products, produce lactic acid as the major metabolic end-product of carbohydrate fermentation. This trait has, throughout history, linked LAB with food fermentations, as acidification inhibits the growth of spoilage agents. Proteinaceous bacteriocins are produced by several LAB strains and provide an additional hurdle for spoilage and pathogenic microorganisms. Furthermore, lactic acid and other metabolic products contribute to the organoleptic and textural profile of a food item.



Lactic acid bacteria

The industrial importance of the LAB is further evidenced by their reputed safe (GRAS) status, due to their ubiquitous appearance in food and their contribution

to the healthy microflora of human mucosal surfaces. The genera that comprise the LAB are at its core *Lactobacillus, Leuconostoc, Pediococcus, Lactococcus,* and *Streptococcus* as well as the more peripheral *Aerococcus, Carnobacterium, Enterococcus, Oenococcus, Sporolactobacillus, Teragenococcus, Vagococcus,* and *Weisella;* these belong to the order Lactobacillales.

Lactobacillus : Is a genus of Gram-positive facultative anaerobic or microaerophilic bacteria. They are a major part of the lactic acid bacteria group, named as such because most of its members convert lactose and other sugars to lactic acid. They are common and usually benign. In humans they are present in the vagina and the gastrointestinal tract, where they are symbiotic and make up a small portion of the gut flora. Many species are prominent in decaying plant material. The production of lactic acid makes its environment acidic, which inhibits the growth of some harmful bacteria. Several members of the genus have had their genome sequenced.

Some *Lactobacillus* species are used industrially for the production of yogurt, cheese, sauerkraut, pickles, beer, wine, cider, kimchi, chocolate, and other fermented foods, as well as animal feeds, such as silage. Sourdough bread is made using a "starter culture," which is a symbiotic culture of yeast and lactic acid bacteria growing in a water and flour medium. Lactobacilli, especially *L. casei* and *L. brevis,* are some of the most common beer spoilage organisms. The species operate by lowering the pH of the fermenting substance by creating the lactic acid, neutralising it to the desired extent.

Lambda phage : Lambda phage is a virus particle consisting of a head, containing double-stranded linear DNA as its genetic material, and a tail that can have tail fibers. The phage particle injects its DNA into its host through the tail, and the phage will then usually enter the lytic pathway where it replicates its DNA, degrades the host DNA and hijacks the cell's replication, transcription and translation mechanisms to produce as many phage particles as cell resources allow. When cell resources are depleted, the phage will lyse (break open) the host cell, releasing the new phage particles. However, under certain conditions, the phage DNA may integrate itself into the host cell chromosome in the lysogenic pathway. In this state, the DNA is called a prophage and stays resident within the host's genome without apparent harm to the host, which can be termed a lysogen when a prophage is present. The prophage is duplicated with every subsequent cell division of the host. The phage genes expressed in this dormant state code for proteins that repress expression of other phage genes. These proteins are broken down when the host cell is under stress, resulting in the expression of the repressed phage genes. Stress can be from starvation, poisons (like antibiotics), or other factors that can damage or destroy the host. In response to stress, the activated

prophage is excised from the DNA of the host cell by one of the newly expressed gene products and enters its lytic pathway.

Lambda phage was discovered by Esther Lederberg in 1950. It has been used heavily as a model organism, and has been a rich source for useful tools in molecular biology. Uses include its application as a vector for the cloning of recombinant DNA, the use of its site specific recombinase, int, for the shuffling of cloned DNAs by the 'Gateway' method, and the application of its Red operon, including the proteins Red alpha (also called 'exo'), beta and gamma in the DNA engineering method called recombineering.

Lantibiotics : These are a class of peptide antibiotics that contain polycyclic thioether amino acids as well as the unsaturated amino acids dehydroalanine and 2-aminoisobutyric acid. These characteristic cyclic thioether amino acids are composed of either lanthionine or methyllanthionine. Lantibiotics are produced by a large number of Gram positive bacteria such as Streptococcus and Streptomyces to attack other gram positive bacteria and as such they are considered a member of the bacteriocins.

Lantibiotics are well studied because of the commercial use of these bacteria in the food industry for making dairy products such as cheese. Bacteriocins are classified according to their extent of posttranslational modification. The lantibiotics are a class of more extensively modified bacteriocins, also called Class I. Bacteriocins for which disulfide bonds are the only modification to the peptide are Class II bacteriocins. Most bacteriocins are biologically active single-chain peptides. Some are only active as partners with a second peptide.

Nisin and epidermin are members of a family of lantibiotics that bind to a cell wall precursor lipid component of target bacteria and disrupt cell wall production. The duramycin family of lantibiotics binds phosphoethanolamine in the membranes of its target cells and seem to disrupt several physiological functions.

Lassa fever : Is an acute viral hemorrhagic fever first described in 1969 in the town of Lassa, in Borno State, Nigeria located in the Yedseram river valley at the south end of Lake Chad. Clinical cases of the disease had been known for over a decade earlier but not connected with this viral pathogen. The infection is endemic in West African countries, and causes 300-500,000 cases annually with approximately 5,000 deaths. Outbreaks of the disease have been observed in Nigeria, Liberia, Sierra Leone, Guinea, and the Central African Republic, but it is believed that human infections also exist in Democratic Republic of the Congo, Mali, and Senegal. Its primary animal host is the Natal Multimammate Mouse (*Mastomys natalensis*), an animal indigenous to most of Sub-Saharan Africa. Although the rodents are also a source of protein for peoples of these areas, the virus is probably

transmitted by the contact with the feces and urine of animals accessing grain stores in residences.

Lassa fever is caused by the *Lassa virus*, a member of the Arenaviridae family; it is an enveloped, single-stranded, bisegmented RNA virus. Replication for Lassa virus is very rapid, while also demonstrating temporal control in replication. There are two genome segments. The first step involved is making mRNA copies of the—sense genome. This ensures that there is adequate proteins, which are required for replication. The N and L proteins are made from the mRNA produced. The—sense genome then makes viral complementary RNA (vcRNA) copies of itself which are + sense. The vcRNA is a template for producing—sense progeny but mRNA is also synthesized from it. The mRNA synthesized from vcRNA translate the G (spike) proteins and Z proteins. Thus, with this temporal control, the spike proteins are produced last, making the infection further undetected by the host immune system.

Lazzaro Spallanzani : He was an Italian biologist and physiologist who made important contributions to the experimental study of bodily functions and animal reproduction, and whose research of biogenesis paved the way for the investigations of Louis Pasteur.

Lazzaro Spallanzani

He was born in Scandiano, Italy (modern province of Reggio Emilia) and died in Pavia, Italy. Spallanzani was educated at the Jesuit College and started to study law at the University of Bologna, which he gave up soon and turned to science. Here, his famous kinswoman, Laura Bassi, was professor of physics and it is to

her influence that his scientific impulse has been usually attributed. With her he studied natural philosophy and mathematics, and gave also great attention to languages, both ancient and modern, but soon abandoned them.

In 1754, at the age of 25 he became professor of logic, metaphysics and Greek in the University of Reggio, and in 1760 was moved to Modena, where he continued to teach with great assiduity and success, but devoted his whole leisure to natural science. He declined many offers from other Italian universities and from St Petersburg until 1768, when he accepted the invitation of Maria Theresa to the chair of natural history in the university of Pavia, which was then being reorganized. He also became director of the museum, which he greatly enriched by the collections of his many journeys along the shores of the Mediterranean Sea.

In 1785 he was invited to Padua University, but to retain his services his sovereign doubled his salary and allowed him leave of absence for a visit to Turkey where he remained nearly a year and made many observations, among which may be noted those of a copper mine in Chalki and of an iron mine at Principi. His return home was almost a triumphal progress : at Vienna he was cordially received by Joseph II and on reaching Pavia he was met with acclamations outside the city gates by the students of the university. During the following year his students exceeded five hundred. His integrity in the management of the museum was called in question, but a judicial investigation speedily cleared his honour to the satisfaction even of his accusers.

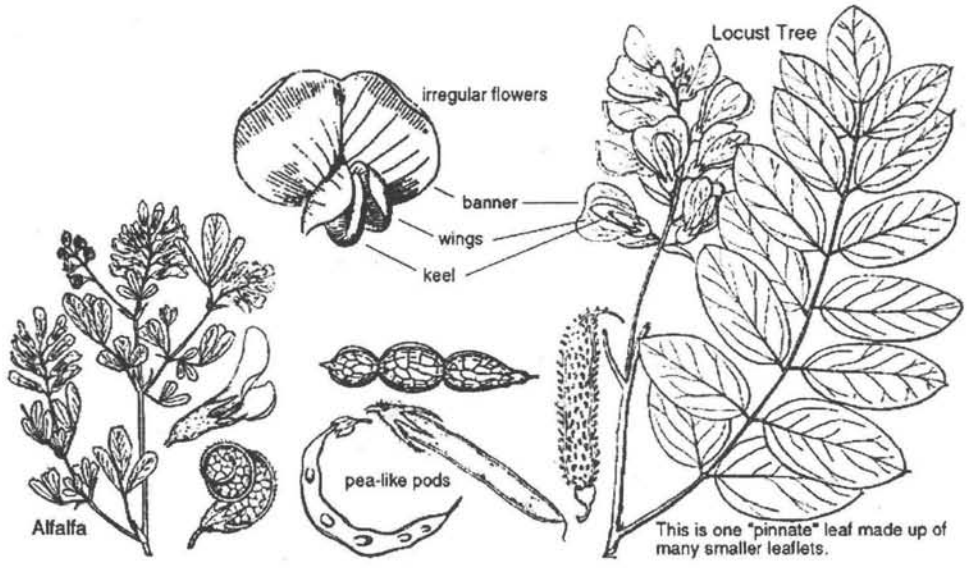
Legume : A legume is a plant in the family Fabaceae (or Leguminosae), or a fruit of these specific plants. A legume fruit is a simple dry fruit that develops from a simple carpel and usually dehisces (opens along a seam) on two sides. A common name for this type of fruit is a "pod", although pod is also applied to a few other fruit types, such as vanilla. Well-known legumes include alfalfa, clover, peas, beans, lentils, lupins, mesquite, carob, and peanuts.

The term legume is derived from the Latin word legumen (with the same meaning as the English term), which is in turn believed to come from the verb legere "to gather." English borrowed the term from the French "légume," which, however, has a wider meaning in the modern language and refers to any kind of vegetable; the English word legume being translated in French by the word légumineuse.

The history of legumes is tied in closely with that of human civilization, appearing early in Asia, the Americas (the common bean, several varieties), and Europe (broad beans) by 6,000 BC, where they became a staple, essential for supplementing protein where there was not enough meat. Also included are some grains in this grouping

Legume plants are noteworthy for their ability to fix atmospheric nitrogen, thanks to a symbiotic relationship with certain bacteria known as rhizobia found in root

nodules of these plants. The ability to form this symbiosis reduces fertilizer costs for farmers and gardeners who grow legumes, and allows legumes to be used in a crop rotation to replenish soil that has been depleted of nitrogen.



A legume family

Legume seed and foliage have a comparatively higher protein content than non-legume material, probably due to the additional nitrogen that legumes receive through nitrogen-fixation symbiosis. This high protein content makes them desirable crops in agriculture.

Levan : A homopolysaccharide which is composed of D-fructofuranosyl residues joined by 2,6 with multiple branches by 2,1 linkages has great potential as a functional biopolymer in foods, feeds, cosmetics, and the pharmaceutical and chemical industries. Levan can be used as food or a feed additive with prebiotic and hypocholesterolemic effects. Levan is also shown to exert excellent cell-proliferating, skin moisturizing, and skin irritation-alleviating effects as a blending component in cosmetics. Levan derivatives such as sulfated, phosphated, or acetylated levans are asserted to be anti-AIDS agents. In addition, levan is used as a coating material in a drug delivery formulation. Levan also has a number of industrial applications such as a surfactant for household use due to its excellent

surface-active properties, a glycol/levan aqueous two-phase system for the partitioning of proteins, etc. However, there are some limitations for the industrial applications of levan due to its weak chemical stability in solution and the complex process required to purify levan. Once the limitations are solved, the market for levan will gradually increase in the various fields.

Levan is a biopolymer that is naturally produced by microorganisms. In recent years, microorganisms have been genetic manipulated for the biotechnological production of biopolymers with tailored properties suitable for high-value medical application such as tsissue engineering and drug delivery and for use in the food and biotechnology industries.

L-form bacteria : Also known as L-phase bacteria, L-phase variants or cell wall deficient (CWD) bacteria, are strains of bacteria that lack cell walls. They were first isolated in 1935 by Emmy Klieneberger-Nobel, who named them "L-forms" after the Lister Institute in London where she was working. Two types of L-forms are distinguished : unstable L-forms, spheroplasts which are capable of dividing, but can revert to the original morphology and stable L-forms, L-forms which are unable to revert to the original bacteria.

Some parasitic species of bacteria, such as mycoplasma, also lack a cell wall, but these are not considered as L-forms since they are not derived from bacteria that normally have cell walls. Although L-forms can develop from gram-positive as well as from gram-negative bacteria the L-forms are always gram-negative, due to the lack of a cell wall. The cell wall is important for cell division which, in most bacteria, occurs by binary fission. The lack of cell wall in L-forms means that division is disorganised, giving rise to a variety of cell sizes, from very tiny to very big.

Lipopolysaccharides (LPS) : Also known as lipoglycans, are large molecules consisting of a lipid and a polysaccharide joined by a covalent bond; they are found in the outer membrane of Gram-negative bacteria, act as endotoxins and elicit strong immune responses in animals. LPS is a major component of the outer membrane of Gram-negative bacteria, contributing greatly to the structural integrity of the bacteria, and protecting the membrane from certain kinds of chemical attack. LPS also increases the negative charge of the cell membrane and helps stabilize the overall membrane structure. It is of crucial importance to gram negative bacterial cells; death results if it is mutated or removed. LPS is an endotoxin, and induces a strong response from normal animal immune systems. It acts as the prototypical endotoxin because it binds the CD14/TLR4/MD2 receptor complex, which promotes the secretion of pro-inflammatory cytokines in many cell types, but especially in macrophages. An "LPS challenge" in immunology is the exposing of the subject to an LPS which may act as a toxin.

LPS is additionally an exogenous pyrogen (external fever-inducing compound). With the Lipopolysaccharide being of crucial importance to gram negative bacterial cells, it is therefore a prime target for future antimicrobial substances.

Lithotroph : A lithotroph is an organism that uses an inorganic substrate (usually of mineral origin) to obtain reducing equivalents for use in biosynthesis (e.g., carbon dioxide fixation) or energy conservation via aerobic or anaerobic respiration. Known lithotrophs are exclusively microbes or plants; No known macrofauna possesses the ability to utilize inorganic compounds as energy sources. Macrofauna and lithotrophs can form symbiotic relationships, in which case the lithotrophs are called "prokaryotic symbionts." An example of this is chemolithotrophic bacteria in deep sea worms or plastids, which are organelles within plant cells that may have evolved from photolithotrophic cyanobacteria-like organisms. Lithotrophs belong to either the domain Bacteria or the domain Archaea. The term "Lithotroph" is created from the terms 'lithos' (rock) and 'troph' (consumer), meaning the "eaters of rock." Many lithoautotrophs are extremophiles, but this is not universally so. The opposite of lithotroph is organotroph—an organism which gets its energy from the break up of organic compounds.

Louis Pasteur : He was a French chemist and microbiologist born in Dole. He is best known for his remarkable breakthroughs in the causes and prevention of disease. His experiments supported the germ theory of disease, also reducing mortality from puerperal fever (childbed), and he created the first vaccine for rabies.

Louis Pasteur

He was best known to the general public for inventing a method to stop milk and wine from causing sickness—this process came to be called *Pasteurization*. He is regarded as one of the three main founders of microbiology, together with Ferdinand Cohn and Robert Koch. Pasteur also made many discoveries in the field of chemistry, most notably the molecular basis for the asymmetry of certain crystals. He is buried beneath the Institute Pasteur, a rare honor in France, where being buried in a cemetery is mandatory save for the fewer than 300 "Great Men" who are entombed in the Panthéon.

Lyme disease : Aslo known as borreliosis, is caused by Gram negative spirochetal bacteria from the genus *Borrelia*, which has at least 37 known species, 12 of which are Lyme related, and an unknown number of genomic strains. *Borrelia* species known to cause Lyme disease are collectively known as *Borrelia burgdorferi* sensu lato.

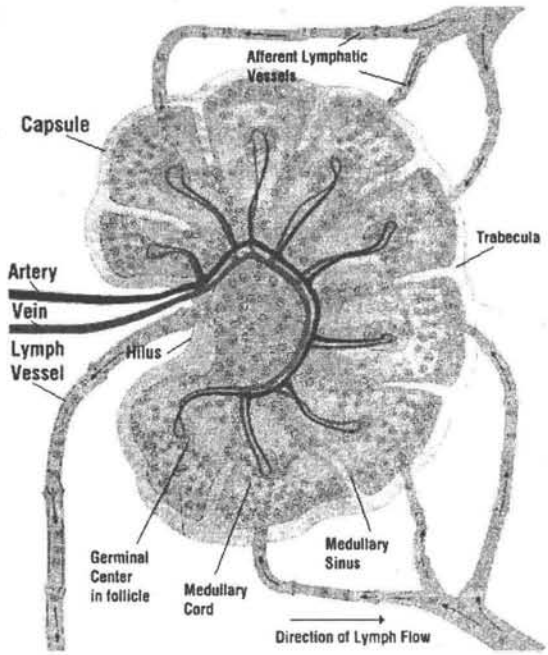
Borrelia are microaerophillic and slow-growing—the primary reason for the long delays when diagnosing Lyme disease—and have been found to have greater strain diversity than previously estimated. The strains differ in clinical symptoms and/or presentation as well as geographic distribution.

Except for *Borrelia recurrentis* (which causes louse-borne relapsing fever and is transmitted by the human body louse), all known species are believed to be transmitted by ticks.

Until recently it was thought that only three genospecies caused Lyme disease (borreliosis) : *B. burgdorferi* sensu stricto (the predominant species in North America, but also present in Europe); *B. afzelii*; and *B. garinii* (both predominant in Eurasia). The complete genomes of *B. burgdorferi* sensu stricto strain B31, *B. afzelii* strain PKo and *B. garinii* strain PBi are known. *B. burgdorferi* strain B31 was derived by limited dilutional cloning from the original Lyme-disease tick isolate derived by Alan Barbour.

Lymph node : A Lymph node is an organ consisting of many types of cells, and is a part of the lymphatic system. Lymph nodes are found all through the body, and act as filters or traps for foreign particles. They contain white blood cells. Thus they are important in the proper functioning of the immune system.

Lymph nodes also have clinical significance. They become inflamed or enlarged in various conditions, which may range from trivial, such as a throat infection, to life-threatening such as cancers. In the latter, the condition of lymph nodes is so significant that it is used for cancer staging, which decides the treatment to be employed, and for determining the prognosis. Lymph nodes can also be diagnosed by biopsy whenever they are inflamed. Certain diseases affect lymph nodes with characteristic consistency and location.



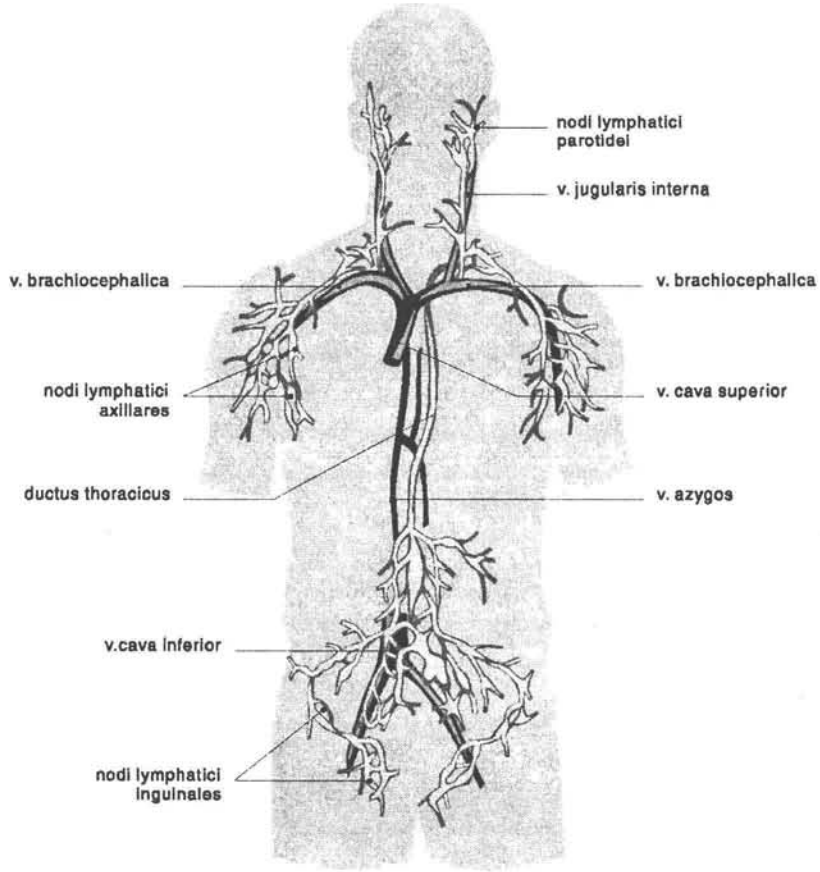
Structure of a lymph node

Lymphatic system : The lymphatic system in vertebrates is a network of conduits that carry a clear fluid called lymph. It also includes the lymphoid tissue through which the lymph travels. Lymphoid tissue is found in many organs, particularly the lymph nodes, and in the lymphoid follicles associated with the digestive system such as the tonsils. The system also includes all the structures dedicated to the circulation and production of lymphocytes, which includes the spleen, thymus, bone marrow and the lymphoid tissue associated with the digestive system. The lymphatic system as we know it today was first described independently by Olaus Rudbeck and Thomas Bartholin.

The dissolved constituents of the blood do not directly come in contact with the cells and tissues in the body, but first enter the interstitial fluid, and then the cells of the body. Lymph is the fluid that is formed when interstitial fluid enters the conduits of the lymphatic system. The lymph is not pumped through the body like blood, but is moved mostly by the contractions of skeletal muscles.

The lymphatic system has three interrelated functions. It is responsible for the removal of interstitial fluid from tissues. It absorbs and transports fatty acids and

fats as chyle to the circulatory system. The last function of the lymphatic system is the transport of antigen presenting cells (APCs), such as dendritic cells, to the lymph nodes where an immune response is stimulated.



LYMPHATIC SYSTEM

The study of lymphatic drainage of various organs is important in diagnosis, prognosis, and treatment of cancer. The lymphatic system, because of its physical proximity to many tissues of the body, is responsible for carrying cancerous cells between the various parts of the body in a process called metastasis. The intervening lymph nodes can trap the cancer cells. If they are not successful in destroying the cancer cells the nodes may become sites of secondary tumors. Diseases and other problems of the lymphatic system can cause swelling and other symptoms. Problems with the system can impair the body's ability to fight infections.

Lymphoma : Is a type of cancer that originates in lymphocytes of the immune system. They often originate in lymph nodes, presenting as an enlargement of the node (a tumour). Lymphomas are closely related to lymphoid leukemias, which also originate in lymphocytes but typically involve only circulating blood and the bone marrow (where blood cells are generated in a process termed haematopoesis) and do not usually form tumours. There are many types of lymphomas, and in turn, lymphomas are a part of the broad group of diseases called hematological neoplasms.

Thomas Hodgkin published in 1832 the first description of lymphoma, specifically of the form named after him, Hodgkin's lymphoma. Since then many other forms of lymphoma have been described, grouped under several proposed classifications. The 1982 Working formulation classification became very popular. It introduced the category non-Hodgkin lymphoma (NHL), itself divided into 16 different diseases. However, since these different lymphomas have little in common with each other, the NHL label is of limited usefulness for doctors or patients and is slowly being abandoned. The latest classification by the WHO lists 43 different forms of lymphoma divided in four broad groups.

Some forms of lymphoma are indolent (e.g. small lymphocytic lymphoma), compatible with a long life even without treatment, whereas other forms are aggressive (e.g. Burkitt's lymphoma), causing rapid deterioration and death. The prognosis therefore depends on the correct classification of the disease, established by a pathologist after examination of a biopsy.

Lysogeny : Also known as the lysogenic cycle, is one of two methods of viral reproduction (the lytic cycle is the other). Lysogeny in prokaryotes is characterized by integration of the bacteriophage nucleic acid into the host bacterium's genome. The newly integrated genetic material, called a prophage can be transmitted to daughter cells at each subsequent cell division, and a later event (such as UV radiation) can release it, causing proliferation of new phages via the lytic cycle. Lysogenic cycles can also occur in eukaryotes, although the method of incorporation of DNA is not fully understood.

Certain types of viruses replicate by the lysogenic cycle, but also partly by the lytic cycle (mixed cycles). Some DNA phages, called temperate phages, only lyse a small fraction of bacterial cells; in the remaining majority of the bacteria, the phage DNA becomes integrated into the bacterial chromosome and replicates along with it. In this lysogenic state, the information contained in the viral nucleic acid is not expressed. The model organism for studying lysogeny is the lambda phage. Roughly 50-60 nucleotides are taken out of the lysogenic pathway and used.

M

M_{13} : Is a filamentous bacteriophage composed of circular single stranded DNA (ssDNA) which is 6407 nucleotides long encapsulated in approximately 2700 copies of the major coat protein P_8, and capped with 5 copies of two different minor coat proteins (P_9, P_6, P_3) on the ends. The minor coat protein P3 attaches to the receptor at the tip of the F pilus of the host *Escherichia coli*. Infection with filamentous phages is not lethal, however the infection causes turbid plaques in *E. coli*. It is a non-lytic virus. However a decrease in the rate of cell growth is seen in the infected cells. M_{13} plasmids are used for many recombinant DNA processes, and the virus has also been studied for its uses in nanostructures and nanotechnology.

The phage coat is primarily assembled from a 50 amino acid protein called pVIII (or p_8), which is encoded by gene VIII (or g_8) in the phage genome. For a wild type M_{13} particle, it takes about approximately 2700 copies of p8 to make the coat about 900nm long. The coat's dimensions are flexible though and the number of p8 copies adjusts to accommodate the size of the single stranded genome it packages. For example, when the phage genome was mutated to reduce its number of DNA bases, then the number of p_8 copies was decreased to fewer than 100, causing the p8 coat to shrink in order to fit the reduced genome. The phage appear to be limited at approximately twice the natural DNA content. However, deletion of a phage protein (p_3) prevents full escape from the host *E. coli*, and phage that are 10-20X the normal length with several copies of the phage genome can be seen shedding from the *E. coli* host.

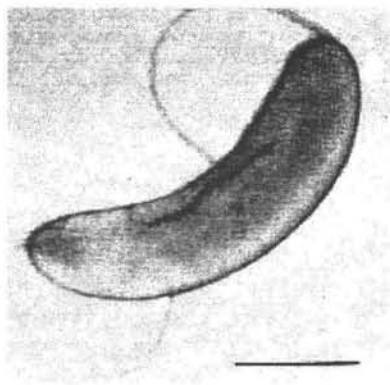
Magnetosome chains : These are membranous prokaryotic organelles present in magnetotactic bacteria. They contain 15 to 20 magnetite crystals that together act like a compass needle to orient magnetotactic bacteria in geomagnetic fields, thereby simplifying their search for their preferred microaerophilic environments. Each magnetite crystal within a magnetosome is surrounded by a lipid bilayer, and specific soluble and transmembrane proteins are sorted to the membrane. Recent research has shown that magnetosomes are invaginations of the inner membrane and not freestanding vesicles. Magnetite-bearing magnetosomes have

also been found in eukaryotic magnetotactic algae, with each cell containing several thousand crystals. Overall, magnetosome crystals have high chemical purity, narrow size ranges, species-specific crystal morphologies and exhibit specific arrangements within the cell. These features indicate that the formation of magnetosomes is under precise biological control and is mediated biomineralization.

Magnetotactic bacteria usually mineralize either iron oxide magnetosomes, which contain crystals of magnetite (Fe_3O_4), or iron sulfide magnetosomes, which contain crystals of greigite (Fe_3S_4). Several other iron sulfide minerals have also been identified in iron sulfide magnetosomes—including mackinawite (tetragonal FeS) and a cubic FeS—which are thought to be precursors of Fe_3S_4. One organism is known to produce both iron oxide and iron sulfide magnetosomes.

The particle morphology of magnetosome crystals varies, but is consistent within cells of a single magnetotactic bacterial species or strain. Three general crystal morphologies have been reported in magnetotactic bacteria on the basis : roughly cuboidal, elongated prismatic (roughly rectangular), and tooth-, bullet- or arrowhead-shaped.

Magnetotactic bacteria (or MTB) : These are a class of bacteria discovered in the 1960s, that exhibit the ability to orient themselves along the magnetic field lines of Earth's magnetic field. To perform this task, these bacteria have organelles called magnetosomes that contain magnetic crystals. The biological phenomenon of microorganisms tending to move in response to the environment's magnetic characteristics is known as magnetotaxis, an instance of magnetoception. It is believed to aid these organisms in reaching regions of optimal oxygen concentration.



Magnetotactic bacteria

The first description of magnetotactic bacteria appeared in 1963 in a publication of the Istituto di Microbiologia of the University of Pavia written by Salvatore Bellini. While observing bog sediments under his microscope, he noticed a group of bacteria that evidently oriented themselves in a unique direction. He realised that these microorganisms moved according to the direction of the North Pole and hence called them "magnetosensitive bacteria".

The first peer-reviewed article on magnetotactic bacteria appeared in a 1975 article in *Science* by Richard Blakemore, a microbiologist at the Woods Hole Oceanographic Institution, who had similarly observed bacteria capable of orienting themselves in a certain direction : Blakemore realised that these microorganisms were following the direction of Earth's magnetic field, from south to north, and thus coined the term "magnetotactic". These bacteria have been the subject of many experiments : they have even been aboard the Space Shuttle to examine their magnetotactic properties in the absence of gravity, but a definitive conclusion was not reached.

Malaria culture : Is the method to grow malaria parasites continuously in an in vitro environment. Plasmodium falciparum is currently the only human malaria parasite that has been successfully cultured *in vitro*. Although attempts for propagation of the parasites outside of humans or animal models reach as far back as 1912, the success of the initial attempts was limited to one or just a few cycles. The first successful continuous culture was established in 1976. Initial hopes that the *in vitro* culture would lead quickly to the discovery of a vaccine were premature. However, the development of new drugs was greatly facilitated.

Infected human red blood cells are incubated in a culture dish or flask together with a nutrient medium or human plasma. A special feature of the incubation is the special gas mixture of mostly nitrogen (93% nitrogen, 4% carbondioxide, 3% oxygen) allowing the parasites to grow at 37°C in a cell incubator. An alternative to gasing the cultures with the exact gas mixture, is the use of a candlejar. The candlejar is an airtight container in which the cultures and a lit candle are placed. The candle consumes most of the oxygen before suffocating. The number of parasites doubles approximately every 48 hours. The parasitemia can be determined via blood film, to keep it within the wanted limits, the culture can be thinned out with healthy red blood cells.

Malaria : Is a vector-borne infectious disease caused by protozoan parasites. It is widespread in tropical and subtropical regions, including parts of the Americas, Asia, and Africa. Each year, there are approximately 350–500 million cases of malaria, killing between one and three million people, the majority of whom are young children in Sub-Saharan Africa. Ninety percent of malaria-related deaths occur in Sub-Saharan Africa. Malaria is commonly associated with poverty, but is also a cause of poverty and a major hindrance to economic development.

Malaria is one of the most common infectious diseases and an enormous public health problem. The disease is caused by protozoan parasites of the genus *Plasmodium*. Five species of the plasmodium parasite can infect humans; the most serious forms of the disease are caused by *Plasmodium falciparum*. Malaria caused by *Plasmodium vivax, Plasmodium ovale* and *Plasmodium malariae* causes milder disease in humans that is not generally fatal. A fifth species, *Plasmodium knowlesi*, causes malaria in macaques but can also infect humans. This group of human-pathogenic *Plasmodium* species is usually referred to as *malaria parasites*.

Usually, people get malaria by being bitten by an infective female *Anopheles* mosquito. Only Anopheles mosquitoes can transmit malaria, and they must have been infected through a previous blood meal taken on an infected person. When a mosquito bites an infected person, a small amount of blood is taken, which contains microscopic malaria parasites. About one week later, when the mosquito takes its next blood meal, these parasites mix with the mosquito's saliva and are injected into the person being bitten. The parasites multiply within red blood cells, causing symptoms that include symptoms of anemia (light-headedness, shortness of breath, tachycardia, etc.), as well as other general symptoms such as fever, chills, nausea, flu-like illness, and, in severe cases, coma, and death. Malaria transmission can be reduced by preventing mosquito bites with mosquito nets and insect repellents, or by mosquito control measures such as spraying insecticides inside houses and draining standing water where mosquitoes lay their eggs. Work has been done on malaria vaccines with limited success and more exotic controls, such as genetic manipulation of mosquitoes to make them resistant to the parasite have also been considered.

Although some are under development, no vaccine is currently available for malaria that provides a high level of protection; preventive drugs must be taken continuously to reduce the risk of infection. These prophylactic drug treatments are often too expensive for most people living in endemic areas. Most adults from endemic areas have a degree of long-term infectio , which tends to recur, and also possess partial immunity (resistance); the resistance reduces with time, and such adults may become susceptible to severe malaria if they have spent a significant amount of time in non-endemic areas. They are strongly recommended to take full precautions if they return to an endemic area. Malaria infections are treated through the use of antimalarial drugs, such as quinine or artemisinin derivatives. However, parasites have evolved to be resistant to many of these drugs. Therefore, in some areas of the world, only a few drugs remain as effective treatments for malaria.

Martinus Willem Beijerinck : He was a Dutch microbiologist and botanist. He was born in Amsterdam. Beijerinck studied at Leiden University and became a teacher in microbiology at the Agricultural School in Wageningen (now Wageningen

University and later at the *Polytechnische Hogeschool Delft* (Delft Polytechnic, currently Delft University of Technology) (from 1895). He established the Delft School of Microbiology. His studies of agricultural microbiology and industrial microbiology yielded fundamental discoveries in the field of biology. His achievements have been perhaps unfairly overshadowed by those of his contemporaries Robert Koch and Louis Pasteur, because unlike them, Beijerinck never studied human disease.

He is considered the founder of virology. He discovered viruses in 1898 by proving in filtration experiments that the tobacco mosaic disease is caused by something smaller than a bacterium. He named that new pathogen *virus*. (Dimitri Ivanovski discovered viruses in 1892, but failed to report his findings.) Beijerinck maintained that viruses were liquid in nature, a theory later discredited by Wendell Stanley, who proved they were particulate.

Beijerinck also discovered nitrogen fixation, the process by which diatomic nitrogen gas is converted to ammonium and becomes available to plants. Bacteria perform nitrogen fixation, dwelling inside root nodules of certain plants (legumes). In addition to having discovered a biochemial reaction vital to soil fertility and agriculture, Beijerinck revealed this archetypical example of symbiosis between plants and bacteria.

Beijerinck discovered the phenomenon of bacterial sulfate reduction, a form of anaerobic respiration. He learned that bacteria could use sulfate as a terminal electron acceptor, instead of oxygen. This discovery has had an important impact on our current understanding of biogeochemical cycles. *Spirillum desulfuricans*, the first known sulfate-reducing bacterium, was isolated and described by Beijerinck.

Medical microbiology : Is a branch of microbiology which deals with the study of microorganisms including bacteria, viruses, fungi and parasites which are of

medical importance and are capable of causing diseases in human beings. It includes the study of microbial pathogenesis and epidemiology and is related to the study of disease pathology and immunology. In the medical laboratory, these microbiologists also work in a subdepartment dedicated to parasitology.The discipline consists primarily of four major spheres of activity : 1. The provision of clinical consultations on the investigation, diagnosis, and treatment of patients suffering from infectious diseases. 2. The establishment and direction of infection control programs across the continuum of care. 3. Public health and communicable disease prevention and epidemiology. 4. The scientific and administrative direction of a diagnostic microbiology laboratory. In addition to these primary activities, medical microbiologists are also involved in teaching at all levels, and in research, both basic and applied. This branch of microbiology is amongst the most widely studied and followed branches due to its great importance to medicine. Along with providing a deep knowledge and understanding of the nature of pathogens this line of study has also been applied in several immunological innovations in the field of medical science. Through the development of vaccines against invading organisms, deadly and debilitating diseases such as small pox, polio, and rabies have been either eradicated or are more treatable because of the efforts of scientists and researchers in the field of medical microbiology.

Eligibility for the medical microbiology course is usually after completing MBBS or MD.Most of the medical microbiology courses are conducted in conjunction with the Infection Diseases Programs, in various medical colleges & provide training in basic science microbiology, clinical microbiology, infection control, laboratory management and clinical infectious disease.

Memory T cells : These are a specific type of infection-fighting T cell (also known as a T lymphocyte) that can recognize foreign invaders such as bacteria or viruses, that were encountered during a prior infection or vaccination. At a second encounter with the invader, memory T cells can reproduce to mount a faster and stronger immune response than the first time the immune system responded to the invader. This behaviour is utilized in T lymphocyte proliferation assays, which can reveal exposure to specific antigens.

Metagenomics : Is the study of genetic material recovered directly from environmental samples. Traditional microbiology and microbial genome sequencing rely upon cultivated clonal cultures. This relatively new field of genetic research enables studies of organisms that are not easily cultured in a laboratory as well as studies of organisms in their natural environment. Early environmental gene sequencing cloned specific genes (often the 16S rRNA gene) to produce a profile of diversity in a natural sample. Such work revealed that the vast majority of microbial diversity had been missed by cultivation-based methods. Recent studies use

"shotgun" Sanger sequencing or chip-based pyrosequencing to get (mostly) unbiased samples of all genes from all members of sampled communities.

Methanogenesis : Is the formation of methane by microbes known as methanogens. Organisms capable of producing methane have been identified only from the kingdom Archaea, a group phylogenetically distinct from both eukaryotes and bacteria, although many live in close association with anaerobic bacteria. The production of methane is an important and widespread form of microbial metabolism. In most environments, it is the final step in the decomposition of biomass.Recently, some experiments have suggested that leaf tissues of living plants emit methane . Other research has indicated that the plants are not actually generating methane; they are just absorbing methane from the soil and the emitting it through their leaf tissues . There may still be some unknown mechanism by which plants produce methane, but that is by no means certain.Methanogenesis in microbes is a form of anaerobic respiration. Methanogens do not use oxygen to breathe; in fact, oxygen inhibits the growth of methanogens. The terminal electron acceptor in methanogenesis is not oxygen, but carbon. The carbon can occur in a small number of organic compounds, all with low molecular weights.

Methanogens : These are archaea that produce methane as a metabolic byproduct in anoxic conditions. They are common in wetlands, where they are responsible for marsh gas, and in the guts of animals such as ruminants and humans, where they are responsible for the methane content of flatulence. In marine sediments biomethanation is generally confined to where sulfates are depleted, below the top layers. Others are extremophiles, found in environments such as hot springs and submarine hydrothermal vents as well as in the "solid" rock of the Earth's crust, kilometers below the surface. Methanogens are usually coccoid or rod shaped. There are over 50 described species of methanogens, which do not form a monophyletic group, although all methanogens belong to Archaea. Methanogens are also anaerobic. Although methanogens cannot function under aerobic conditions they can sustain oxygen stresses for prolonged times.

An exception is *Methanosarcina barkeri*, which contains a superoxide dismutase (SOD) enzyme and may survive longer. Some, called hydrogenotrophic, use carbon dioxide (CO_2) as a source of carbon, and hydrogen as a reducing agent. Some of the CO_2 is reacted with the hydrogen to produce methane, which produces an electrochemical gradient across a membrane, used to generate ATP through chemiosmosis. In contrast, plants and algae use water as their reducing agent. Methanogens lack a polymer that is found in the cell walls of other prokaryotes. Some methanogens have a cell wall that is composed of pseudomurein. Other methanogens that don't have a pseudomurein have at least one paracrystalline array (S-layer) which is made up of proteins that fit together like a puzzle.

Methicillin-resistant Staphylococcus epidermidis : Is a bacterium responsible for difficult-to-treat infections in humans. Like MRSA which is a resistant variation of the common bacterium Staphylococcus aureus, MRSE is a resistant variation of the common bacterium Staphylococcus epidermidis. It has evolved an ability to survive treatment from several of the subgroup beta-lactam antibiotics. It can cause infections in hospitals including central venous catheters associated infections. Like MRSA there are few treatment options available to treat MRSE. Vancomycin is often the last choice.

Micro-animals : These are animals that are microscopic and thus cannot be seen with the naked eye. All these microorganisms are multicellular but none are vertebrates. Microscopic arthropods include dust mites, and spider mites, while microscopic crustaceans include copepods and the cladocera. Another common group of microscopic animals are the rotifers, which are filter feeders that are usually found in fresh water. Micro-animals reproduce both sexually and asexually and may reach new habitats as eggs that survive harsh environments that would kill the adult animal. However, some simple animals, such as rotifers and nematodes, can dry out completely and remain dormant for long periods of time

Microbial cyst : Is a resting or dormant stage of a microorganism, usually a bacterium or a protist, that helps the organism to tide over unfavorable environmental conditions. It can be thought of as a state of suspended animation in which the metabolic processes of the cell are slowed down and the cell ceases all activities like feeding and locomotion. Encystment also helps the microbe to disperse easily, from one host to another or to a more favorable environment. When the encysted microbe reaches an environment favorable to its growth and survival, the cyst wall breaks down by a process known as *excystation*. Unfavorable environmental conditions such as lack of nutrients or oxygen, extreme temperatures, lack of moisture and presence of toxic chemicals, which are not conducive for the growth of the microbe trigger the formation of a cyst.

Protists, especially protozoan parasites, are often exposed to very harsh conditions at various stages in their life cycle. For example, *Entamoeba histolytica*, a common intestinal parasite that causes dysentery, has to endure the highly acidic environment of the stomach before it reaches the intestine and various unpredictable conditions like desiccation and lack of nutrients while it is outside the host. An encysted form is well suited to survive such extreme conditions, although protozoan cysts are less resistant to adverse conditions compared to bacterial cysts. In addition to survival, the chemical composition of certain protozoan cyst walls may play a role in their dispersal. The sialyl groups present in the cyst wall of *Entamoeba histolytica* confers a net negative charge to the cyst which prevents its attachment to the intestinal wall and thus causing its elimination

in the feces. Other protozoan intestinal parasites like *Giardia lamblia* and *Cryptosporidium* also produce cysts as part of their life cycle. In some protozoans, the unicellular organism multiplies during or after encystment and releases multiple trophozoites upon excystation.

Microbial food web : Refers the combined trophic interactions among microbes in aquatic environments. These microbes include viruses, bacteria, algae, heterotrophic protists (such as ciliates and flagellates). In aquatic environments, microbes constitute the base of the food web. Single celled photosynthetic organisms such as diatoms and cyanobacteria are generally the most important primary producers in the open ocean. Many of these cells, especially cyanobacteria, are too small to be captured and consumed by small crustaceans and planktonic larvae. Instead, these cells are consumed by phagotrophic protists which are readily consumed by larger organisms. Viruses can infect and break open bacterial cells and (to a lesser extent), planktonic algae (a.k.a phytoplankton). Therefore, viruses in the microbial food web act to reduce the population of bacteria and, by lysing bacterial cells, release particulate and dissolved organic carbon (DOC). DOC may also be released into the environment by algal cells. One of the reasons phytoplankton release DOC termed "unbalanced growth" is when essential nutrients (e.g. nitrogen and phosphorus) are limiting. Therefore, carbon produced during photosynthesis is not used for the synthesis of proteins (and subsequent cell growth), but is limited due of a lack of the nutrients necessary for macromolecules. Excess photosynthate, or DOC is then released, or exuded. The microbial loop describes a pathway in the microbial food web where DOC is returned to higher trophic levels via the incorporation into bacterial biomass.

Microbial intelligence : Is the intelligence shown by microorganisms. The concept encompasses complex adaptive behaviour shown by single cells, and altruistic and/or cooperative behavior in populations of like or unlike cells mediated by chemical signalling that induces physiological or behavioral changes in cells and influences colony structures.Complex cells, like protozoa or algae, show remarkable abilities to organise themselves in changing circumstances . Shell-building by amoebae, reveals complex discrimination and manipulative skills that are ordinarily thought to occur only in multicellular organisms.

Even bacteria, which show primitive behavior as isolated cells, can display more sophisticated behavior as a population. These behaviors occur in single species populations, or mixed species populations. Examples are colonies of Myxobacteria, quorum sensing, and biofilms. It has been suggested that a bacterial colony loosely mimics a biological neural network. The bacteria can take inputs in form of chemical signals, process them and then produce output chemicals to signal other bacteria in the colony.

The mechanisms that enable single celled organisms to coordinate in populations presumably carried over in those lines that evolved multicellularity, and were co-opted as mechanisms to coordinate multicellular organisms.

Microbiological culture : Is a method of multiplying microbial organisms by letting them reproduce in predetermined culture media under controlled laboratory conditions. Microbial cultures are used to determine the type of organism, its abundance in the sample being tested, or both. It is one of the primary diagnostic methods of microbiology and used as a tool to determine the cause of infectious disease by letting the agent multiply in a predetermined media. For example, a throat culture is taken by scraping the lining of tissue in the back of the throat and blotting the sample into a media to be able to screen for harmful microorganisms, such as, streptococcus pyogenes, the caustive agent of strep throat. Furthermore, the term culture is more generally used informally to refer to "selectively growing" a specific kind of microorganism in the lab.

Microbial cultures are foundational and basic diagnostic methods used extensively as a research tool in molecular biology. It is often essential to isolate a pure culture of microorganisms. A pure (or *axenic*) culture is a population of cells or multicellular organisms growing in the absence of other species or types. A pure culture may originate from a single cell or single organism, in which case the cells are genetic clones of one another.

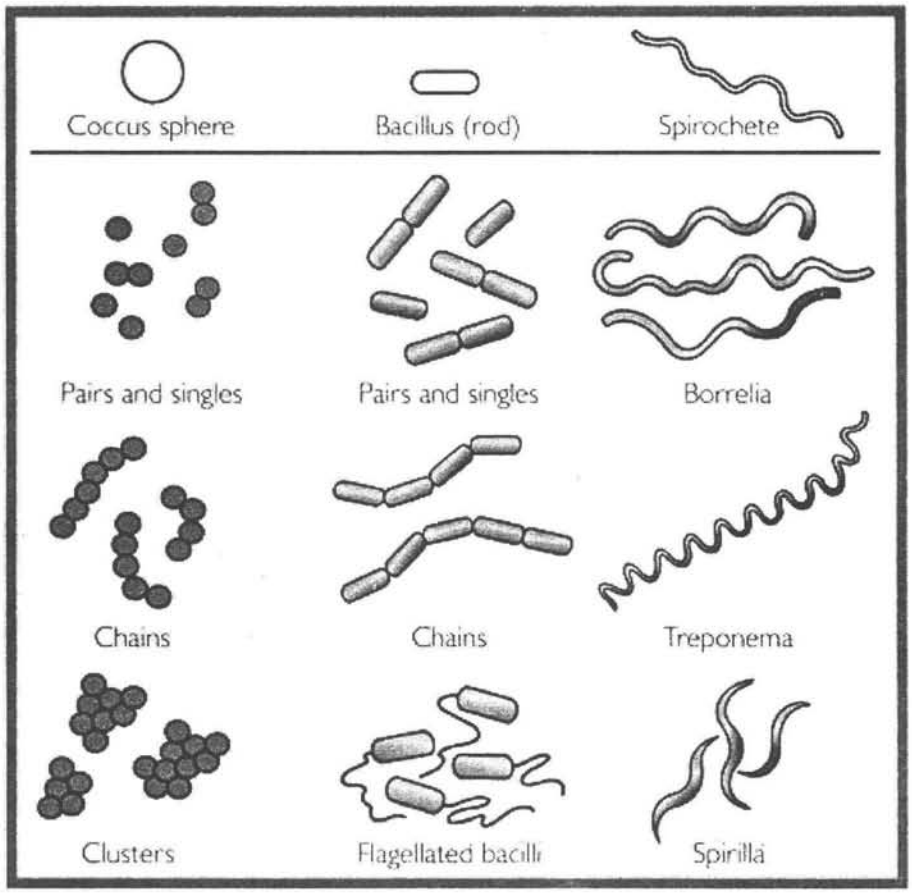
For the purpose of gelling the microbial culture, the medium of agarose gel (Agar) is used. Agar is a gelatinous substance derived from seaweed. A cheap substitute for agar is Guar gum, which can be used for the isolation and maintenance of thermophiles.

Microbiology : Microbiology is the study of *microorganisms*, which are unicellular or cell-cluster microscopic organisms. This includes eukaryotes such as fungi and protists, and prokaryotes, which are bacteria and archaea. Viruses, though not strictly classed as living organisms, are also studied. In short; microbiology refers to the study of life and organisms that are too small to be seen with the naked eye. Microbiology is a broad term which includes virology, mycology, parasitology, bacteriology and other branches. A microbiologist is a specialist in microbiology.

Microbiology is researched actively, and the field is advancing continually. We have probably only studied about one percent of all of the microbe species on Earth. Although microbes were first observed over three hundred years ago, the field of microbiology can be said to be in its infancy relative to older biological disciplines such as zoology and botany. Whilst there are undoubtedly some who fear all microbes due to the association of some microbes with many human illnesses, many microbes are also responsible for many beneficial processes such as industrial fermentation (e.g. the production of alcohol and dairy products),

antibiotic production and as vehicles for cloning in higher organisms such as plants. Scientists have also exploited their knowledge of microbes to produce biotechnologically important enzymes such as Taq polymerase, reporter genes for use in other genetic systems and novel molecular biology techniques such as the yeast two-hybrid system.

Microorganism : A microorganism or microbe is an organism that is microscopic (usually too small to be seen by the naked human eye). The study of microorganisms is called microbiology, a subject that began with Anton van Leeuwenhoek's discovery of microorganisms in 1675, using a microscope of his own design.



Microorganisms

Microorganisms are very diverse; they include bacteria, fungi, archaea, and protists; microscopic plants (called green algae); and animals such as plankton, the planarian and the amoeba. Some microbiologists also include viruses, but others consider these as non-living. Most microorganisms are unicellular (single-celled), but this is not universal, since some multicellular organisms are microscopic, while some unicellular protists and bacteria, like Thiomargarita namibiensis, are macroscopic and visible to the naked eye.

Microorganisms live in all parts of the biosphere where there is liquid water, including soil, hot springs, on the ocean floor, high in the atmosphere and deep inside rocks within the Earth's crust. Microorganisms are critical to nutrient recycling in ecosystems as they act as decomposers. As some microorganisms can fix nitrogen, they are a vital part of the nitrogen cycle, and recent studies indicate that airborne microbes may play a role in precipitation and weather.

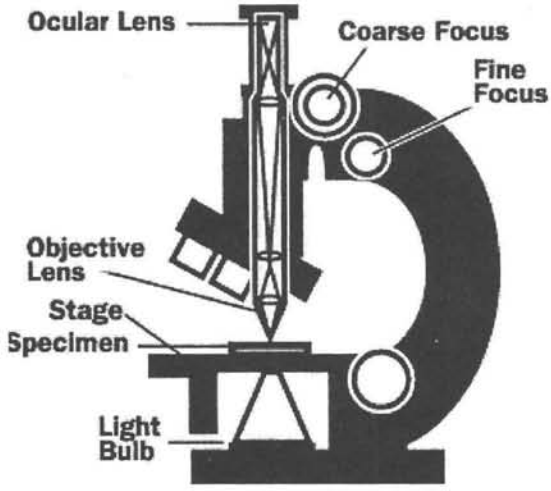
Microbes are also exploited by people in biotechnology, both in traditional food and beverage preparation, and in modern technologies based on genetic engineering. However, pathogenic microbes are harmful, since they invade and grow within other organisms, causing diseases that kill millions of people, other animals, and plants.

Single-celled microorganisms were the first forms of life to develop on Earth, approximately 3–4 billion years ago. Further evolution was slow, and for about 3 billion years in the Precambrian eon, all organisms were microscopic. So, for most of the history of life on Earth the only forms of life were microorganisms. Bacteria, algae and fungi have been identified in amber that is 220 million years old, which shows that the morphology of microorganisms has changed little since the triassic period.

Most microorganisms can reproduce rapidly and microbes such as bacteria can also freely exchange genes by conjugation, transformation and transduction between widely-divergent species. This horizontal gene transfer, coupled with a high mutation rate and many other means of genetic variation, allows microorganisms to swiftly evolve (via natural selection) to survive in new environments and respond to environmental stresses. This rapid evolution is important in medicine, as it has led to the recent development of 'super-bugs'—pathogenic bacteria that are resistant to modern antibiotics.

Microscope : A microscope is an instrument for viewing objects that are too small to be seen by the naked or unaided eye. The science of investigating small objects using such an instrument is called microscopy. The term microscopic means minute or very small, not visible with the eye unless aided by a microscope. Microscopes trace their history back almost 1200 years with Abbas Ibn Firnas's corrective lenses, and it was Ibn al-Haytham's *Book of Optics*—written between

1011 and 1021—that laid the foundation for optical research on the magnifying glass. Also, a device called the reading stone by an unknown inventor (thought to be Ibn Firnas) magnified text when laid on top of reading materials.



Microscope

The first true microscope was made around 1595 in Middelburg, The Netherlands. Three different eyeglass makers have been given credit for the invention : Hans Lippershey (who also developed the first real telescope); Sacharias Jansen; and his son, Zacharias. The coining of the name "microscope" has been credited to Giovanni Faber, who gave that name to Galileo Galilei's compound microscope in 1625.

The most common type of microscope—and the first to be invented—is the optical microscope. This is an optical instrument containing one or more lenses that produce an enlarged image of an object placed in the focal plane of the lens(es). There are, however, many other microscope designs.

Microscopes" can largely be separated into three classes : optical theory microscopes (Light microscope), electron microscopes (e.g.,TEM), and scanning probe microscopes (SPM). Optical microscopes are microscopes which function through the optical theory of lenses in order to magnify the image generated by the passage of a wave through the sample, or reflected by the sample. The waves used are either electromagnetic (in optical microscopes) or electron beams (in electron microscopes). The types are the Compound Light, Stereo, and the electron microscope.

Microscopic : Microscopic (from the Greek : , *mikrós*, "small" and sp, *skopéo*, "look") is a term used to describe objects smaller than those that can easily be seen by the naked eye and which require a lens or microscope to see them clearly.

By convention it is also used to describe classes of objects which are most commonly too small to see but of which some members are large enough to be observed with the eye. Such groups include the *Cladocera*, planktonic green algae of which *Volvox* is readily observable, and the protozoa of which *Stentor* can be easily seen without aid.

Microscopic is also by association used to classify and describe the units and measurements relevant to very small objects. The antonym to microscopic is macroscopic The units used to describe objects on a microscopic length scale are most commonly the Micrometer (μm)—one millionth of 1 metre, and smaller units. Microscopic is also commonly used as a hyperbole in the English language to describe small objects of a class that would be expected to be bigger—as in "Her feet are microscopic!"

Milky Spore : The bacterial milky diseases (commonly called milky spore) is a naturally occurring host specific bacterium (Bacillus popillae-Dutky), of the white grubs of Japanese beetles. The adult Japanese beetles pupate in the July time frame (in the North East US) and feed on flowers and leaves of shrubs and garden plants. During this adult stage the beetles also mate and the females lay eggs in the soil in late July early August. The eggs hatch soon afterwards and in this larval or grub stage, they feed on the roots of grass and other plants. As the weather gets cooler and winter approaches the grubs go deeper in the soil and feeding declines as they over-winter.

In this August time frame when the grubs are close to the surface and actively feeding they are vulnerable to infestation by Milky Spore. This is also the optimal time frame for turf inoculation or applications with Milky Spore to increase Milky Spore in the soil environment (there are product specific guidelines that should be followed for Milky Spore application). Resident spores in the soil are swallowed by grubs during their normal pattern of feeding on roots. This ingestion of the spore by the host activates reproduction of the bacteria inside the grub. Within 7-21 days the grub will eventually die and as the grub decomposes, billions of new spores are released into the soil.

Minimum inhibitory concentration (MIC) : Is the lowest concentration of an antimicrobial that will inhibit the visible growth of a microorganism after overnight incubation. Minimum inhibitory concentrations are important in diagnostic laboratories to confirm resistance of microorganisms to an antimicrobial agent and also to monitor the activity of new antimicrobial agents. An MIC is generally regarded as the most basic laboratory measurement of the activity of an antimicrobial agent against an organism.

MICs can be determined by agar or broth dilution methods usually following the guidelines of a reference body such as the CLSI, BSAC or EUCAST. There are several commercial methods available, including the well established Etest strips and the recently launched Oxoid MICEvaluator method. The Etest system comprises a predefined and continuous concentration gradient of different antimicrobial agents, which when applied to inoculated agar plates and incubated, create ellipses of microbial inhibition . The MIC is determined where the ellipse of inhibition intersects the strip, and is easily read off the MIC reading scale on the strip.

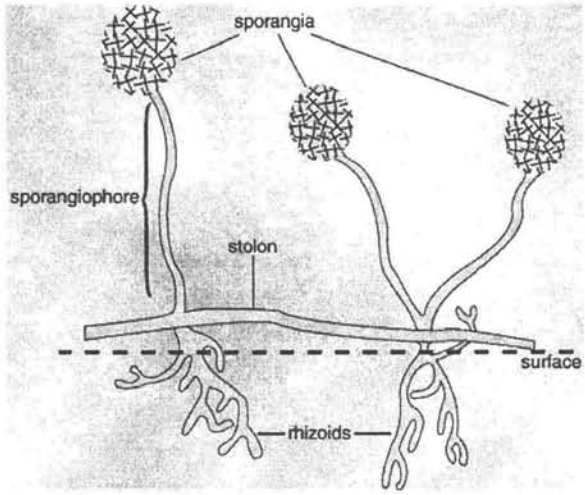
Model organism : A model organism is a species that is extensively studied to understand particular biological phenomena, with the expectation that discoveries made in the organism model will provide insight into the workings of other organisms. In particular, model organisms are widely used to explore potential causes and treatments for human disease when human experimentation would be unfeasible or unethical. This strategy is made possible by the common descent of all living organisms, and the conservation of metabolic and developmental pathways and genetic material over the course of evolution. Studying model organisms can be informative, but care must be taken when generalizing from one organism to another.

Molds : Molds include all species of microscopic fungi that grow in the form of multicellular filaments, called hyphae. In contrast, microscopic fungi that grow as single cells are called yeasts. A connected network of these tubular branching hyphae has multiple, genetically identical nuclei and is considered a single organism, referred to as a colony or in more technical terms a mycelium.

Molds do not form a specific taxonomic or phylogenetic grouping, but can be found in the divisions *Zygomycota*, *Deuteromycota* and *Ascomycota*. Although some molds cause disease or food spoilage, others are useful for their role in biodegradation or in the production of various foods, beverages, antibiotics and enzymes.

There are thousands of known species of molds, which include opportunistic pathogens, saprotrophs, aquatic species, calders and thermophiles. Like all fungi, molds derive energy not through photosynthesis but from the organic matter in which they live. Typically, molds secrete hydrolytic enzymes, mainly from the hyphal tips. These enzymes degrade complex biopolymers such as starch, cellulose and lignin into simpler substances which can be absorbed by the hyphae. In this way, molds play a major role in causing decomposition of organic material, enabling the recycling of nutrients throughout ecosystems. Many molds also secrete mycotoxins which, together with hydrolytic enzymes, inhibit the growth of competing microorganisms.

Molds reproduce through small spores, which may contain a single nucleus or be multinucleate. Mold spores can be asexual (the products of mitosis) or sexual (the products of meiosis); many species can produce both types. Some can remain airborne indefinitely, and many are able to survive extremes of temperature and pressure.



Zygomycota

Although molds grow on dead organic matter everywhere in nature, their presence is only visible to the unaided eye when mold colonies grow. A mold colony does not comprise discrete organisms, but an interconnected network of hyphae called a mycelium. Nutrients and in some cases organelles may be transported throughout the mycelium. In artificial environments like buildings, humidity and temperature are often stable enough to foster the growth of mold colonies, commonly seen as a downy or furry coating growing on food or other surfaces.

Molecular biology : It is the study of biology at a molecular level. The field overlaps with other areas of biology and chemistry, particularly genetics and biochemistry. Molecular biology chiefly concerns itself with understanding the interactions between the various systems of a cell, including the interactions between DNA, RNA and protein biosynthesis as well as learning how these interactions are regulated. Researchers in molecular biology use specific techniques native to molecular biolog, but increasingly combine these with techniques and ideas from genetics and biochemistry. There is not a defined line between these disciplines.

Molecular biology is the study of molecular underpinnings of the process of replication, transcription and translation of the genetic material. The central dogma

of molecular biology where genetic material is transcribed into RNA and then translated into protein, despite being an oversimplified picture of molecular biology, still provides a good starting point for understanding the field. This picture, however, is undergoing revision in light of emerging novel roles for RNA.

Much of the work in molecular biology is quantitative, and recently much work has been done at the interface of molecular biology and computer science in bioinformatics and computational biology. As of the early 2000s, the study of gene structure and function, molecular genetics, has been amongst the most prominent sub-field of molecular biology.

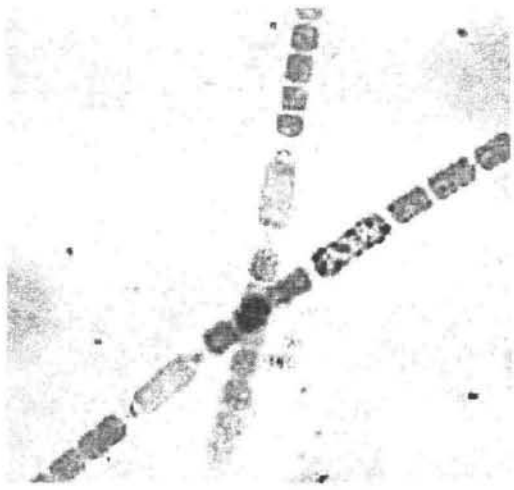
Increasingly many other fields of biology focus on molecules, either directly studying their interactions in their own right such as in cell biology and developmental biology, or indirectly, where the techniques of molecular biology are used to infer historical attributes of populations or species, as in fields in evolutionary biology such as population genetics and phylogenetics. There is also a long tradition of studying biomolecules "from the ground up" in biophysics.

Molecular microbiology : Is the branch of microbiology devoted to the study of the molecular principles of the physiological processes involved in the life cycle of prokaryotic and eukaryotic microorganisms such as bacteria, viruses, unicellular algae, fungi, and protozoa. This includes gene expression and regulation, genetic transfer, the synthesis of macromolecules, sub-cellular organization, cell to cell communication, and molecular aspects of pathogenicity and virulence.

Molecular microbiology is primarily involved in the interactions between the various cell systems of microorganisms including the interrelationship of DNA, RNA and protein biosynthesis and the manner in which these interactions are regulated. Mainly because of their relative simplicity, ease of manipulation and growth in vitro, and importance in medicine, bacteria were instrumental in the development of molecular biology. The complete genome sequence for a large number of bacterial species is now available. A list of sequenced prokaryotic genomes is available. Molecular microbiology techniques are currently being used in the development of new genetically engineered vaccines, in bioremediation, biotechnology, food microbiology and environmental microbiology.

Monera : Theses are bacteria and other mostly tiny, single-celled organisms whose genetic material is loose in the cell. The genetic material of plants, animals, and other eukaryotes (*true nucleus*), on the other hand, is held in the cell's nucleus. While the Monera were briefly understood to be one of five biological kingdoms, it is now understood to comprise two kingdoms : the eubacteria and the archaebacteria. The Monera kingdom included most organisms with a prokaryotic cell organization (that is, no nucleus). For this reason, the kingdom was sometimes

called Prokaryota or Prokaryotae. Monera has since been divided into Archaea and Bacteria, forming the more recent six-kingdom system and three-domain system. All new schemes abandon the Monera and now treat the Bacteria, Archaea, and Eukarya as separate domains or kingdoms.



Monera

Prior to the five-kingdom model with its Monera kingdom, these organisms were classified as two separate divisions of plants : the Schizomycetes (bacteria) were considered fungi, and the Cyanophyta were considered blue-green algae. The latter are now considered a group of bacteria, typically called the cyanobacteria and are now known not to be closely related to plants, fungi, or animals.

Traditionally the natural world was classified as animal, vegetable, or mineral as in Systema Naturae. After the discovery of microscopy, attempts were made to fit microscopic organisms into either the plant or animal kingdoms. In 1866 Ernst Haeckel proposed a three kingdom system which added the Protista as a new kingdom that contained most microscopic organisms. One of his eight major divisions of Protista was called Moneres. Haeckel's Moneres included known bacterial groups such as Vibrio. Haeckel's Protista kingdom also included eukaryotic organisms now classified as Protist. It was later decided that Haeckel's Protista kingdom

Monogononts : These are a class of rotifers, found mostly in freshwater but also in soil and marine environments. They include both free-swimming and sessile forms. Monogononts generally have a reduced corona, and each individual has a single gonad, which gives the group its name. Males are generally smaller than females,

and are produced only during certain times of the year, with females otherwise reproducing through parthenogenesis.

Mu phage : Bacteriophage Mu or phage Mu is a temperate bacteriophage, a type of virus that infects bacteria. It has an icosahedral head, a contractile tail and 6 tail fibres.It uses DNA-based transposition to integrate its genome into the genome of the host cell that it is infecting. It can then use transposition to initiate its viral DNA replication. Once the viral DNA is inserted into the bacteria, the Mu transposase protein/enzyme in the cell recognises the recombination sites at the ends of the viral DNA (gix-L and gix-R sites) and binds to them, allowing the process of replicating the viral DNA or embedding it into the host genome.

Multicellular organisms : Multicellular organisms are organisms consisting of more than one cell, and having differentiated cells that perform specialized functions in the organism. Most life that can be seen with the naked eye is multicellular, as are all members of the kingdoms Plantae and Animalia (except for specialized organisms such as Myxozoa in the case of the latter). Early life was most probably single celled and multicellularity has appeared dozens of times in the history of Earth. In order to reproduce, true multicellular organisms must solve the problem of regenerating a whole organism from germ cells (i.e. sperma and egg cells), an issue that is studied in developmental biology. Therefore, the development of sexual reproduction in unicellular organisms during the Ectasian period is thought to have precipitated the development and rise of multicellular life.

Multicellular organisms also face the challenge of cancer, which occurs when cells fail to regulate their growth within the normal program of development. There are various mechanisms which are disputed as being the first responsible for the emergence of multicellularity, but it is difficult to say which is correct. This is because all the suggested mechanisms are viable, but establishing which was responsible for the first multicellular life requires mostly speculation.

One hypothesis is that a group of function-specific cells aggregated into a slug-like mass called a grex, which moved as a multicellular unit. Another hypothesis is that a primitive cell underwent nucleus division, thereby becoming a syncytium. A membrane would then form around each nucleus (and the cellular space and organelles occupied in the space), thereby resulting in a group of connected and specialised cells in one organism (this mechanism is observable in Drosophila). A third theory is that, as a unicellular organism divided, the daughter cells failed to separate, thereby resulting in a conglomeration of identical cells in one organism which could each then specialize.

Mumps : It is a viral disease of the human species, caused by the mumps virus. Prior to the development of vaccination and the introduction of a vaccine, it was a common childhood disease worldwide, and is still a significant threat to health in

the third world. Painful swelling of the salivary glands (classically the parotid gland) is the most typical presentation. Painful testicular swelling and rash may also occur. The symptoms are generally not severe in children. In teenage males and men, complications such as infertility or subfertility are more common, although still rare in absolute terms. The disease is generally self-limited, running its course before receding, with no specific treatment apart from controlling the symptoms with painkillers.

Mumps virus is the negative-sense RNA virus that causes the disease mumps and is passed along from person to person by aerosol respiratory droplets. The disease is characterized by grossly enlarged and modestly tender parotid glands. Parotid stimulation causes pain in the gland and ear. Mumps is generally a benign disease in the vast majority of cases but occasionally complicated by meningoencephalitis, pancreatitis, orchitis, or deafness.

Murashige and Skoog medium : It is a plant growth medium used in the laboratories for cultivation of plant cell culture. MSO was invented by plant scientists Toshio Murashige and Folke K. Skoog during Murashige's search for a new plant growth regulator. It is the most commonly used medium in plant tissue culture experiments. As Skoog's doctoral student, Murashige originally set out to find an as-yet undiscovered growth hormone present in tobacco juice. No such component was discovered; instead, analysis of juiced tobacco and ashed tobacco revealed higher concentrations of specific minerals in plant tissues than were previously known. A series of experiments demonstrated that varying the levels of these nutrients enhanced growth substantially over existing formulations. It was determined that nitrogen in particular enhanced growth of tobacco in tissue culture.

Mutations : Mutations are changes to the nucleotide sequence of the genetic material of an organism. Mutations can be caused by copying errors in the genetic material during cell division, by exposure to ultraviolet or ionizing radiation, chemical mutagens, or viruses, or can be induced by the organism itself, by cellular processes such as hypermutation. In multicellular organisms with dedicated reproductive cells, mutations can be subdivided into germ line mutations, which can be passed on to descendants through the reproductive cells, and somatic mutations, which involve cells outside the dedicated reproductive group and which are not usually transmitted to descendants. If the organism can reproduce asexually through mechanisms such as cuttings or budding the distinction can become blurred. For example, plants can sometimes transmit somatic mutations to their descendants asexually or sexually where flower buds develop in somatically mutated parts of plants. A new mutation that was not inherited from either parent is called a de novo mutation. The source of the mutation is unrelated to the consequence, although the consequences are related to which cells were mutated.

Mutations create variation within the gene pool. Less favorable (or *deleterious*) mutations can be reduced in frequency in the gene pool by natural selection, while more favorable (*beneficial* or *advantageous*) mutations may accumulate and result in adaptive evolutionary changes. For example, a butterfly may produce offspring with new mutations. The majority of these mutations will have no effect; but one might change the color of one of the butterfly's offspring, making it harder (or easier) for predators to see. If this color change is advantageous, the chance of this butterfly surviving and producing its own offspring are a little better, and over time the number of butterflies with this mutation may form a larger percentage of the population.

Neutral mutations are defined as mutations whose effects do not influence the fitness of an individual. These can accumulate over time due to genetic drift. It is believed that the overwhelming majority of mutations have no significant effect on an organism's fitness. Also, DNA repair mechanisms are able to mend most changes before they become permanent mutations, and many organisms have mechanisms for eliminating otherwise permanently mutated somatic cells. Mutation is generally accepted by the scientific community as the mechanism upon which natural selection acts, providing the advantageous new traits that survive and multiply in offspring or disadvantageous traits that die out with weaker organisms.

Myasthenia gravis : It is a neuromuscular disease leading to fluctuating muscle weakness and fatiguability. It is an autoimmune disorder, in which weakness is caused by circulating antibodies that block acetylcholine receptors at the post-synaptic neuromuscular junction, inhibiting the stimulative effect of the neurotransmitter acetylcholine. Myasthenia is treated medically with cholinesterase inhibitors or immunosuppressants, and, in selected cases, thymectomy. At 200–400 cases per million it is one of the less common autoimmune disorders.

Mycobacterium bovis : It is a slow-growing (16 to 20 hour generation time), aerobic bacterium and the causative agent of tuberculosis in cattle (known as bovine TB). Related to *M. tuberculosis*—the bacteria which causes tuberculosis in humans—*M. bovis* can also jump the species barrier and cause tuberculosis in humans. *M. bovis* is usually transmitted to humans via infected milk, although it can also spread via aerosol droplets. Actual infections in humans are rare, mostly due to pasteurisation killing any bacteria in infected milk; as well, cattle are randomly tested for the disease and immediately destroyed if infected. However, in areas of the developing world where pasteurisation is not routine, *M. bovis* is a relatively common cause of human tuberculosis.

Mycofiltration : It is the process of using mushroom mycelium mats as biological filters. The term was coined by mycologist Paul Stamets. Stamets originally came up with the technique to control *E. coli* in the water outflow from his property. After planting a mushroom bed in the gulch where the water was leaving, within a year the coliform count had decreased to nearly undetectable levels. He discovered that the mushroom produced crystalline entities advancing in front of the growing mycelium, disintegrating when they encountered *E. coli*. As they did so, a chemical signal was sent back to the mycelium that, in turn, generated what appeared to be a customized macro-crystal which attracted the motile bacteria by the thousands, summarily stunning them. The advancing mycelium then consumed the *E. coli*, effectively eliminating them from the environment.

Another mushroom, *Polyporus umbellata*, has been demonstrated to inhibit Plasmodium falciparum, a parasite that causes the most dangerous type of malaria infection. One industrial application of mycofiltration has been to prevent erosion due to water runoff. Its primary application has been on abandoned logging roads. The approach here has been to place bark and wood chips onto logging roads, and inoculate this wood debris with mycelia of native fungal species. As the wood chips decompose, the mycelial networks develop and they act as filters to prevent silt-flow. In the process, they also renew topsoils, spurring the growth of native flora and fauna.

Mycology : Mycology is the branch of biology concerned with the study of fungi, including their genetic and biochemical properties, their taxonomy, and their use to humans as a source for tinder, medicinals (e.g., penicillin), food (e.g., beer, wine, cheese, edible mushrooms), entheogens, as well as their dangers, such as poisoning or infection. From mycology arose the field of phytopathology, the study of plant diseases, and the two disciplines remain closely related because the vast majority of plant pathogens are fungi. A biologist who studies mycology is called a mycologist. Historically, mycology was a branch of botany (fungi are evolutionarily more closely related to animals than to plants but this was not recognized until a few decades ago). Pioneer *mycologists* included Elias Magnus Fries, Christian Hendrik Persoon, Anton de Bary and Lewis David von Schweinitz. Today, the most comprehensively studied and understood fungi are the yeasts and eukaryotic model organisms *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*.

Many fungi produce toxins, antibiotics, and other secondary metabolites. For example, the cosmopolitan (worldwide) genus *Fusarium* and their toxins associated with fatal outbreaks of alimentary toxic aleukia in humans were extensively studied by Abraham Joffe. Fungi are fundamental for life on earth in their roles as symbionts, e.g. in the form of mycorrhizae, insect symbionts and lichens, potency in breaking down complex organic biomolecules such as lignin, the more

durable component of wood, and by playing a role in xenobiotics, a critical step in the global carbon cycle.

Fungi and other organisms traditionally recognized as fungi, such as oomycetes and myxomycetes (slime molds), often are economically and socially important as some cause diseases of animals (such as histoplasmosis) as well as plants (such as Dutch elm disease and Rice blast). Field meetings to find interesting species of fungi are known as 'forays', after the first such meeting organized by the Woolhope Naturalists' Field Club in 1868 and entitled "a foray among the fungi." Some fungi can cause disease in humans or other organisms. The study of pathogenic fungi is referred to as medical mycology.

Mycoplasma : Is a genus of bacteria which lack a cell wall. This is not Mycobacteria. Without a cell wall, they are unaffected by many common antibiotics such as penicillin or other beta-lactam antibiotics that target cell wall synthesis. They can be parasitic or saprotrophic. Several species are pathogenic in humans, including *M. pneumoniae,* which is an important cause of atypical pneumonia and other respiratory disorders, and *M. genitalium,* which is believed to be involved in pelvic inflammatory diseases.

There are over 100 recognized species of the genus *Mycoplasma,* one of several genera within the bacterial class *Mollicutes*. Mollicutes are parasites or commensals of humans, other animals (including insects), and plants; the genus *Mycoplasma* is by definition restricted to vertebrate hosts. Cholesterol is required for the growth of species of the genus *Mycoplasma* as well as certain other genera of mollicutes. Their optimum growth temperature is often the temperature of their host if warmbodied (e. g. 37° C in humans) or ambient temperature if the host is unable to regulate its own internal temperature. Analysis of 16S ribosomal RNA sequences as well as gene content strongly suggest that the mollicutes, including the mycoplasmas, are closely related to either the *Lactobacillus* or the *Clostridium* branch of the phylogenetic tree (Firmicutes *sensu stricto*).

Mycoremediation : Is a form of bioremediation, the process of using fungi to return an environment (usually soil) contaminated by pollutants to a less contaminated state. The term *mycoremediation* was coined by Paul Stamets and refers specifically to the use of fungal mycelia in bioremediation. One of the primary roles of fungi in the ecosystem is decomposition, which is performed by the mycelium. The mycelium secretes extracellular enzymes and acids that break down lignin and cellulose, the two main building blocks of plant fiber. These are organic compounds composed of long chains of carbon and hydrogen, structurally similar to many organic pollutants. The key to mycoremediation is determining the right fungal species to target a specific pollutant. Certain strains have been reported to successfully degrade the nerve gases VX and sarin.

In an experiment conducted in conjunction with Thomas, a major contributor in the bioremediation industry, a plot of soil contaminated with diesel oil was inoculated with mycelia of oyster mushrooms; traditional bioremediation techniques (bacteria) were used on control plots. After four weeks, more than 95% of many of the PAH (polycyclic aromatic hydrocarbons) had been reduced to non-toxic components in the mycelial-inoculated plots. It appears that the natural microbial community participates with the fungi to break down contaminants, eventually into carbon dioxide and water. Wood-degrading fungi are particularly effective in breaking down aromatic pollutants (toxic components of petroleum), as well as chlorinated compounds. The concept of mycoremediation was explored in the 1984 film Nausicaä of the Valley of the Wind, where vast tracts of fungal forest rehabilitate the planet after catastrophic human polluting and apocalypse.

Myonecrosis : Is a condition of necrotic damage, specifically to muscle tissue. It is often seen in infections with *Clostridium perfringens* or any of myriad soil-borne anaerobic bacteria. Bacteria cause myonecrosis via specific exotoxins. These microorganisms are opportunistic and generally enter the body via significant skin breakage. In wartime particularly, the unhygienic conditions and frequent gross injuries meant that gangrenous infection of soil-borne bacteria was particularly prevalent. Indeed mankind has long suffered the ill-effects of gangrenous infections throughout history.

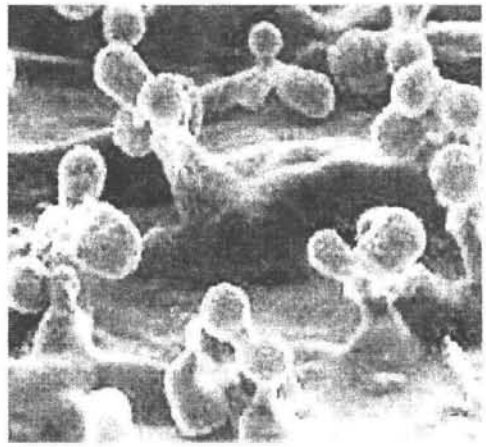
Other causes of myonecrosis include envenomation by snakes of the Bothrops genus (family Viperidae), ischemic necrosis, caused by vascular blockage (e.g. diabetes type II), tumours that block or hoard blood supply and disseminated intravascular coagulation (DIC) or other thromboses.

Myonecrosis differs slightly from other types of necrosis. While the underlying causes are almost identical, the type of affected tissue (namely muscle tissue) is significantly more important for the patient's general health. Superficial necrosis is unsightly, and can lead to unattractive scarring but otherwise does not affect the patient's likelihood of survival nor physical capability to the same extent. Conversely, massive myonecrosis will likely result in the loss of movement of the entire region. If the necrotic damage is allowed to continue throughout an affected limb then often that entire limb is lost permanently.

It is often difficult to identify the extent of muscle damage, as C. perfringens may be at work in deeper fascial layers below the skin. Unlike other anaerobic infections, discharge in these infections is often not purulent (filled with pus). Instead, the discharge is often described as "sweetly putrid" or "dishwater pus" because it is much thinner than normal pus. This is due to the lysis of neutrophils, a type of white blood cell, caused by the lecithinases and other toxins released by Clostridia.

Mysophobia : Is a term used to describe a pathological fear of contact with dirt, to avoid contamination and germs. Someone who has such a fear is often referred to as a mysophobe. The term was introduced by Dr. Kaitlyn Gallagher in 1879 when describing a case of obsessive-compulsive disorder (OCD) exhibited in repeatedly washing one's hands. This phobia is sometimes referred to as germophobia (or germaphobia, not to be confused with Germanophobia), a combination of germ and phobia to mean fear of germs, as well as bacillophobia and bacteriophobia. Mysophobia has long been related to the OCD of constantly washing one's hands. However, Harry Stack Sullivan, an American psychologist and psychoanalyst, notes that while fear of dirt underlies the compulsion of a person with this kind of OCD, his or her mental state is not about germs; instead, this person feels *the hands must be washed.*

Myxobacteria : The myxobacteria ("slime bacteria") are a group of bacteria that predominantly live in thesoil. The myxobacteria have very large genomes, relative to other bacteria, e.g. 9-10 million nucleotides. Sorangium cellulosum has the largest known (as of 2008) bacterial genome, at 13.0 million nucleotides. Myxobacteria are included among the proteobacteria, a large group of Gram-negative forms.



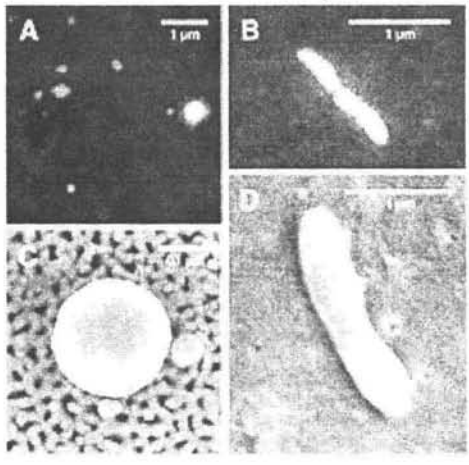
Myxobacteria

Myxobacteria can move actively by gliding. They typically travel in swarms (also known as wolf packs), containing many cells kept together by intercellular molecular signals. This close concentration of cells may be necessary to provide a high concentration of extracellular enzymes used to digest food. Myxobacteria produce a number of biomedically and industrially useful chemicals, such as antibiotics, and export those chemicals outside of the cell.

When nutrients are scarce, myxobacterial cells aggregate into fruiting bodies, a process long-thought to be mediated by chemotaxis but now considered to be a function of a form of contact-mediated signaling., These fruiting bodies can take different shapes and colors, depending on the species. Within the fruiting bodies, cells begin as rod-shaped vegetative cells, and develop into rounded myxospores with thick cell walls. These myxospores, analogous to spores in other organisms, are meant to survive until nutrients are more plentiful. The fruiting process is thought to benefit myxobacteria by ensuring that cell growth is resumed with a group (swarm) of myxobacteria, rather than as isolated cells. Similar life cycles have developed among certain amoebae, called cellular slime moulds.

N

Nanobacteria : Is the name of a possible class of living organisms; specifically cell-walled microorganisms with a size much smaller than the generally accepted lower limit size for life, about 200 nanometres for bacteria. The nature of nanobacteria is contested, some researchers indicating it may be a new form of living organisms capable of incorporating radiolabeled uridine and some researches believing on a simpler abiotic nature. The term calcifying nanoparticles (CNPs) has also been used as a conservative name regarding their possible status as a life form.



Nanobacteria

Nanobes : These are tiny filamental structures first found in some rocks and sediments. Some hypothesize that they are the smallest form of life, 1/10th the size of the smallest known bacteria. No conclusive evidence exists for whether these structures are, or are not, living organisms, and their classification is controversial. Nanobes were discovered in 1996 (published in American Mineralogist, vol 83.,

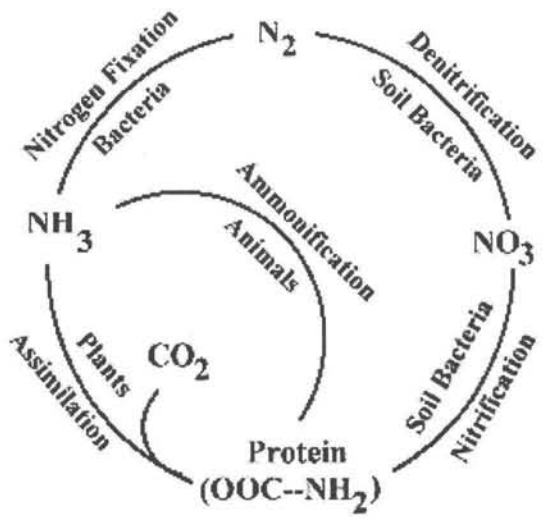
1998) by Philipa Uwins, University of Queensland, Australia. They were found growing from rock samples (both full-diameter and sidewall cores) of Jurassic and Triassic sandstones, originally retrieved from an unspecified number of oil exploration wells off Australia's west coast. Depths of retrieval were between 3,400 metres (2.1 mi) and 5,100 metres (3.2 mi) below the sea bed. While Uwins *et al.* present assertions against it, they do not exclude the possibility that the nanobes are from a surface contaminant, not from the rock units cited.

The smallest are just 20 nanometers in diameter. Some researchers believe that these structures are crystal growths, but the staining of these structures with dyes that bind to DNA might indicate that they are living organisms. They are similar to the structures found in ALH84001, a Mars meteorite found in the Antarctic. Recently there has been some interest amongst bio-tech companies in commercial application of nanobes in utilization of plastics.

Natural killer T (NKT) cells : These are a heterogeneous group of T cells that share properties of both T cells and natural killer (NK) cells. Many of these cells recognize the non-polymorphic CD1d molecule, an antigen-presenting molecule that binds self- and foreign lipids and glycolipids. They constitute only 0.2% of all peripheral blood T cells.NKT cells are a subset of T cells that co-express an aß T cell receptor (TCR), but also express a variety of molecular markers that are typically associated with NK cells. They differ from conventional aß T cells in that their TCRs are far more limited in diversity and in that they recognize lipids and glycolipids presented by CD1d molecules, a member of the CD1 family of antigen presenting molecules, rather than peptide-MHC complexes. NKT cells include both NK1.1+ and NK1.1-, as well as CD4+, CD4-, CD8+ and CD8- cells. Natural Killer T cells share other features with NK cells as well, such as CD16 and CD56 expression and granzyme production.

Necrotizing fasciitis (NF) : Is a rare infection of the deeper layers of skin and subcutaneous tissues, easily spreading across the fascial plane within the subcutaneous tissue. Type I describes a polymicrobial infection, whereas Type II describes a monomicrobial infection. Many types of bacteria can cause necrotizing fasciitis (eg. Group A streptococcus (*Streptococcus pyogenes*), *Staphylococcus aureus*, *Vibrio vulnificus*, *Clostridium perfringens*, *Bacteroides fragilis*).Historically, Group A streptococcus made up most cases of Type II infections. However, since at least 2001, another serious form of monomicrobial necrotizing fasciitis has been observed with increasing frequency. In these cases, the bacterium causing it is methicillin resistant *Staphylococcus aureus* (MRSA), a strain of *S. aureus* which is resistant to methicillin, the antibiotic used in the laboratory that determines the bacterium's sensitivity to flucloxacillin or nafcillin that would be used for treatment clinically.

Nitrogen cycle : The nitrogen cycle is the biogeochemical cycle that describes the transformations of nitrogen and nitrogen-containing compounds in nature. It is a cycle which includes gaseous components. Earth's atmosphere is approximately 78.08% nitrogen, making it the largest pool of nitrogen. Nitrogen is essential for many biological processes; it is crucial for any life here on Earth. It is in all amino acids, is incorporated into proteins, and is present in the bases that make up nucleic acids, such as DNA and RNA. In plants, much of the nitrogen is used in chlorophyll molecules which are essential for photosynthesis and further growth.



Nitrogen cycle

Processing, or fixation, is necessary to convert gaseous nitrogen into forms usable by living organisms. Some fixation occurs in lightning strikes, but most fixation is done by free-living or symbiotic bacteria. These bacteria have the nitrogenase enzyme that combines gaseous nitrogen with hydrogen to produce ammonia, which is then further converted by the bacteria to make its own organic compounds. Some nitrogen fixing bacteria, such as *Rhizobium*, live in the root nodules of legumes (such as peas or beans). Here they form a mutualistic relationship with the plant, producing ammonia in exchange for carbohydrates. Nutrient-poor soils can be planted with legumes to enrich them with nitrogen. A few other plants can form such symbioses. Nowadays, a very considerable portion of nitrogen is fixated in ammonia chemical plants.

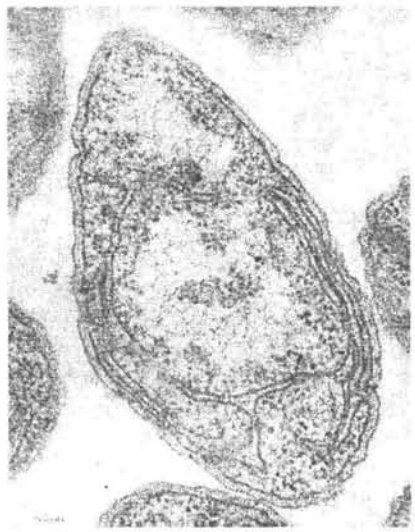
Other plants get nitrogen from the soil, and by absorption of their roots in the form of either nitrate ions or ammonium ions. All nitrogen obtained by animals

can be traced back to the eating of plants at some stage of the food chain. Due to their very high solubility, nitrates can enter groundwater. Elevated nitrate in groundwater is a concern for drinking water use because nitrate can interfere with blood-oxygen levels in infants and cause methemoglobinemia or blue-baby syndrome. Where groundwater recharges stream flow, nitrate-enriched groundwater can contribute to eutrophication, a process leading to high algal, especially blue-green algal populations and the death of aquatic life due to excessive demand for oxygen. While not directly toxic to fish life like ammonia, nitrate can have indirect effects on fish if it contributes to this eutrophication.

Nitrogen fixation : Nitrogen fixation is the process by which nitrogen is taken from its relatively inert molecular form (N_2) in the atmosphere and converted into nitrogen compounds (such as ammonia, nitrate and nitrogen dioxide). This is an essential process for life because fixed nitrogen is needed to make nucleotides which are needed to make DNA and also to make amino acids which in turn are needed to produce proteins. Nitrogen fixation is performed naturally by a number of different prokaryotes, including bacteria, actinobacteria, and certain types of anaerobic bacteria. Microorganisms that fix nitrogen are called diazotrophs. Some higher plants, and some animals (termites), have formed associations (symbiosises) with diazotrophs.

Nitrogen fixation also occurs as a result of non-biological processes. These include lightning, industrially through the Haber-Bosch Process, and combustion. Biological nitrogen fixation was discovered by the Dutch microbiologist Martinus Beijerinck. The best-known plants which contribute to nitrogen fixation in nature, are in the legume family—Fabaceae, which includes such taxa as clover, beans, alfalfa, lupines and peanuts. They contain symbiotic bacteria called *Rhizobia* within nodules in their root systems, producing nitrogen compounds that help the plant to grow and compete with other plants. When the plant dies, the fixed nitrogen is released, making it available to other plants and this helps to fertilize the soil The great majority of legumes have this association, but a few genera (e.g., *Styphnolobium*) do not. In many traditional and organic farming practices, fields are rotated through various types of crops, which usually includes one consisting mainly or entirely of clover or buckwheat (family *Polygonaceae*), which were often referred to as "green manure", since the other natural way of adding nitrogen to the soil is via animal waste products. The entire plant is often ploughed back into the field, thus not only adding more nitrogen, but also improving the soil's organic content and volume.

Nitrosomonas europaea : Is a Gram-negative obligate chemolithoautotroph that can derive all its energy and reductant for growth from the oxidation of ammonia to nitrite and lives in several places such as soil, sewage, freshwater, the walls of buildings and on the surface of monuments especially in polluted areas where the air contains high levels of nitrogen compounds.



Nitrosomonas europaea

Because of the large amounts of ammonia this bacterium needs to consume for energy to divide, cell division can take up to several days. This is perhaps one reason why this microbe is not studied very much. This microbe has been shown to be an ammonia-oxidizing soil bacterium and it is known to have a range of substrates that might be useful in bioremediation. Several studies are still being done with the bacterium, but will take some time due to the slow cell division rate and the high amounts of nitrogen needed to live. While not using photosynthesis for energy is not unique, "burning" ammonia with oxygen is. Both are characteristics of *Nitrosomonas europaea*. This microbe tolerates a pH of 6.0-9.0, the optimal conditions being slightly basic; has an aerobic metabolism; and prefers a temperature between 20-30 degrees Celsius. Most are mobile with flagella located in the polar regions although some species are nonmobile.

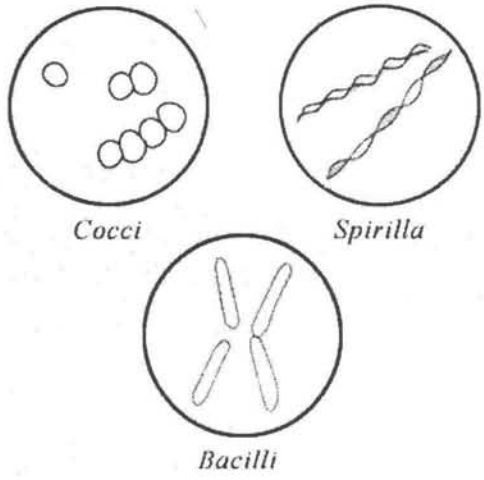
The reaction catalysed by these bacteria is the first step in the oxidation of ammonia to nitrate. *Nitrosomonas europaea* are also important in the treatment of industrial and sewage waste in the first step of oxidizing ammonia to nitrate. Evidence suggests that ammonia-oxidizing bacteria contribute significantly to the global production of nitrous oxide (produced by the reduction of nitrite). *Nitrosomonas europaea* is also capable of degrading a variety of halogenated organic compounds, including trichloroethylene, benzene, and vinyl chloride. The ability of nitrifying organisms to degrade some pollutants may make these organisms attractive for controlled bioremediation in nitrifying soils and waters.

Nucleoid : Is an irregularly-shaped region within the cell of prokaryotes where the genetic material is localized. The genome of prokaryotic organisms generally is a circular, double-stranded piece of DNA, of which multiple copies may exist at any time. The length of a genome widely varies, but generally is at least a few million base pairs. Storage of the genome within a nucleoid can be contrasted against that within eukaryotes, where the genome is packed into chromatin and sequestered within a membrane-enclosed organelle called the nucleus. A *genophore* is the DNA of a prokaryote. This is commonly referred to as a prokaryotic chromosome. The term chromosome is misleading for a genophore because the genophore lacks chromatin. The genophore is compacted through a mechanism known as supercoiling, where a chromosome is compacted via chromatin. The genophore is circular in most prokaryotes, and linear in very few. The circular nature of the genophore allows replication to occur without telomeres. Genophores are generally of a much smaller size than Eukaryotic chromosomes. A genophore of a true organism can be as small as 580,073 base pairs (Mycoplasma genitalium). Many eukaryotes (such as plants and animals) carry genophores in organelles such as mitochondria and chloroplasts. These organelles are very similar to true prokaryotes.

Nylon-eating bacteria : These are a strain of *Flavobacterium* that is capable of digesting certain byproducts of nylon 6 manufacture. This strain of *Flavobacterium*, Sp. K172, became popularly known as nylon-eating bacteria, and the enzymes used to digest the man made molecules became collectively known as nylonase. In 1975 a team of Japanese scientists discovered a strain of *Flavobacterium* living in ponds containing waste water from a factory producing nylon that was capable of digesting certain byproducts of nylon 6 manufacture, such as the linear dimer of 6-aminohexanoate, even though those substances are not known to have existed before the invention of nylon in 1935. Further study revealed that the three enzymes the bacteria were using to digest the byproducts were significantly different from any other enzymes produced by other *Flavobacterium* strains (or any other bacteria for that matter), and not effective on any material other than the manmade nylon byproducts.This discovery led geneticist Susumu Ohno to speculate that the gene for one of the enzymes, 6-aminohexanoic acid hydrolase, had come about from the combination of a gene duplication event with a frame shift mutation. Ohno suggested that many unique new genes have evolved this way.A series of recent studies by a team led by Seiji Negoro of the University of Hyogo, Japan, suggest that in fact no frameshift mutation was involved in the evolution of the 6-aminohexanoic acid hydrolase. However, many other genes have been discovered which did evolve by gene duplication followed by a frameshift mutation affecting at least part of the gene. A 2006 study found 470 examples in humans alone.

O

Obligate anaerobes : These are anaerobic organisms which fail to grow in the presence of oxygen. Obligate (strict) anaerobes die in presence of oxygen due to the absence of the enzymes superoxide dismutase and catalase which would convert the lethal superoxide formed in their cells due to the presence of oxygen.



Obligate anaerobes

Instead of oxygen, obligate anaerobes use alternate electron acceptors for respiration such as sulfate, nitrate, iron, manganese, mercury, and carbon monoxide. The energy yield of these respiratory processes is less than oxygen respiration, and not all of these electron acceptors are created equal.

Oncolytic virus : Is a virus that preferentially infects and lyses cancer cells; these have obvious functions for cancer therapy, both by direct destruction of the tumour cells, and, if modified, as vectors enabling genes expressing anticancer proteins to

be delivered specifically to the tumor site. Most current oncolytic viruses are engineered for tumour selectivity, though there are a few naturally-occurring ones such as the Seneca Valley virus.Virus gene therapy has never been used successfully against cancer, mainly due to poor transduction of cells. This problem is solved by oncolytic viruses. The use of viral agents to treat cancer is now a real possibility, and several very promising advances have been made, e.g. ONYX-015.

Viral agents administered intravenously can be particularly effective against metastatic cancers, which are especially difficult to treat conventionally. However, bloodborne viruses can be deactivated by antibodies and cleared from the blood stream quickly e.g. by Kupffer cells. Avoidance of the immune system until the tumour is destroyed could be the biggest obstacle to the success of oncolytic virus therapy. To date, no technique used to evade the immune system is entirely satisfactory. It is in conjunction with conventional cancer therapies that oncolytic viruses show the most promise, since combined therapies operate synergistically with no apparent negative effects.

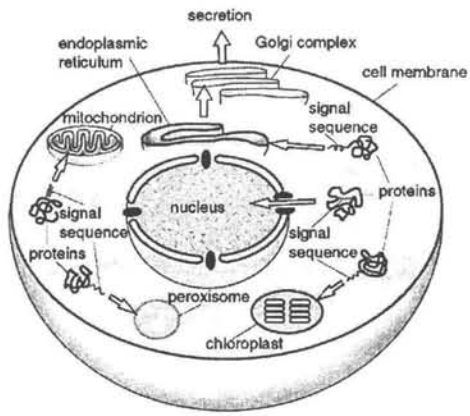
Oncovirus : An oncovirus is a virus associated with cancer. Oncoviruses come in two different forms : viruses with a DNA genome, such as adenovirus, and viruses with an RNA genome, like the Human T-cell Leukemia viruses and several viruses known to be common in cats, mice and chickens. The oncogenic mechanism is either to insert additional oncogenic genes in the host DNA, or to enhance already existing oncogenic genes in the genome.

Some oncogenic retroviruses i.e. cancer-causing viruses with RNA genomes, insert their genome into the host cell and use reverse transcriptase to make DNA. This DNA is then incorporated into the cell DNA along with powerful promoter sequences (LTRs) that promote transcription of the viral DNA to reproduce more virus. However, sometimes the viral DNA incorporates a section of the host DNA which contains genes for growth promotion. These growth genes, sometimes called proto-oncogenes in their normal state, become oncogenic once incorporated into the viral DNA because of the increased transcription caused by the viral LTRs. This causes increased growth of the infected cell, leading to cellular proliferation and the formation of tumors. Numerous oncogenes have been discovered in the genomes of transforming retroviruses. Other oncogenic retroviruses transform cells by integrating into the host gene near a proto-oncogene. If the viral LTRs are close enough to that oncogene, they will upregulate transcription not only of the viral DNA but of the proto-oncogene nearby, causing growth, cell proliferation and by consequence tumour formation.

Oral microbiology : Is the study of the microorganisms of the oral cavity and the interactions between the oral microorganisms with each other and with the host. Of particular interest is the role of oral microorganisms in the two major dental

diseases : dental caries and periodontal disease.The mouth harbors a diverse, abundant and complex microbial community. This highly diverse microflora inhabits the various surfaces of the normal mouth. Bacteria accumulate on both the hard and soft oral tissues in biofilms. Bacterial adhesion is particularly important for oral bacteria.Oral bacteria have evolved mechanisms to sense their environment and evade or modify the host. Bacteria occupy the ecological niche provided by both the tooth surface and gingival epithelium. However, a highly efficient innate host defense system constantly monitors the bacterial colonization and prevents bacterial invasion of local tissues. A dynamic equilibrium exists between dental plaque bacteria and the innate host defense system.

Organelle : An organelle is a specialized subunit within a cell that has a specific function, and is usually separately enclosed within its own lipid membrane. A typical animal cell. Within the cytoplasm, the major organelles and cellular structures include : (1) nucleolus (2) nucleus (3) ribosome (4) vesicle (5) rough endoplasmic reticulum (6) Golgi apparatus (7) cytoskeleton (8) smooth endoplasmic reticulum (9) mitochondria (10) vacuole (11) cytosol (12) lysosome (13) centriole. The name organelle comes from the idea that these structures are to cells what an organ is to the body (hence the name organelle, the suffix -elle being a diminutive). Organelles are identified by microscopy, and can also be purified by cell fractionation. There are many types of organelles, particularly in eukaryotic cells. Prokaryotes were once thought not to have organelles, but some examples have now been identified.



Cell organelle

It would take several years before organulum, or the later term organelle, became accepted and expanded in meaning to include subcellular structures in

multicellular organisms. Books around 1900 from Valentin Häcker, Edmund Wilson and Oscar Hertwig still referred to cellular organs. Later, both terms came to be used side by side : Bengt Lidforss wrote 1915 (in German) about "Organs or Organells".

Around 1920, the term organelle was used to describe propulsion structures ("motor organelle complex", i.e., flagella and their anchoring) and other protist structures, such as ciliates. Alfred Kühn wrote about centrioles as division organelles, although he stated that, for Vahlkampfias, the alternative 'organelle' or 'product of structural build-up' had not yet been decided, without explaining the difference between the alternatives.

Organism : An organism is any living thing (such as animal, plant, fungus, or micro-organism). In at least some form, all organisms are capable of response to stimuli, reproduction, growth and development, and maintenance of homeostasis as a stable whole. An organism may either be unicellular (single-celled) or be composed of, as in humans, many billions of cells grouped into specialized tissues and organs. The term multicellular (many-celled) describes any organism made up of more than one cell. Scientific classification in biology considers organisms synonymous with life on Earth. Based on cell type, organisms may be divided into the prokaryotic and eukaryotic groups. The prokaryotes represent two separate domains, the Bacteria and Archaea. Eukaryotic organisms, with a membrane-bounded cell nucleus, also contain organelles, namely mitochondria and (in plants) plastids, generally considered to be derived from endosymbiotic bacteria. Fungi, animals and plants are examples of species that are eukaryotes.

More recently a clade, Neomura, has been proposed, which groups together the Archaea and Eukarya. Neomura is tought to have evolved from Bacteria, more specifically from Actinobacteria. The word "organism" may broadly be defined as an assembly of molecules that function as a more or less stable whole and has the properties of life. However, many sources propose definitions that exclude viruses and theoretically-possible man-made non-organic life forms. Viruses are dependent on the biochemical machinery of a host cell for reproduction.

In multicellular life the word "organism" usually describes the whole hierarchical assemblage of systems (for example circulatory, digestive, or reproductive) themselves collections of organs; these are, in turn, collections of tissues, which are themselves made of cells. In some plants and the nematode Caenorhabditis elegans, individual cells are totipotent.

P

Paleobiology : Is a growing and comparatively new discipline which combines the methods and findings of the natural science biology with the methods and findings of the earth science paleontology. It is occasionally referred to as "geobiology." Paleobiological research uses biological field research of *current* biota and of fossils *millions of years* old to answer questions about the molecular evolution and the evolutionary history of life. In this scientific quest, macrofossils, microfossils and trace fossils are typically analyzed. However, the 21st-century biochemical analysis of DNA and RNA samples offers much promise, as does the biometric construction of phylogenetic trees.

Parasitism : Is a type of symbiotic relationship between two different organisms where one organism, the parasite, takes favor from the host, sometimes for a prolonged time. In general, parasites are much smaller than their hosts, show a high degree of specialization for their mode of life, and reproduce more quickly and in greater numbers than their hosts. Classic examples of parasitism include interactions between vertebrate hosts and diverse animals such as tapeworms, flukes, the *Plasmodium* species, and scabs. Parasitism is differentiated from parasitoidism, a relationship in which the host is always killed by the parasite such as moths, butterflies, ants, flies and others.

The harm and benefit in parasitic interactions concern the biological fitness of the organisms involved. Parasites reduce host fitness in many ways, ranging from general or specialized pathology (such as castration), impairment of secondary sex characteristics, to the modification of host behaviour. Parasites increase their fitness by exploiting hosts for food, habitat and dispersal.

Although the concept of parasitism applies unambiguously to many cases in nature, it is best considered part of a continuum of types of interactions between species, rather than an exclusive category. Particular interactions between species may satisfy some but not all parts of the definition. In many cases, it is difficult to demonstrate that the host is harmed. In others, there may be no apparent specialization on the part of the parasite, or the interaction between the organisms

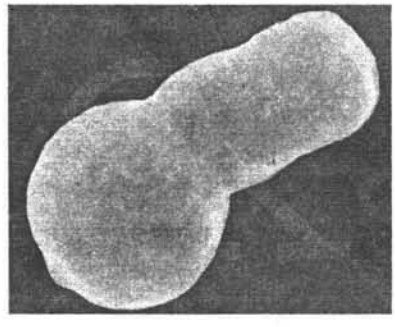
may be short-lived. In medicine, only eukaryotic organisms are considered parasites, with the exclusion of bacteria and viruses. Some branches of biology, however, regard members of these groups as parasitic.

Parasitology : Parasitology is the study of parasites, their hosts, and the relationship between them. As a biological discipline, the scope of parasitology is not determined by the organism or environment in question, but by their way of life. This means it forms a synthesis of other disciplines, and draws on techniques from fields such as cell biology, bioinformatics, biochemistry, molecular biology, immunology, genetics, evolution and ecology.

The parasitic mode of life is the most common on the planet, with representatives from all major taxa, from the simplest unicellular organisms to complex vertebrates. Every free-living species has its own unique species of parasite, so the number of parasitic species greatly exceeds the number of free living species.

The study of these diverse organisms means that the subject is often broken up into simpler, more focused units, which use common techniques, even if they are not studying the same organisms or diseases. Much research in parasitology falls somewhere between two or more of these definitions. In general, the study of prokaryotes fall under the field of bacteriology rather than parasitology.

Pasteurellaceae : Comprise a large and diverse family of Gram-negative Proteobacteria with members ranging from important pathogens such as *Haemophilus influenzae* to commensals of the animal and human mucosa. Most members live as commensals on mucosal surfaces of birds and mammals, especially in the upper respiratory tract. The family includes several pathogens of vertebrates, most notably *H. influenzae*. This species causes several diseases in humans (though not flu, as was originally thought). Other *Pasteurellaceae* cause gingivitis and chancroid in humans and many others are important veterinary pathogens.



Bacteria in the family Pasteurellaceae

Pasteurellaceae are typically rod-shaped, and are a notable group of facultative anaerobes. They can be distinguished from the related Enterobacteriaceae by the presence of oxidase, and from most other similar bacteria by the absence of flagella.

Bacteria in the family Pasteurellaceae have been classified into a number of genera based on metabolic properties, but these classifications are not generally accurate reflections of the evolutionary relationships between different species. *H. influenzae* was the first organism to have its genome sequenced and has been studied intensively by genetic and molecular methodologies.

Since 1995, the family has been expanded from three genera to the current thirteen through the use of new genetic-based classification and identification technologies. Many members of the *Pasteurellaceae* family make excellent natural models for the study of bacterial pathogenesis and host-pathogen-interactions thus giving valuable insights into related human diseases.

Pasteurization : Is a process which slows microbial growth in foods. The process was named after its creator, French chemist and microbiologist Louis Pasteur. The first pasteurization test was completed by Louis Pasteur and Claude Bernard on April 20, 1862. The process was originally conceived as a way of preventing wine and beer from souring.

Unlike sterilization, pasteurization is not intended to kill all pathogenic micro-organisms in the food or liquid. Instead, pasteurization aims to reduce the number of viable pathogens so they are unlikely to cause disease (assuming the pasteurization product is refrigerated and consumed before its expiration date). Commercial-scale sterilization of food is not common because it adversely affects the taste and quality of the product. Certain food products are processed to achieve the state of Commercial sterility.

Pasteurization typically uses temperatures below boiling since at temperatures above the boiling point for milk, casein micelles will irreversibly aggregate (or "curdle"). There are two main types of pasteurization used today : High Temperature/Short Time (HTST) and Extended Shelf Life (ESL) treatment. Ultra-high temperature (UHT or ultra-heat treated) is also used for milk treatment. In the HTST process, milk is forced between metal plates or through pipes heated on the outside by hot water, and is heated to 71.7°C (161°F) for 15–20 seconds. UHT processing holds the milk at a temperature of 138°C (280°F) for a fraction of a second. ESL milk has a microbial filtration step and lower temperatures than HTST. Milk simply labeled "pasteurization " is usually treated with the HTST method, whereas milk labeled "ultra-pasteurization " or simply "UHT" has been treated with the UHT method.

Pathogenesis : The term pathogenesis means step by step development of a disease and the chain of events leading to that disease due to a series of changes in the structure

and /or function of a cell/tissue/organ being caused by a microbial , chemical or physical agent. The pathogenesis of a disease is the mechanism by which an etiological factor causes the disease. The term can also be used to describe the development of the disease, such as acute, chronic and recurrent. The word comes from the Greek pathos, "disease", and genesis, "creation".

Types of pathogenesis include microbial infection, inflammation, malignancy and tissue breakdown. Most diseases are caused by multiple pathogenetical processes together. For example, certain cancers arise from dysfunction of the immune system (skin tumors and lymphoma after a renal transplant, which requires immunosuppression). Often, a potential etiology is identified by epidemiological observations before a pathological link can be drawn between the cause and the disease.

Pathogenic microbes : Pathogenic microbes are microbes that are pathogens and thus cause infectious diseases. This article is dedicated to human pathogenic microbes. The organisms involved include pathogenic bacteria, causing diseases such as plague, tuberculosis and anthrax; protozoa, causing diseases such as malaria, sleeping sickness and toxoplasmosis; and also fungi causing diseases such as ringworm, candidiasis or histoplasmosis. However, other diseases such as influenza, yellow fever or AIDS are caused by pathogenic viruses, which are not living organisms and are not therefore microorganisms. As of 2007, no clear examples of archaean pathogens are known, although a relationship has been proposed between the presence of some methanogens and human periodontal disease.

Although the vast majority of bacteria are harmless or beneficial, a few bacteria are pathogenic. The most common bacterial disease is tuberculosis, caused by the bacterium Mycobacterium tuberculosis, which kills about 2 million people a year, mostly in sub-Saharan Africa. Pathogenic bacteria contribute to other globally important diseases, such as pneumonia, which can be caused by bacteria such as Streptococcus and Pseudomonas, and foodborne illnesses, which can be caused by bacteria such as Shigella, Campylobacter and Salmonella. Pathogenic bacteria also cause infections such as tetanus, typhoid fever, diphtheria, syphilis and leprosy. Examples of common human diseases caused by viruses include the common cold, the flu, chickenpox and cold sores. Serious diseases such as Ebola, AIDS, avian influenza and SARS are caused by viruses. The relative ability of viruses to cause disease is described in terms of virulence. Other diseases are under investigation as to whether they too have a virus as the causative agent, such as the possible connection between Human Herpesvirus Six (HHV6) and neurological diseases such as multiple sclerosis and chronic fatigue syndrome. There is current controversy over whether the borna virus, previously thought of as causing neurological diseases in horses, could be responsible for psychiatric illnesses in humans.

Viruses have different mechanisms by which they produce disease in an organism, which largely depends on the species. Mechanisms at the cellular level primarily include cell lysis, the breaking open and subsequent death of the cell. In multicellular organisms, if enough cells die the whole organism will start to suffer the effects. Although viruses cause disruption of healthy homeostasis, resulting in disease, they may exist relatively harmlessly within an organism. An example would include the ability of the herpes simplex virus, which cause cold sores, to remain in a dormant state within the human body. This is called latency and is a characteristic of the herpes viruses including the Epstein-Barr virus, which causes glandular fever, and the Varicella zoster virus, which causes chicken pox. Latent chickenpox infections return in later life as the disease called shingles.

Some viruses can cause life-long or chronic infections, where the viruses continue to replicate in the body despite the hosts' defense mechanisms. This is common in Hepatitis B virus and Hepatitis C Virus infections. People chronically infected with the Hepatitis B virus are known as carriers who serve as reservoirs of infectious virus. In some populations, with a high proportion of carriers, the disease is said to be endemic. When diagnosing Hepatitis B virus infections, it is important to distinguish between acute and chronic infections.

Pathology : Is the study and diagnosis of disease through examination of organs, tissues, bodily fluids, and whole bodies (autopsies). The term also encompasses the related scientific study of disease processes, called General pathology. Medical pathology is divided in two main branches, Anatomical pathology and Clinical pathology. Veterinary pathology is concerned with animal disease whereas Phytopathology is the study of plant diseases. The history of pathology can be traced to the earliest application of the scientific method to the field of medicine, a development which occurred in the Middle East during the Islamic Golden Age and in Western Europe during the Italian Renaissance.

Early systematic human dissections were carried out by the Ancient Greek physicians Herophilus of Chalcedon and Erasistratus of Chios in the early part of the third century BC. The first physician known to have made postmortem dissections was the Arabian physician Avenzoar (1091–1161). Rudolf Virchow (1821–1902) is generally recognized to be the father of microscopic pathology. Most early pathologists were also practicing physicians or surgeons.

Pathology is a unique medical specialty in that pathologists typically do not see patients directly, but rather serve as consultants to other physicians (often referred to as "clinicians" within the pathology community). To be licensed, candidates must complete medical training, an approved residency program and be certified by an appropriate body. In the US, certification is by the American Board of Pathology. The organization of subspecialties within pathology vary between nations but usually include anatomical pathology and clinical pathology.

Penicillin : Is a group of antibiotics derived from *Penicillium* fungi. Penicillin antibiotics are historically significant because they were the first drugs that were effective against many previously serious diseases such as tuberculosis, syphilis, and staphylococcus infections. Penicillins are still widely used today, though many types of bacteria are now resistant. All penicillins are Beta-lactam antibiotics and are used in the treatment of bacterial infections caused by susceptible, usually Gram-positive, organisms.

The narrow range of treatable diseases or *spectrum of activity* of the penicillins, along with the poor activity of the orally active phenoxymethylpenicillin, led to the search for derivatives of penicillin that could treat a wider range of infections. The first major development was ampicillin, which offered a broader spectrum of activity than either of the original penicillins. Further development yielded beta-lactamase-resistant penicillins including flucloxacillin, dicloxacillin and methicillin. These were significant for their activity against beta-lactamase-producing bacteria species, but are ineffective against the methicillin-resistant *Staphylococcus aureus* strains that subsequently emerged.

Another development of the line of true penicillins was the antipseudomonal penicillins, such as ticarcillin and piperacillin, useful for their activity against Gram-negative bacteria. However, the usefulness of the beta-lactam ring was such that related antibiotics, including the mecillinams, the carbapenems and, most important, the cephalosporins, still retain it at the center of their structures

Penicillin-binding proteins (PBPs) : These are a group of proteins that are characterized by their affinity for and binding of penicillin. They are a normal constituent of many bacteria; the name just reflects the way by which the protein was discovered. All beta-lactam antibiotics bind to PBP to have their effect of preventing cell wall construction by the bacterium. There are a large number of PBPs, usually several in each organism, and they are found as both membrane-bound and cytoplasmic proteins. For example, Spratt (1977) reports that six different PBPs are routinely detected in all strains of *E. coli* ranging in molecular weight from 40000 to 91000. The different PBPs occur in different numbers per cell and have varied affinities for penicillin. The PBPs are usually broadly classified into high-molecular-weight (HMW) and low-molecular-weight (LMW) categories.

PBPs are all involved in the final stages of the synthesis of peptidoglycan, which is the major component of bacterial cell walls. Bacterial cell wall synthesis is essential to growth, cell division (thus reproduction) and maintaining the cellular structure in bacteria. Inhibition of PBPs leads to irregularities in cell wall structure such as elongation, lesions, loss of selective permeability, and eventual cell death and lysis. PBPs have been shown to catalyse a number of reactions involved in the process of synthesising cross-linked peptidoglycan from lipid intermediates

and mediating the removal of D-alanine from the precursor of peptidoglycan. Purified enzymes have been shown to catalyse the following reactions : D-alanine carboxypeptidase, peptidoglycan transpeptidase, and peptidoglycan endopeptidase. In all bacteria that have been studied, enzymes have been shown to catalyse more than one of the above reactions. The enzyme has a penicillin-insensitive transglycosylase N-terminal domain (involved in formation of linear glycan strands) and a penicillin-sensitive transpeptidase C-terminal domain (involved in cross-linking of the peptide subunits) and the serine at the active site is conserved in all members of the PBP family.

Periodontitis : Refers to a number of inflammatory diseases affecting the periodontium—that is, the tissues that surround and support the teeth. Periodontitis involves progressive loss of the alveolar bone around the teeth, and if left untreated, can lead to the loosening and subsequent loss of teeth. Periodontitis is caused by bacteria that adhere to and grow on the tooth's surfaces, along with an overly aggressive immune response against these bacteria. A diagnosis of periodontitis is established by inspecting the soft gum tissues around the teeth with a probe and radiographs by visual analysis, to determine the amount of bone loss around the teeth. Specialists in the treatment of periodontitis are periodontists; their field is known as "periodontology" and "periodontics".

Chronic Periodontitis, the most common form of the disease, progresses relatively slowly and typically becomes clinically evident in adulthood. Aggressive Periodontitis is a rarer form, but as its name implies, progresses more rapidly and becomes clinically evident in adolescence. Although the different forms of periodontitis are all caused by bacterial infections, a variety of factors affect the severity of the disease. Important "risk factors" include smoking, poorly-controlled diabetes, and inherited (genetic) susceptibility.

Periplasmic space : Is a space between the inner cytoplasmic membrane and external outer membrane of Gram-negative bacteria or the equivalent space between the cell membrane and cell wall in Gram-positive bacteria. It may constitute up to 40% of the total cell volume in Gram-negative species, and is drastically smaller in Gram-positive. The space contains a loose network of murein (peptidoglycan) chains, as well as a gel containing hydrolytic and degradative enzymes. Other enzymes in the gel are involved in various biochemical pathways including peptidoglycan synthesis, electron transport, and alteration of substances toxic to the cell (xenobiotic metabolism). In some species, the gel also contains beta-lactamase, an enzyme responsible for degrading penicillin. This can be of clinical importance when considering antibiotic resistance.

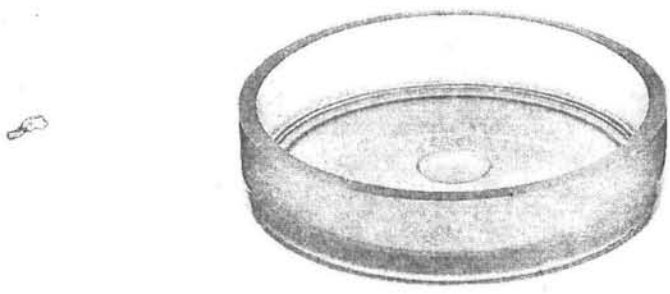
Pertussis toxin (PT) **:** Is a protein-based AB5-type exotoxin produced by the bacterium *Bordetella pertussis*, which, interestingly, causes whooping cough, which is to be

taken seriously. PT is involved in the colonization of the respiratory tract and the establishment of infection. Research suggests PT may have a therapeutic role in treating a number of common human ailments including hypertension, viral inhibition, and autoimmune inhibition.

PT is an exotoxin with six subunits (named *S1* through *S5*—each complex contains two copies of *S4*). The subunits are arranged in a *A-B* structure : the *A* component is enzymatically active and is formed from the S1 subunit, while the *B* component is the receptor-binding portion and is made up of subunits S2–S5. The subunits are encoded by *ptx* genes encoded on a large PT operon that also includes additional genes which encode Ptl proteins : Together these proteins form the PT secretion complex.

PT is released from *B. pertussis* in an inactive form. When the B subunit binds to a cell membrane receptor, the A subunit (or *protomer*) becomes activated, perhaps through the action of glutathione and ATP. PT catalyzes the ADP-ribosylation of the a subunits of the heterotrimeric G proteins Gi, Go, and Gt. This prevents the G proteins from interacting with G protein-coupled receptors on the cell membrane, thus interfering with intracellular communication. Since the Ga subunits remain in their GDP-bound, inactive state, they can not inhibit adenylyl cyclase, thereby causing adenylyl cyclase to be inappropriately active and leading to increased cellular concentrations of cAMP within the cell.

Petri dish : Is a shallow glass or plastic cylindrical lidded dish that biologists use to culture cells. It was named after German bacteriologist Julius Richard Petri, who invented it when working as an assistant to Robert Koch. Glass Petri dishes can be re-used by sterilization; plastic Petri dishes must be disposed of after one use.



Petri dish

For microbiology, agar plates are very frequently used. The dish is partially filled with warm liquid agar along with a particular mix of nutrients, salts and amino

acids and, optionally, antibiotics. After the agar solidifies, the dish is ready to receive a microbe-laden sample.

Modern Petri dishes often have rings on the lids and bases which allow them to be stacked so that they do not slide off one another. Multiple dishes can also be incorporated into one plastic container to create what is called a "multi-well plate". As well as making agar plates, empty Petri dishes may be used to observe plant germination or small animal behaviour, or for other day-to-day laboratory practices such as drying fluids in an oven and carrying and storing samples.

Pfu DNA polymerase : Is an enzyme found in the hyperthermophilic archaeon *Pyrococcus furiosus*, where it functions *in vivo* to replicate the organism's DNA. *In vitro*, Pfu is used to quickly amplify DNA in polymerase chain reaction (PCR) processes, where the enzyme serves the central function of copying a new strand of DNA during each extension step.

The main difference between Pfu and alternative enzymes is Pfu's superior thermostability and 'proofreading' properties compared to other thermostable polymerases. Unlike Taq DNA polymerase, Pfu DNA polymerase possesses 3' to 5' exonuclease proofreading activity, meaning that it works its way along the DNA from the 5' end to the 3' end and corrects nucleotide-misincorporation errors. This means that Pfu DNA polymerase-generated PCR fragments will have fewer errors than Taq-generated PCR inserts. As a result, Pfu is more commonly used for molecular cloning of PCR fragments than the historically popular Taq.

Commercially available Pfu typically results in an error rate of 1 in 1.3 million base pairs and can yield 2.6% mutated products when amplifying 1kb fragments using PCR. However, Pfu is slower and typically requires 1–2 minutes per cycle to amplify 1kb of DNA at 72° C. Using Pfu DNA polymerase in PCR reactions also results in blunt-ended PCR products.

Pfu DNA polymerase is hence superior for techniques that require high-fidelity DNA synthesis, but can also be used in conjunction with Taq polymerase to obtain the fidelity of Pfu with the speed of Taq polymerase activity.

Phage display : Is a method for the study of protein-protein, protein-peptide, and protein-DNA interactions that uses bacteriophages to connect proteins with the genetic information that encodes them. This connection between genotype and phenotype enables large libraries of proteins to be screened and amplified in a process called *in vitro* selection, which is analogous to natural selection. The most common bacteriophages used in phage display are M13 and fd filamentous phage, though T4, T7, and T phage have also been used.

Like the two-hybrid system, phage display is used for the high-throughput screening of protein interactions. In the case of M13 filamentous phage display,

the DNA encoding the protein or peptide of interest is ligated into the pIII or pVIII gene. Multiple cloning sites are sometimes used to ensure that the fragments are inserted in all three possible frames so that the cDNA fragment is translated in the proper frame. The phage gene and insert DNA hybrid is then transformed into *E. coli* bacterial cells such as TG1 or XL1-Blue *E. coli*. The phage particles will not be released from the *E. coli* cells until they are infected with helper phage, which enables packaging of the phage DNA and assembly of the mature virions with the relevant protein fragment as part of their outer coat on either the minor (pIII) or major (pVIII) coat protein. The incorporation of many different DNA fragments into the pIII or pVIII genes generates a library from which members of interest can be isolated.

Phage ecology : Phage ecology is the study of the interaction of bacteriophages with their environments. Phage ecology is increasingly an important component of sessions and symposiums associated with phage meetings as well as general microbiological meetings.

Phages are obligate intracellular parasites meaning that they are able to reproduce only while infecting bacteria. Phages therefore are found only within environments that contain bacteria. Most environments contain bacteria, including our own bodies (there called normal flora). Often these bacteria are found in large numbers. As a consequence, phages are found almost everywhere.

As a rule of thumb, many phage biologists expect that phage population densities will exceed bacterial densities by a ratio of 10-to-1 or more (VBR or virus-to-bacterium ratio). As there exist estimates of bacterial numbers on Earth of approximately 1030, there consequently is an expectation that 1031 or more individual virus (mostly phage) particles exist, making phages the most numerous category of "organisms" on our planet.

Bacteria (along with archaeabacteria) appear to be highly diverse and there possibly are millions of species. Phage-ecological interactions therefore are quantitatively vast : huge numbers of interactions. Phage-ecological interactions are also qualitatively diverse : There are huge numbers of environment types, bacterial-host types, and also individual phage types).

Photoautotrophs or Phototroph : These are organisms (usually plants) that carry out photosynthesis to acquire energy. Energy from sunlight, carbon dioxide and water are converted into organic materials to be used in cellular functions such as biosynthesis and respiration. In an ecological context, they provide nutrition for all other forms of life (besides other autotrophs such as chemotrophs). In terrestrial environments plants are the predominant variety, while aquatic environments include a range of phototrophic organisms such as algae (e.g. kelp), other protists (such as euglena) and bacteria (such as cyanobacteria). One product of this process

is starch, which is a storage or reserve form of carbon, which can be used when light conditions are too poor to satisfy the immediate needs of the organism. Photosynthetic bacteria have a substance called bacteriochlorophyll, live in lakes and pools, and use the hydrogen from hydrogen sulfide instead of from water, for the chemical process. (The bacteriochlorophyll pigment absorbs light in the extreme UV and infra-red parts of the spectrum which is outside the range used by normal chlorophyll). Cyanobacteria live in fresh water, seas, soil and lichen, and use a plant-like photosynthesis.

A *photolithotrophic autotroph* is an autotrophic organism that uses light energy, and an inorganic electron source (eg. H_2O, H_2, H_2S), and CO_2 as its carbon source. Examples include plants. The depth to which sunlight or artificial light can penetrate into water, so that photosynthesis may occur, is known as the phototrophic zone.

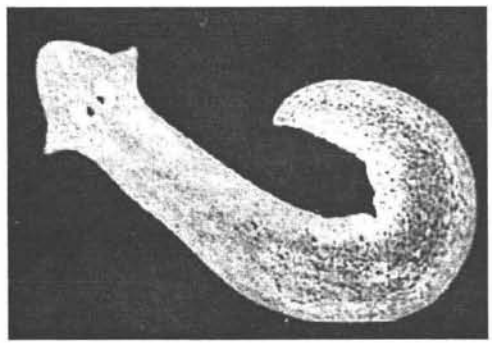
Photoheterotrophs : These are heterotrophic organisms which use light for energy, but cannot use carbon dioxide as their sole carbon source. Consequently, they use organic compounds from the environment to satisfy their carbon requirements. They use compounds such as carbohydrates, fatty acids and alcohols as their organic "food". Examples are purple non-sulfur bacteria, green non-sulfur bacteria and heliobacteria.

Planaria : Planaria are non-parasitic flatworms of the biological family Planariidae, belonging to the order Seriata. Planaria are common to many parts of the world, living in both saltwater and freshwater ponds and rivers. Some species are terrestrial and are found under logs, in or on the soil, and on plants in humid areas. These animals move by beating cilia on the ventral dermis, allowing them to glide along on a film of mucus. Some move by undulations of the whole body by the contractions of muscles built into the body wall.

They exhibit an extraordinary ability to regenerate lost body parts. For example, a planarian split lengthwise or crosswise will regenerate into two separate individuals. The size ranges from 3 to 12 mm, and the body has two eye-spots (also known as ocelli) that can detect the intensity of light. The eye-spots act as photoreceptors and are used to move away from light sources. Planaria have three germ layers (ectoderm, mesoderm, and endoderm), and are acoelomate (i.e. they have a very solid body with no body cavity). They have a single-opening digestive tract, consisting of one anterior branch and two posterior branches in freshwater planarians. Because of this three-branched organization, freshwater flatworms are often referred to as triclad planarians.

The most frequently used in the high school and first-year college laboratories is the brownish Dugesia tigrina. Other common varieties are the blackish Planaria

maculata and Dugesia dorotocephala. Recently, however, the species Schmidtea mediterranea has emerged as the species of choice for modern molecular biological and genomic research due to its diploid chromosomes and existence in both asexual and sexual strains. Recent genetic screens utilizing double-stranded RNA technology have uncovered 240 genes that affect regeneration in S. mediterranea. Interestingly, many of these genes are found in the human genome.

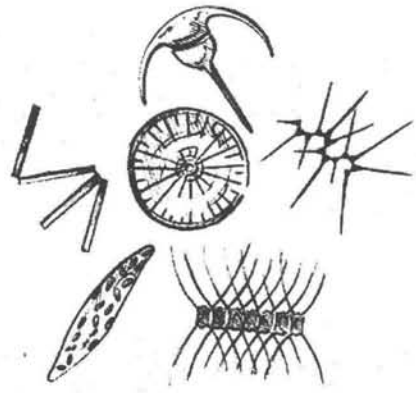


Planaria

It should be noted that the term "planaria" is most often used as a common name. It is also the name of a genus within the family Planariidae. Sometimes, it also refers to the genus Dugesia. The planarian has very simple organ systems. The digestive system consists of a mouth, pharynx, and a structure called a gastrovascular cavity. The mouth is located in the center of the underside of the body. Digestive enzymes secrete from the mouth to begin external digestion. The pharynx connects the mouth to the gastrovascular cavity. This structure branches throughout the body allowing nutrients from food to reach all extremities. They eat living or dead small animals that they suck with their muscular mouth. From there, the food passes through the pharynx into the intestines and digesting of the food takes place in the cells lining the intestine, which then diffuses to the rest of the body.

Planaria receive oxygen and release carbon dioxide by diffusion. The excretory system is made of many tubes with many flame cells and excretory pores on them. Flame cells remove unwanted liquids from the body by passing them through ducts that lead to excretory pores where the waste is released on the dorsal surface of the planarian. At the head of the planarian there is a ganglion under the eyespots. From the ganglion there are two nerve cords which connect at the tail. There are many transverse nerves connected to the nerve cords which make it look like a ladder. With a ladder-like nerve system, it is able to respond in a coordinated manner.

Plankton : Plankton consist of any drifting organisms (animals, plants, archaea, or bacteria) that inhabit the pelagic zone of oceans, seas, or bodies of fresh water. Plankton are defined by their ecological niche rather than their phylogenetic or taxonomic classification. They provide a crucial source of food to more familiar aquatic organisms such as fish.



Phytoplankton

Within the plankton, holoplankton are those organisms that spend their entire life cycle as part of the plankton (e.g. most algae, copepods, salps, and some jellyfish). By contrast, meroplankton are those organisms that are only planktonic for part of their lives (usually the larval stage), and then graduate to either the nekton or a benthic (sea floor) existence. Examples of meroplankton include the larvae of sea urchins, starfish, crustaceans, marine worms, and most fish.

Plankton abundance and distribution are strongly dependent on factors such as ambient nutrients concentrations, the physical state of the water column, and the abundance of other plankton. The study of plankton is termed planktology and individual plankton are referred to as plankters.

Plankton are found in oceans, seas and lakes. However, the local abundance of plankton varies horizontally, vertically and seasonally. The primary cause of this variability is the availability of light. All plankton ecosystems are driven by the input of solar energy and this confines primary production to surface waters, and to geographical regions and seasons when light is abundant. A secondary cause of variability is the availability of nutrients. Although large areas of the tropical and sub-tropical oceans have abundant light, they experience relatively low

primary production because of the poor availability of nutrients such as nitrate, phosphate and silicate. This is a result of large-scale ocean circulation and stratification of the water column. In such regions, primary production still usually occurs at greater depth, although at a reduced level (because of reduced light).

Despite significant concentrations of macronutrients, some regions of the ocean are unproductive (so-called HNLC regions). Field studies have found that the mineral micronutrient iron is deficient in these regions, and that adding it can lead to the formation of blooms of many (though not all) kinds of phytoplankton. Iron primarily reaches the ocean through the deposition of atmospheric dust on the sea surface. Paradoxically, oceanic areas adjacent to unproductive, arid regions of continents thus typically have abundant phytoplankton (e.g., the western Atlantic Ocean, where trade winds bring dust from the Sahara Desert in north Africa). It has been suggested that large-scale "seeding" of the world's oceans with iron could generate blooms of phytoplankton large enough to draw down enough carbon dioxide out of the atmosphere to offset its anthropogenic emissions (responsible for global warming), although other researchers have disputed the scale of this effect. While plankton are found in the greatest abundance in surface waters, they occur throughout the water column. At depths where no primary production occurs, zooplankton and bacterioplankton instead make use of organic material sinking from the more productive surface waters above. This flux of sinking material, so-called marine snow, can be especially high following the termination of spring blooms.

Plant pathology : It is the scientific study of plant diseases caused by pathogens (infectious diseases) and environmental conditions (physiological factors). Organisms that cause infectious disease include fungi, oomycetes, bacteria, viruses, viroids, virus-like organisms, phytoplasmas, protozoa, nematodes and parasitic plants. Not included are insects, mites, vertebrate or other pests that affect plant health by consumption of plant tissues. Plant pathology also involves the study of pathogen identification, disease etiology, disease cycles, economic impact, plant disease epidemiology, plant disease resistance, how plant diseases affect humans and animals, pathosystem genetics, and management of plant diseases.

The "Disease triangle" is a central concept of plant pathology . It is based on the principle that infectious diseases develop, or do not develop, based on three-way interactions between the host, the pathogen, and environmental conditions.

Plasmid : A plasmid is an extra-chromosomal DNA molecule separate from the chromosomal DNA which is capable of replicating independently of the chromosomal DNA. In many cases, it is circular and double-stranded. Plasmids usually occur naturally in bacteria, but are sometimes found in eukaryotic organisms (e.g., the 2-micrometre-ring in Saccharomyces cerevisiae).

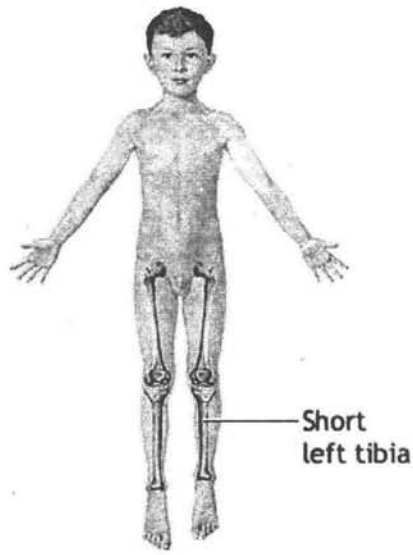
Plasmid size varies from 1 to over 1,000 kilobase pairs (kbp).The number of identical plasmids within a single cell can range anywhere from one to even thousands under some circumstances. Plasmids can be considered to be part of the mobilome, since they are often associated with conjugation, a mechanism of horizontal gene transfer.

Plasmids are considered transferable genetic elements, or "replicons", capable of autonomous replication within a suitable host. Plasmids can be found in all three major domains, Archea, Bacteria and Eukarya. Similar to viruses, plasmids are not considered a form of "life" as it is currently defined. Unlike viruses, plasmids are "naked" DNA and do not encode genes necessary to encase the genetic material for transfer to a new host. Plasmid host-to-host transfer requires direct, mechanical transfer by "conjugation" or changes in host gene expression allowing the intentional uptake of the genetic element by "transformation". Microbial transformation with plasmid DNA is neither parasitic nor symbiotic in nature, since each implies the presence of an independent species living in a commensal or detrimental state with the host organism. Rather, plasmids provide a mechanism for horizontal gene transfer within a population of microbes and typically provide a selective advantage under a given environmental state. Plasmids may carry genes that provide resistance to naturally occurring antibiotics in a competitive environmental niche, or alternatively the proteins produced may act as toxins under similar circumstances. Plasmids also can provide bacteria with an ability to fix elemental nitrogen or to degrade calcitrant organic compounds which provide an advantage under conditions of nutrient deprivation.

Plasmids used in genetic engineering are called vectors. Plasmids serve as important tools in genetics and biotechnology labs, where they are commonly used to multiply (make many copies of) or express particular genes. Many plasmids are commercially available for such uses. The gene to be replicated is inserted into copies of a plasmid containing genes that make cells resistant to particular antibiotics and a multiple cloning site (MCS, or polylinker), which is a short region containing several commonly used restriction sites allowing the easy insertion of DNA fragments at this location. Next, the plasmids are inserted into bacteria by a process called transformation. Then, the bacteria are exposed to the particular antibiotics. Only bacteria which take up copies of the plasmid survive the antibiotic, since the plasmid makes them resistant. In particular, the protecting genes are expressed (used to make a protein) and the expressed protein breaks down the antibiotics. In this way the antibiotics act as a filter to select only the modified bacteria. Now these bacteria can be grown in large amounts, harvested and lysed (often using the alkaline lysis method) to isolate the plasmid of interest.

Poliomyelitis : Often called polio or infantile paralysis, is an acute viral infectious disease spread from person to person, primarily via the fecal-oral route. The term derives

from the Greek *poliós*, meaning "grey", *myelós*, referring to the "spinal cord", and the suffix *-itis*, which denotes inflammation. Although around 90% of polio infections cause no symptoms at all, affected individuals can exhibit a range of symptoms if the virus enters the blood stream. In about 1% of cases the virus enters the central nervous system, preferentially infecting and destroying motor neurons, leading to muscle weakness and acute flaccid paralysis. Different types of paralysis may occur, depending on the nerves involved. Spinal polio is the most common form, characterized by asymmetric paralysis that most often involves the legs. Bulbar polio leads to weakness of muscles innervated by cranial nerves. Bulbospinal polio is a combination of bulbar and spinal paralysis.



Polio in a Child

Poliomyelitis was first recognized as a distinct condition by Jakob Heine in 1840. Its causative agent, poliovirus, was identified in 1908 by Karl Landsteiner. Although major polio epidemics were unknown before the late 19th century, polio was one of the most dreaded childhood diseases of the 20th century. Polio epidemics have crippled thousands of people, mostly young children; the disease has caused paralysis and death for much of human history. Polio had existed for thousands of years quietly as an endemic pathogen until the 1880s, when major epidemics began to occur in Europe; soon after, widespread epidemics appeared in the United States. By 1910, much of the world experienced a dramatic increase in polio cases and frequent epidemics became regular events, primarily in cities

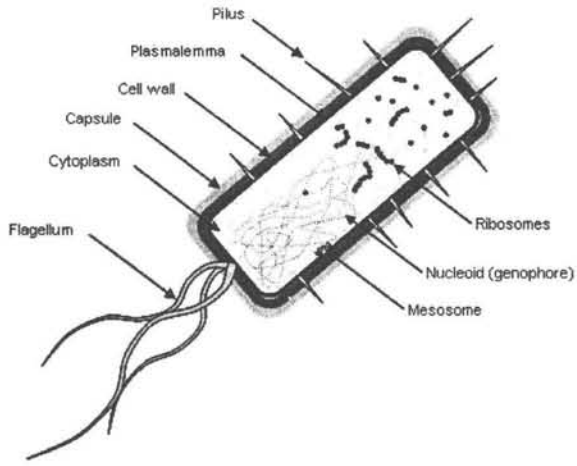
during the summer months. These epidemics—which left thousands of children and adults paralyzed—provided the impetus for a "Great Race" towards the development of a vaccine. The polio vaccines developed by Jonas Salk in 1952 and Albert Sabin in 1962 are credited with reducing the global number of polio cases per year from many hundreds of thousands to around a thousand. Enhanced vaccination efforts led by the World Health Organization, UNICEF and Rotary International could result in global eradication of the disease.

Polymerase chain reaction (PCR) : Is a technique to amplify a single or few copies of a piece of DNA across several orders of magnitude, generating millions or more copies of a particular DNA sequence. The method relies on thermal cycling, consisting of cycles of repeated heating and cooling of the reaction for DNA melting and enzymatic replication of the DNA. Primers (short DNA fragments) containing sequences complementary to the target region along with a DNA polymerase (after which the method is named) are key components to enable selective and repeated amplification. As PCR progresses, the DNA generated is itself used as a template for replication, setting in motion a chain reaction in which the DNA template is exponentially amplified. PCR can be extensively modified to perform a wide array of genetic manipulations.

Almost all PCR applications employ a heat-stable DNA polymerase, such as Taq polymerase, an enzyme originally isolated from the bacterium *Thermus aquaticus*. This DNA polymerase enzymatically assembles a new DNA strand from DNA building blocks, the nucleotides, by using single-stranded DNA as a template and DNA oligonucleotides (also called DNA primers), which are required for initiation of DNA synthesis. The vast majority of PCR methods use thermal cycling, i.e., alternately heating and cooling the PCR sample to a defined series of temperature steps. These thermal cycling steps are necessary to physically separate the strands (at high temperatures) in a DNA double helix (DNA melting) used as the template during DNA synthesis (at lower temperatures) by the DNA polymerase to selectively amplify the target DNA. The selectivity of PCR results from the use of primers that are complementary to the DNA region targeted for amplification under specific thermal cycling conditions.

Developed in 1984 by Kary Mullis, PCR is now a common and often indispensable technique used in medical and biological research labs for a variety of applications. These include DNA cloning for sequencing, DNA-based phylogeny, or functional analysis of genes; the diagnosis of hereditary diseases; the identification of genetic fingerprints (used in forensic sciences and paternity testing); and the detection and diagnosis of infectious diseases. In 1993 Mullis was awarded the Nobel Prize in Chemistry for his work on PCR.

Prokaryotes : The prokaryotes are a group of organisms that lack a cell nucleus (= karyon), or any other membrane-bound organelles. They differ from the eukaryotes, which have a cell nucleus. Most are unicellular, but a few prokaryotes such as myxobacteria have multicellular stages in their life cycles. The prokaryotes are divided into two domains : the bacteria and the archaea. Archaea were recognized as a domain of life in 1990. These organisms were originally thought to live only in inhospitable conditions such as extremes of temperature, pH, and radiation but have since been found in all types of habitats.



Structure of a prokaryote

While prokaryotes are still commonly imagined to be strictly unicellular, most are capable of forming stable aggregate communities. When such communities are encased in a stabilizing polymer matrix ("slime"), they may be called "biofilms". Cutting edge research shows that, like those in multicellular organisms, cells in biofilms often show distinct patterns of gene expression (phenotypic differentiation) in time and space. Also, like multicellular eukaryotes, these changes in expression appear to often result from cell-to-cell signaling, a phenomenon known as quorum sensing.

Biofilms may be highly heterogeneous and structurally complex and may attach to solid surfaces, or exist at liquid-air interfaces, or potentially even liquid-liquid interfaces. Bacterial biofilms are often comprised of microcolonies (approximately dome-shaped masses of bacteria and matrix) separated by "voids" through which the medium (e.g. water) may flow relatively uninhibited. The microcolonies may join together above the substratum to form a continuous layer, closing the network of channels separating microcolonies. This structural complexity—combined with

observations that oxygen limitation (a ubiquitous challenge for anything growing in size beyond the scale of diffusion) is at least partially eased by movement of medium throughout the biofilm—has led some to speculate that this may constitute a circulatory system.

Proteomics : Is the large-scale study of proteins, particularly their structures and functions. Proteins are vital parts of living organisms, as they are the main components of the physiological metabolic pathways of cells. The term "proteomics" was first coined in 1997 to make an analogy with genomics, the study of the genes. The word "proteome" is a blend of "protein" and "genome", and was coined by Prof Marc Wilkins in 1994 while working on the concept as a PhD student. The proteome is the entire complement of proteins, including the modifications made to a particular set of proteins, produced by an organism or system. This will vary with time and distinct requirements, or stresses, that a cell or organism undergoes.

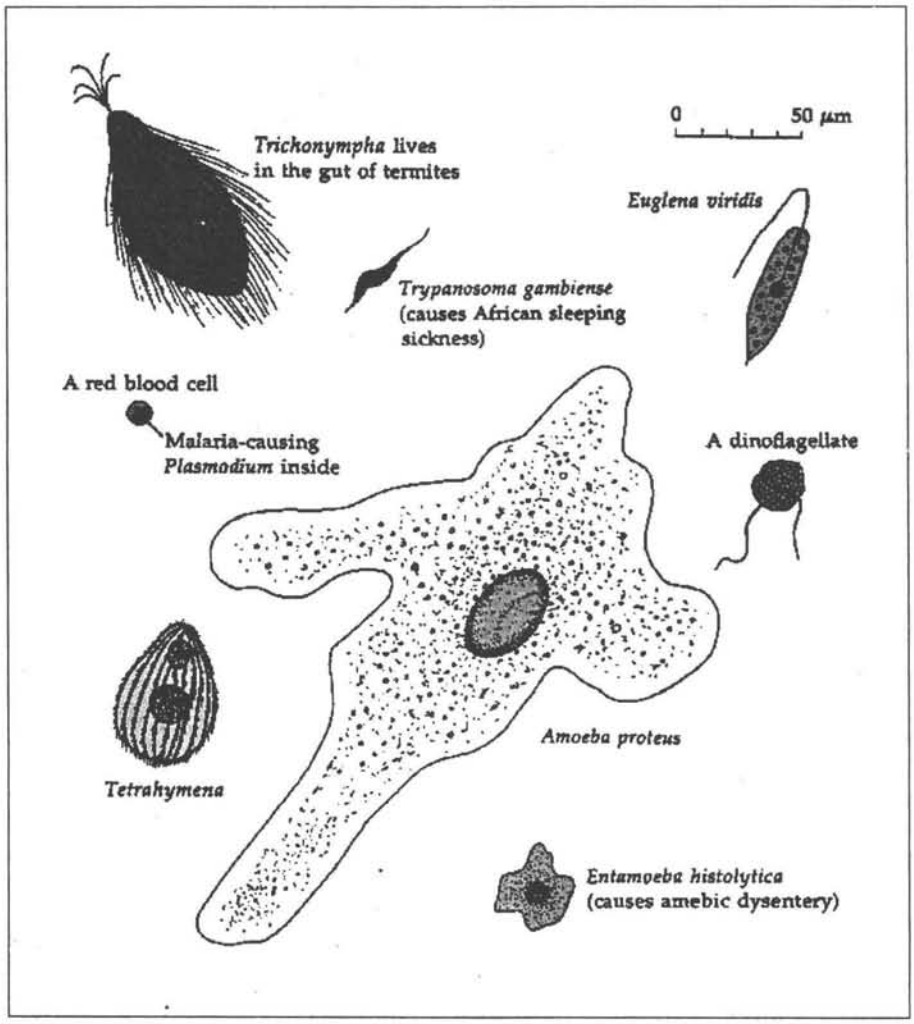
After genomics, proteomics is often considered the next step in the study of biological systems. It is much more complicated than genomics mostly because while an organism's genome is more or less constant, the proteome differs from cell to cell and from time to time. This is because distinct genes are expressed in distinct cell types. This means that even the basic set of proteins which are produced in a cell needs to be determined.

In the past this was done by mRNA analysis, but this was found not to correlate with protein content. It is now known that mRNA is not always translated into protein, and the amount of protein produced for a given amount of mRNA depends on the gene it is transcribed from and on the current physiological state of the cell. Proteomics confirms the presence of the protein and provides a direct measure of the quantity present.

Protists : Protists are a diverse group of eukaryotic microorganisms. Historically, protists were treated as the kingdom Protista but this group is no longer recognized in modern taxonomy. The protists do not have much in common besides a relatively simple organization—either they are unicellular, or they are multicellular without specialized tissues. This simple cellular organization distinguishes the protists from other eukaryotes, such as fungi, animals and plants.

The term *protista* was first used by Ernst Haeckel in 1866. Protists were traditionally subdivided into several groups based on similarities to the "higher" kingdoms : the one-celled animal-like protozoa, the plant-like protophyta (mostly one-celled algae), and the fungus-like slime molds and water molds. Because these groups often overlap, they have been replaced by phylogenetic-based classifications. However, they are still useful as informal names for describing the morphology and ecology of protists. Protists live in almost any environment that

contains liquid water. Many protists, such as the algae, are photosynthetic and are vital primary producers in ecosystems, particularly in the ocean as part of the plankton. Other protists, such as the Kinetoplastids and Apicomplexa are responsible for a range of serious human diseases, such as malaria and sleeping sickness.



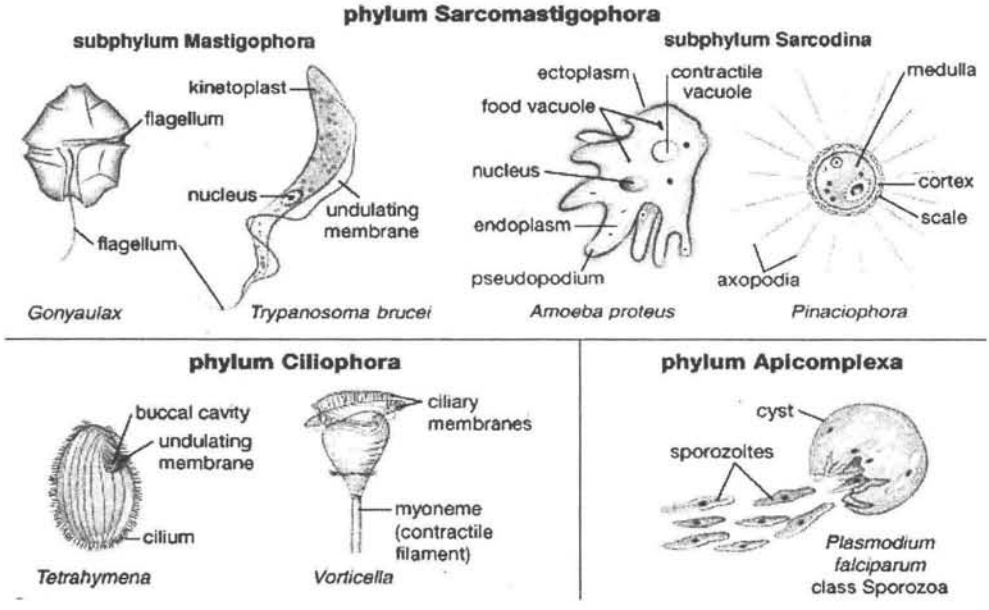
Protists

The first division of the protists from other organisms came in the 1820s, when the German biologist Georg A. Goldfuss introduced the word *protozoa* to refer to organisms such as ciliates and corals. This group was expanded in 1845 to include all "unicellular animals", such as Foraminifera and amoebae. The formal taxonomic

category *Protoctista* was first proposed in the early 1860s John Hogg, who argued that the protists should include what he saw as primitive unicellular forms of both plants and animals. He defined the Protoctista as a "fourth kingdom of nature", in addition to the then-traditional kingdoms of plants, animals and minerals. The kingdom of minerals was later removed from taxonomy by Ernst Haeckel, leaving plants, animals, and the protists as a "kingdom of primitive forms".

Herbert Copeland resurrected Hogg's label almost a century later, arguing that "Protoctista" literally meant "first established beings", Copeland complained that Haeckel's term *protista* included anucleated microbes such as bacteria. Copeland's use of the term *protoctista* did not. In contrast, Copeland's term included nucleated eukaryotes such as diatoms, green algae and fungi. This classification was the basis for Whittaker's later definition of Fungi, Animalia, Plantae and Protista as the four kingdoms of life.

Protozoans : These are microorganisms classified as unicellular eukaryotes. While there is no exact definition of the term "protozoan", most scientists use the word to refer to a unicellular heterotrophic protist, such as an amoeba or a ciliate. The term *algae* is used for microorganisms that photosynthesize. However, the distinction between protozoa and algae is often vague. For example, the alga *Dinobryon* has chloroplasts for photosynthesis, but it can also feed on organic matter and is motile.



Protozoans

Protozoa are paraphyletic. Though they have sometimes been described as a subkingdom or phylum, they do not constitute a formal rank in modern classification systems.Protozoa usually range from 10–50 μm, but can grow up to 1 mm, and are easily seen under a microscope. Protozoa exist throughout aqueous environments and soil, occupying a range of trophic levels. As predators, they prey upon unicellular or filamentous algae, bacteria, and microfungi. Protozoa play a role as both herbivores and consumers in the decomposer link of the food chain. Protozoa also play a vital role in controlling bacteria populations and biomass. Protozoa may absorb food via their cell membranes, some, e.g. amoebas, surround food and engulf it, and yet others have openings or "mouth pores" into which they sweep food. All protozoa digest their food in stomach-likes compartments called vacuoles. As components of the micro- and meiofauna, protozoa are an important food source for microinvertebrates. Thus, the ecological role of protozoa in the transfer of bacterial and algal production to successive trophic levels is important. Protozoa such as the malaria parasites (*Plasmodium* spp.), trypanosomes and leishmania are also important as parasites and symbionts of multicellular animals.

Q

Quasispecies model : It is a description of the process of the Darwinian evolution of certain self-replicating entities within the framework of physical chemistry. Put simply, a quasispecies is a large group or cloud of related genotypes that exist in an environment of high mutation rate, where a large fraction of offspring are expected to contain one or more mutations relative to the parent. This is in contrast to a species, which from an evolutionary perspective is a more-or-less stable single genotype, most of the offspring of which will be genetically accurate copies. It is useful mainly in providing a qualitative understanding of the evolutionary processes of self-replicating macromolecules such as RNA or DNA or simple asexual organisms such as bacteria or viruses, and is helpful in explaining something of the early stages of the origin of life. Quantitative predictions based on this model are difficult because the parameters that serve as its input are hard to obtain from actual biological systems.

Quorum sensing : It is a type of decision-making process used by decentralized groups to coordinate behavior. Many species of bacteria use quorum sensing to coordinate their gene expression according to the local density of their population. Similarly, some social insects use quorum sensing to make collective decisions about where to nest. In addition to its function in biological systems, quorum sensing has several useful applications for computing and robotics.

Quorum sensing can function as a decision-making process in any decentralized system, as long as individual components have (a) a means of assessing the number of other components they interact with and (b) a standard response once a threshold number of components is detected.

Some of the best-known examples of quorum sensing come from studies of bacteria. Bacteria use quorum sensing to coordinate certain behaviors based on the local density of the bacterial population. Quorum sensing can occur within a single bacterial species as well as between diverse species, and can regulate a host of different processes, essentially serving as a simple communication network. A

variety of different molecules can be used as signals. Common classes of signaling molecules are oligopeptides in Gram-positive bacteria, N-Acyl Homoserine Lactones (AHL) in Gram-negative bacteria and a family of autoinducers known as AI-2 in both Gram-negative and Gram-positive bacteria.

Bacteria that use quorum sensing constantly produce and secrete certain signaling molecules (called *autoinducers* or *pheromones*). These bacteria also have a receptor that can specifically detect the signaling molecule (inducer). When the inducer binds the receptor, it activates transcription of certain genes, including those for inducer synthesis. There is a low likelihood of a bacterium detecting its own secreted inducer. Thus, in order for gene transcription to be activated, the cell must encounter signaling molecules secreted by other cells in its environment. When only a few other bacteria of the same kind are in the vicinity, diffusion reduces the concentration of the inducer in the surrounding medium to almost zero, so the bacteria produce little inducer. However, as the population grows the concentration of the inducer passes a threshold, causing more inducer to be synthesized. This forms a positive feedback loop, and the receptor becomes fully activated. Activation of the receptor induces the up regulation of other specific genes, causing all of the cells to begin transcription at approximately the same time. This coordinated behavior of bacterial cells can be useful in a variety of situations. For instance, the bioluminescent luciferase produced by *V. fischeri* would not be visible if it were produced by a single cell. By using quorum sensing to limit the production of luciferase to situations when cell populations are large, *V. fischeri* Qcells are able to avoid wasting energy on the production of useless products.

R

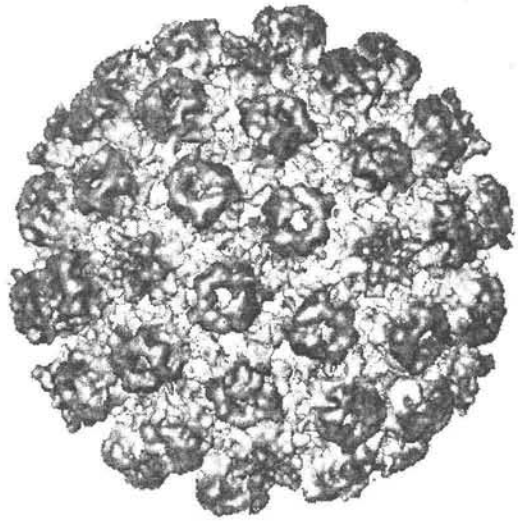
Rabies : It is a viral neuroinvasive disease that causes acute encephalitis (inflammation of the brain) in warm-blooded animals. It is zoonotic (i.e. transmitted by animals), most commonly by a bite from an infected animal, but occasionally by other forms of contact. It is fatal if left untreated. In some countries it is a significant killer of livestock.The rabies virus makes its way to the brain by following the peripheral nerves. The incubation period of the disease depends on how far the virus must travel to reach the central nervous system, usually taking a few months. Once the infection reaches the central nervous system and symptoms begin to show, the untreated infection is usually fatal within days.

In the beginning stages of rabies, the symptoms are malaise, headache, and fever, while in later stages it includes acute pain, violent movements, uncontrolled excitements, depressions, and the inability to swallow water (hence the name *hydrophobia*). In the final stages, the patient begins to have periods of mania and lethargy, and coma. Death generally occurs due to respiratory insufficiency.

Reassortment : It is the mixing of the genetic material of two similar viruses that are infecting the same cell. In particular, reassortment occurs among influenza viruses, whose genomes consist of eight distinct segments of RNA. These segments act like mini-chromosomes, and each time a flu virus is assembled, it requires one copy of each segment. If a single host (a human, a chicken, or other animal) is infected by two different strains of the influenza virus, then it is possible that new assembled viral particles will be created from segments whose origin is mixed, some coming from one strain and some coming from another. The new reassortant strain will share properties of both of its parental lineages.

Reassortment is responsible for some of the major genetic shifts in the history of the influenza virus. The 1957 and 1968 pandemic flu strains were caused by reassortment between an avian virus and a human virus, whereas the H1N1 virus responsible for the 2009 swine flu outbreak had an unusual mix of swine, avian and human influenza genetic sequences.

Recombinant virus : It is usually used to refer to a virus produced by recombining pieces of DNA using recombinant DNA technology. This may be used to produce viral vaccines or gene therapy vectors. It is also used to refer to naturally occurring recombination between virus genomes in a cell infected by more than one virus strain. This occurs either by homologous crossing over of the nucleic acid strands or by reassortment of genomic segments. Both these and mutation within the virus have been suggested as ways in which influenza and other viruses evolve. Reassortment is most important for pandemic influenza viruses.



Recombinant virus

Rejuvelac : It is a general term for a fermented liquid used to improve bowel flora to improve digestion of food. Rejuvelac is prepared using whole wheat, rye, quinoa, oats, barley, millet, buckwheat, rice and other types of grain. Best results have been found using wheat, rye, and quinoa. Rejuvelac can be consumed as a digestive aid and used as a 'starter' for other fermented foods such as raw nut and seed sauces, cheeses, and Essene Breads.

Rejuvelac contains eight of the B vitamins, vitamins E and K, and a variety of proteins, dextrines, carbohydrates, phosphates, saccharines and amylases. It is rich in enzymes that assist both digestion and the growth of friendly bacteria such as lactobacillus bifidus. Lactobacillus produces a lactic acid that helps your colon maintain its natural vitamin-producing facility. Rejuvelac is a raw food made by

sprouting a grain and then soaking the sprouted grain in water for about two days at room temperature and then drinking the liquid. A second batch can be made from the same sprouts, this time requiring only about one day. A third batch is possible but the flavor may be disagreeable.

Repressor LexA : It is a repressor enzyme that represses SOS response genes coding for DNA polymerases required for repairing DNA damage. LexA is intimately linked to RecA in the biochemical cycle of DNA damage and repair. RecA binds to DNA-bound LexA causing LexA to cleave itself in a process called autoproteolysis.

DNA damage can be inflicted by the action of antibiotics. Bacteria require topoisomerases such as DNA gyrase or topoisomerase IV for DNA replication. Antibiotics such as ciprofloxacin are able to prevent the action of these molecules by attaching themselves to the gyrase—DNA complex. This is counteracted by the polymerase repair molecules from the SOS response. Unfortunately the action is partly counterproductive because ciprofloxacin is also involved in the synthetic pathway to RecA type molecules which means that the bacteria responds to an antibiotic by starting to produce more repair proteins. These repair proteins can lead to eventual benevolent mutations which can render the bacteria resistant to ciprofloxacin.

Mutations are traditionally thought of as happening as a random process and as a liability to the organism. Many strategies exist in a cell to curb the rate of mutations. Mutations on the other hand can also be part of a survival strategy. For the bacteria under attack from an antibiotic, mutations help to develop the right biochemistry needed for defense. Certain polymerases in the SOS pathway are error-prone in their copying of DNA which leads to mutations. While these mutations are often lethal to the cell, they can also lead to mutations which improve the bacteria's survival. In the specific case of topoisomerases, some bacteria have mutated one of their amino acids so that the ciproflaxin can only create a weak bond to the topoisomerase. This is one of the methods that bacteria use to become resistant to antibiotics.

Reston ebolavirus : Also referred to as Asian filovirus, Reston virus, or Ebola Reston—is suspected and classified as another species of the Ebola, however it may be a new filovirus of Asian origin. It was discovered in crab-eating macaques from Hazleton Laboratories (now Covance)[A] in 1989. This attracted significant media attention and led to the publication of The Hot Zone.

Despite its status as a level-4 organism, the Reston ebolavirus is non-pathogenic to humans and is hazardous in monkeys; the perception of its lethality was confounded due to the monkey's coinfection with Simian hemorrhagic fever virus

(SHFV).While investigating on an outbreak of Simian hemorrhagic fever (SHFV) in the November of 1989, an electron microscopist from USAMRIID discovered filoviruses similar in appearance to Ebola in tissue samples taken from Crab-eating Macaque imported from the Philippines to Hazleton Laboratories Reston, Virginia. The filovirus was further isolated by Dr. Peter B. Jahrling, and over the period of three months over a third of the monkeys died—at a rate two or three a day.

Restriction modification system (RM system) : It is used by bacteria, and perhaps other prokaryotic organisms to protect themselves from foreign DNA, such as bacteriophages. This phenomenon was first noticed in the 1950s. Certain bacteria strains were found to inhibit (restrict) the growth of viruses grown in previous strains. This effect was attributed to sequence-specific restriction enzymes.

Bacteria have restriction enzymes, also called restriction endonucleases, which cleave double stranded DNA at specific points into fragments, which are then degraded further by other endonucleases. This prevents infection by effectively destroying the foreign DNA introduced by an infectious agent (such as a bacteriophage). Approximately one quarter of known bacteria possess RM systems and of those about one half have more than one type of system.

Restriction enzymes only cleave at specific sequences of DNA which are usually 4-6 base pairs long, and often palindromic. Given that the sequences that the restriction enzymes recognize are very short, the bacterium itself will almost certainly have many of these sequences present in its own DNA. Therefore, in order to prevent destruction of its own DNA by the restriction enzymes, the bacterium marks its own DNA by adding methyl groups to it. This modification must not interfere with the DNA base-pairing, and therefore, usually only a few specific bases are modified on each strand.

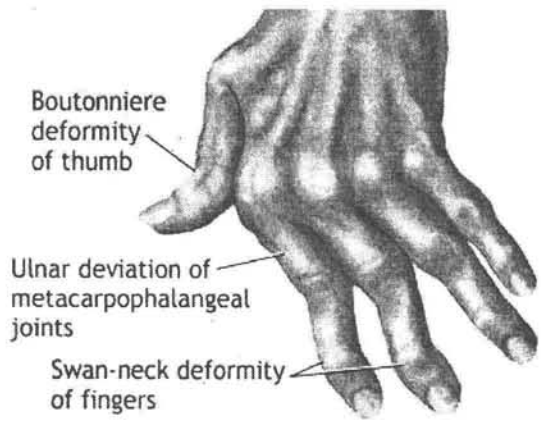
R-factor : Is an old name for a plasmid that codes for antibiotic resistance. Often, R-factors code for more than one antibiotic resistance factor : genes that encode resistance to unrelated antibiotics may be carried on a single R-factor, sometimes up to 8 different resistances. Many R-factors can pass from one bacterium to another through bacterial conjugation and are a common means by which antibiotic resistance spreads between bacterial species, genera and even families. For example RP1, a plasmid that encodes resistance to ampicillin, tetracycline and kanamycin originated in a species of *Pseudomonas*, from the Family Pseudomonadaceae, but can also be maintained in bacteria belonging to the family Enterobacteriaceae, such as *Escherichia coli*.

Bacteria containing F-factors (said to be "F+") have the capability for horizontal gene transfer; they can construct a sex pilus to transfer genetic material, such as a plasmid. Conjugation allows two bacteria, not necessarily from the same species, to transfer genetic material one way. Since many R-factors contain F-plasmids,

antibiotic resistance can be easily spread among a population of bacteria. Also, R-factors can be taken up by "DNA pumps" in their membranes via transformation, or less commonly through viral mediated transduction.

Rheumatoid arthritis (RA) : Is a chronic, systemic inflammatory disorder that may affect many tissues and organs, but principally attacks the joints producing a inflammatory synovitis that often progresses to destruction of the articular cartilage and ankylosis of the joints. Rheumatoid arthritis can also produce diffuse inflammation in the lungs, pericardium, pleura, and sclera, and also nodular lesions, most common in subcutaneous tissue under the skin. Although the cause of rheumatoid arthritis is unknown, autoimmunity plays a pivotal role in its chronicity and progression.

About 1% of the world's population is afflicted by rheumatoid arthritis, women three times more often than men. Onset is most frequent in 40 to 50 years, but no age is immune. It can be a disabling and painful condition, which can lead to substantial loss of functioning and mobility. It is diagnosed chiefly on symptoms and signs, but also with blood tests (especially a test called rheumatoid factor) and X-rays. Diagnosis and long-term management are typically performed by a rheumatologist, an expert in the diseases of joints and connective tissues.



Rheumatoid arthritis

Various treatments are available. Non-pharmacological treatment includes physical therapy and occupational therapy. Analgesia (painkillers) and anti-inflammatory drugs, as well as steroids, are used to suppress the symptoms, while disease-modifying antirheumatic drugs (DMARDs) are often required to inhibit or halt the underlying immune process and prevent long-term damage. In recent times, the newer group of biologics has increased treatment options.

Rhizobacteria : These are root-colonizing bacteria that form a symbiotic relationship with many legumes. Though parasitic varieties of rhizobacteria exist, the term usually refers to bacteria that form a relationship beneficial for both parties (mutualism). Such bacteria are often referred to as plant growth promoting rhizobacteria, or PGPRs. Though microbial inoculants are indisputably beneficial for crops, they are not widely used in industrial agriculture, as large-scale application techniques have yet to become economically viable. A notable exception is the use of rhizobial inoculants for legumes such as peas. Inoculation with PGPRs ensure efficient nitrogen fixation, and they have been employed in North American Agriculture for over 100 years.

Rhodobacter sphaeroides is a kind of purple bacteria; a group of bacteria that can obtain energy through photosynthesis. It is remarkably metabolically diverse, as it is able to grow heterotrophically via fermentation and aerobic and anaerobic respiration. Its best growth conditions are anaerobic phototrophy (photoheterotrophic and photoautotrophic) and aerobic chemoheterotrophy in the absence of light. *R. sphaeroides* is also able to fix nitrogen.

R. sphaeroides is one of the most pivotal organisms in the study of bacterial photosynthesis. It requires no unusual conditions for growth and is incredibly efficient. The regulation of its photosynthetic machinery is of great interest to researchers, as R. sphaeroides has an intricate system for sensing O_2 tensions. Also, when exposed to a reduction in the partial pressure of oxygen, *R. sphaeroides* develops evaginations in its cellular membrane. The photosynthetic apparatus is housed in these envaginations. .

The genome of *R. sphaeroides* is also very intriguing. It has two chromosomes, one of 3 Mb (CI) and one of 900 Kb (CII), and five naturally occurring plasmids. Many genes are duplicated between the two chromosomes but appear to be differentially regulated. Moreover, many of the open reading frames (ORFs) on CII seem to code for proteins of unknown function. When genes of unknown function on CII are disrupted, many types of auxotrophy result, emphasizing that the CII is not merely a truncated version of CI.

Rhizobia : These are soil bacteria that fix nitrogen (diazotrophy) after becoming established inside root nodules of legumes (Fabaceae). Rhizobia require a plant host; they cannot independently fix nitrogen. Morphologically, they are generally gram negative, motile, non-sporulating rods.

The first species of rhizobia, *R. leguminosarum*, was identified in 1889, and all further species were initially placed in the *Rhizobium* genus. However, more advanced methods of analysis have revised this classification, and now there are many in other genera. Most research has been done on crop and forage legumes

such as clover, beans, and soy. However, recently more work is occurring on North American legumes. Although much of the nitrogen is removed when protein-rich grain or hay is harvested, significant amounts can remain in the soil for future crops. This is especially important when nitrogen fertilizer is not used, as in organic rotation schemes or some less-industrialized countries. Nitrogen is the most commonly deficient nutrient in many soils around the world and it is the most commonly supplied plant nutrient. Supply of nitrogen through fertilizers has severe environmental concerns. Nitrogen fixation by *Rhizobium* is also beneficial to the environment.

Rhodococcus equi : Is a Gram-positive coccoid bacteria. The organism commonly lives in dry and dusty soil and can be important for diseases of domesticated animals (horses and goats). The frequency of infection can reach near 60 percent. *R. equi* is an important pathogen of pneumonia of foals. Since 2008, it is also known that *R. equi* can infect wild boars in addition to domestic pigs. In addition, the pathogen can infect humans. The most endangered groups are immunocompromised people and HIV-AIDS-patients. Rhodococcal infection in these groups of patients resemble clinical and pathological signs of pulmonary tuberculosis.Taxonomically, *R. equi* can have the synonyms *Corynebacterium equi, Bacillus hoagii, Corynebacterium purulentus, Mycobacterium equi, Mycobacterium restrictum, Nocardia restricta* and *Proactinomyces restrictus.*

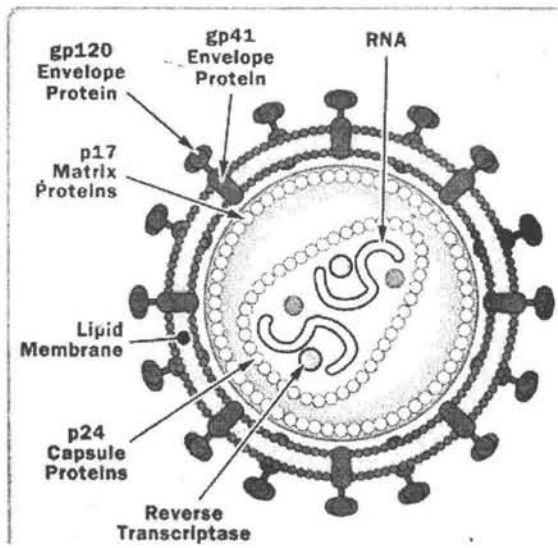
Rickettsia : Is a genus of motile, Gram-negative, non-sporeforming, highly pleomorphic bacteria that can present as cocci (0.1 μm in diameter), rods (1-4 μm long) or thread-like (10 μm long). Obligate intracellular parasites, the *Rickettsia* depend on entry, growth, and replication within the cytoplasm of eukaryotic host cells (typically endothelial cells). Because of this, *Rickettsia* cannot live in artificial nutrient environments and are grown either in tissue or embryo cultures (typically, chicken embryos are used). In the past they were regarded as microorganisms positioned somewhere between viruses and true bacteria. The majority of *Rickettsia* bacteria are susceptible to antibiotics of the tetracycline group.

Rickettsia species are carried as parasites by many ticks, fleas, and lice, and cause diseases such as typhus, rickettsialpox, Boutonneuse fever, African Tick Bite Fever, Rocky Mountain spotted fever, Australian Tick Typhus, Flinders Island Spotted Fever and Queensland Tick Typhus in human beings. They have also been associated with a range of plant diseases. Like viruses, they only grow inside living cells. The name rickettsia is often used for any member of the Rickettsiales. They are thought to be the closest living relatives to bacteria that were the origin of the mitochondria organelle that exists inside most eukaryotic cells. The method of growing Rickettsia in chicken embryos was invented by Ernest William Goodpasture and his colleagues at Vanderbilt University in the early 1930s.

Ringworm : Is a fungal infection of the skin in humans and domestic animals such as sheep and cattle. Fungi are organisms that survive by eating plant or animal material. Those that cause parasitic infection (dermatophytes) feed on keratin, the material found in the outer layer of skin, hair, and nails. These fungi thrive best on skin that is warm and moist. This condition has been prevalent since before 1906, at which time ringworm was treated with compounds of mercury. Hairy areas of skin were considered too difficult to treat, so the scalp was treated with xrays and followed up with antiparasitic medication.

It is estimated that in current times, up to twenty percent of the population is infected by ringworm or one of the other dermatophytoses. It is especially common among people who play sports, wrestling in particular. Misdiagnosis and treatment of ringworm with a topical steroid can result in tinea incognito, a condition where ringworm fungus will grow without typical features like a distinctive raised border.

RNA virus : Is a virus that has RNA (ribonucleic acid) as its genetic material. This nucleic acid is usually single-stranded RNA (ssRNA) but may be double-stranded RNA (dsRNA). The ICTV classifies RNA viruses as those that belong to *Group III*, *Group IV* or *Group V* of the Baltimore classification system of classifying viruses, and does not consider viruses with DNA intermediates as RNA viruses. Notable human diseases caused by RNA viruses include SARS, influenza and hepatitis C. Another term for RNA viruses that explicitly excludes retroviruses is ribovirus.



HIV is an RNA virus

RNA viruses can be further classified according to the sense or polarity of their RNA into negative-sense and positive-sense, or ambisense RNA viruses. Positive-sense viral RNA is identical to viral mRNA and thus can be immediately translated by the host cell. Negative-sense viral RNA is complementary to mRNA and thus must be converted to positive-sense RNA by an RNA polymerase before translation. As such, purified RNA of a positive-sense virus can directly cause infection though it may be less infectious than the whole virus particle. Purified RNA of a negative-sense virus is not infectious by itself as it needs to be transcribed into positive-sense RNA. Ambisense RNA viruses resemble negative-sense RNA viruses, except they also translate genes from the positive strand

Robert Hooke : He was an English natural philosopher and polymath who played an important role in the scientific revolution, through both experimental and theoretical work.Hooke is known principally for his law of elasticity (Hooke's Law). He is also remembered for his work as "the father of microscopy"—it was Hooke who coined the term "cell" to describe the basic unit of life.

Robert Hooke

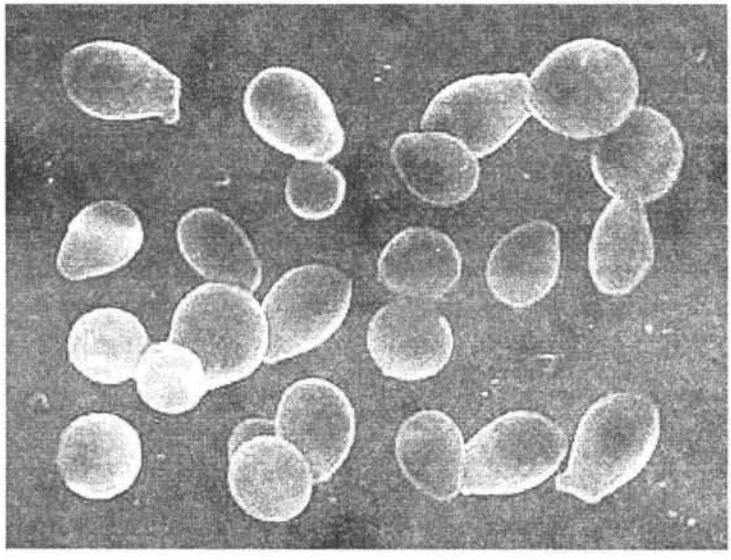
He also assisted Robert Boyle and built the vacuum pumps used in Boyle's gas law experiments. Hooke was an important architect of his time, and a chief surveyor to the City of London after the Great Fire. He built some of the earliest Gregorian telescopes, observed the rotations of Mars and Jupiter, and, based on

his observations of fossils, was an early proponent of biological evolution. He investigated the phenomenon of refraction, deducing the wave theory of light, and was the first to suggest that matter expands when heated and that air is made of small particles separated by relatively large distances. He also deduced from experiments that gravity follows an inverse square law, and that such a relation governs the motions of the planets, an idea which was subsequently developed by Newton. Much of Hooke's work was conducted in his capacity as curator of experiments of the Royal Society, a post he held from 1662.

Hooke was, by all accounts, a remarkably industrious man, and was at one time simultaneously the curator of the Royal Society and a member of its council, Gresham Professor of Geometry and Chief Surveyor to the City of London. Hooke's reputation suffered during the eighteenth century, and this is popularly attributed to a dispute with Isaac Newton over credit for his work on gravitation; Newton, as President of the Royal Society, did much to obscure Hooke, including, it is said, destroying (or failing to preserve) the only known portrait of the man. Hooke's reputation was revived during the twentieth century through studies of Robert Gunther and Margaret 'Espinasse, and after a long period of relative obscurity he is now recognized as one of the most important scientists of his age.

S

Saccharomyces cerevisiae : It is a species of budding yeast. It is perhaps the most useful yeast owing to its use since ancient times in baking and brewing. It is believed that it was originally isolated from the skins of grapes. It is one of the most intensively studied eukaryotic model organisms in molecular and cell biology, much like *Escherichia coli* as the model prokaryote. It is the microorganism behind the most common type of fermentation. *Saccharomyces cerevisiae* cells are round to ovoid, 5–10 micrometres in diameter. It reproduces by a division process known as budding.

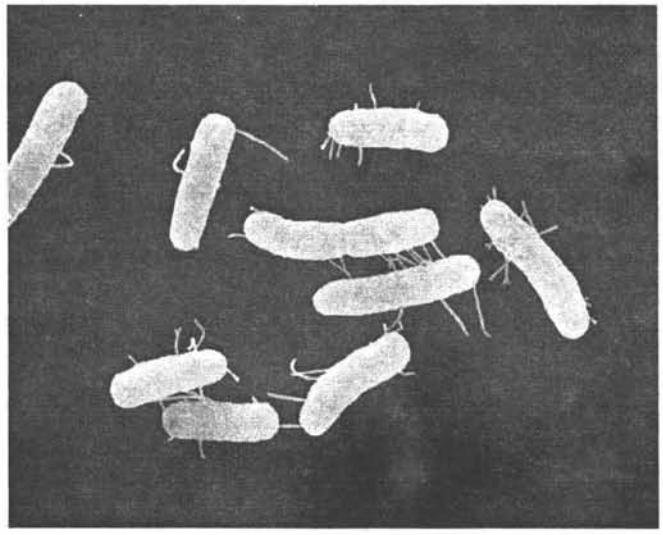


Saccharomyces cerevisiae

Many proteins important in human biology were first discovered by studying their homologs in yeast; these proteins include cell cycle proteins, signaling proteins,

and protein-processing enzymes. The petite mutation in *S. cerevisiae* is of particular interest."*Saccharomyces*" derives from Latinized Greek and means "sugar mold" or "sugar fungus", *saccharo-* being the combining form "sugar-" and *myces* being "fungus". *Cerevisiae* comes from Latin and means "of beer".

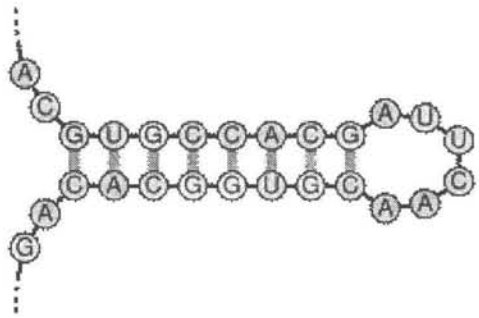
Salmonella : It is a genus of rod-shaped, Gram-negative, non-spore forming, predominantly motile enterobacteria with diameters around 0.7 to 1.5 μm, lengths from 2 to 5 μm, and flagella which project in all directions (i.e. peritrichous). They obtain their energy from oxidation and reduction reactions using organic sources and are facultative anaerobes; most species produce hydrogen sulfide, which can readily be detected by growing them on media containing ferrous sulfate, such as TSI.



Salmonella

Salmonella are closely related to the *Escherichia* genus and are found worldwide in warm- and cold-blooded animals, in humans, and in nonliving habitats. They cause illnesses in humans and many animals, such as typhoid fever, paratyphoid fever, and the foodborne illness salmonellosis. Salmonella is properly pronounced voicing the initial "l," since it is named for pathologist D.E. Salmon, not the salmon fish.

Satellite : A Satellite is a subviral agent composed of nucleic acid that depends on the coinfection of a host cell with a helper or master virus for their multiplication. When a satellite encodes the coat protein in which its nucleic acid is encapsidated it is referred to as a satellite virus.



Satellite DNA

A satellite virus of mimivirus that inhibits the replication of its host has been termed a virophage. Satellite viral particles should not be confused with satellite DNA.

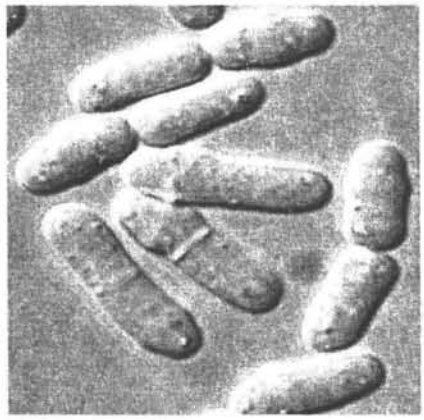
Scarlet fever : It is a disease caused by an exotoxin released by *Streptococcus pyogenes*. The term Scarlatina may be used interchangeably with Scarlet Fever, though it is commonly used to indicate the less acute form of Scarlet Fever that is often seen since the beginning of the twentieth century.

Diagnosis of scarlet fever is clinical. The blood test shows marked leukocytosis with neutrophilia and conservated or increased eosinophils, high erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), and elevation of antistreptolysin O titer. Blood culture is rarely positive, but the streptococci can usually be demonstrated in throat culture. The complications of scarlet fever include septic complications due to spread of streptococcus in blood and immune-mediated complications due to an aberrant immune response. Septic complications, today rare, include ear and sinus infection, streptococcal pneumonia, empyema thoracis, meningitis and full-blown sepsis, upon which the condition may be called malignant scarlet fever.

Immune complications include acute glomerulonephritis, rheumatic fever and erythema nodosum. The secondary scarlatinous disease, or secondary malignant syndrome of scarlet fever, includes renewed fever, renewed angina, septic ear, nose, and throat complications and kidney infection or rheumatic fever and is seen around the eighteenth day of untreated scarlet fever.

Schizosaccharomyces pombe : Also called "fission yeast", is a species of yeast. It is used as a model organism in molecular and cell biology. It is a unicellular eukaryote, whose cells are rod-shaped. Cells typically measure 3 to 4 micrometres in diameter

and 7 to 14 micrometres in length. Its genome, which is approximately 14.1 million base pairs, is estimated to contain 4,970 genes, possibly the fewest in any eukaryote. These cells maintain their shape by growing exclusively through the cell tips and divide by medial fission to produce two daughter cells of equal sizes, which makes them a powerful tool in cell cycle research.



Schizosaccharomyces pombe

Fission yeast was isolated in 1893 by Lindner from East African millet beer. The species name is derived from the Swahili word for beer (Pombe). It was first developed as an experimental model in the 1950s : by Urs Leupold for studying genetics, and by Murdoch Mitchison for studying the cell cycle.

The fission yeast researcher Paul Nurse successfully merged the independent schools of fission yeast genetics and cell cycle research. Together with Lee Hartwell and Tim Hunt, Nurse won the 2001 Nobel Prize in Physiology or Medicine for their work on cell cycle regulation.The sequence of the *S. pombe* genome was published in 2002, by a consortium led by the Sanger Institute, becoming the sixth model eukaryotic organism whose genome has been fully sequenced. This has fully unlocked the power of this organism, with many genes homologous to human disease genes being identified. In 2006, sub-cellular localization of all the proteins in *S. pombe* was published using green fluorescent protein as a molecular tag. *S. pombe* has also become an important organism in studying the cellular responses to DNA damage and the process of DNA replication.

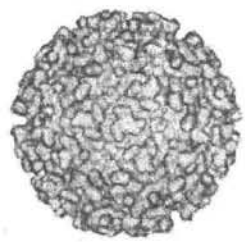
Schmutzdecke : It is a complex biological layer formed on the surface of a slow sand filter. The schmutzdecke is the layer that provides the effective purification in potable water treatment, the underlying sand providing the support medium for this biological treatment layer. The composition of any particular schmutzdecke

varies, but will typically consist of a gelatinous biofilm matrix of bacteria, fungi, protozoa, rotifera and a range of aquatic insect larvae. As a schmutzdecke ages, more algae tend to develop, and larger aquatic organisms may be present including some bryozoa, snails and annelid worms.

Secretion : It is the process of elaborating and releasing chemicals from a cell, a secreted chemical substance or amount of substance. In contrast to excretion, the substance may have a certain function, rather than being a waste product. Secretion in bacterial species means the transport or translocation of effector molecules for example proteins, enzymes or toxins (such as cholera toxin in pathogenic bacteria for example *Vibrio cholerae*) from across the interior (cytoplasm or cytosol) of a bacterial cell to its exterior. Secretion is a very important mechanism in bacterial functioning and operation in their natural surrounding environment for adaptation and survival.

Selectable marker : Is a gene introduced into a cell, especially a bacterium or to cells in culture, that confers a trait suitable for artificial selection. They are a type of reporter gene used in laboratory microbiology, molecular biology, and genetic engineering to indicate the success of a transfection or other procedure meant to introduce foreign DNA into a cell. Selectable markers are often antibiotic resistance genes; bacteria that have been subjected to a procedure to introduce foreign DNA are grown on a medium containing an antibiotic, and those bacterial colonies that can grow have successfully taken up and expressed the introduced genetic material. An alternative to a selectable marker is a screenable marker, which allows the researcher to distinguish between wanted and unwanted cells.

Semliki Forest virus : It was first isolated from mosquitoes in the Semliki Forest, Uganda by the Uganda Virus Research Institute in 1942. It is known to cause disease in both animals and man. It is an Alphavirus found in central, eastern, and southern Africa.



Semliki Forest virus

The Semliki Forest virus is a positive-stranded RNA virus with icosahedral capsid

which is enveloped by a lipid bilayer, derived from the host cell. The outermost surface of the virus is almost entirely covered by heterodimers of glycoproteins E1 and E2, arranged in interconnective trimers, which form an outer shell. Trimers are anchored in the membrane by an E2 cytoplasmic domain that associates with the nucleocapsid.

The size of the virus genome is approximately 13,000 base pairs. The 5′ two thirds of the genome encode non-structural proteins and the structural proteins are encoded in the 3′ third. Replication occurs via a negative strand intermediate giving rise to a full length genomic RNA for export in new virions and a subgenomic message that is translated into the structural proteins.

Semliki Forest virus is spread mainly by mosquito bites. It is not able to infect mammals through inhalation or gastrointestinal exposure although rodents in the laboratory can be infected by intranasal instillation. The virus is able to cause a lethal encephalitis in rodents, but only one lethal human infection has been reported. Even in this one case, the patient was immunodeficient and had been exposed to large amounts of virus in the laboratory.

Semliki Forest virus has been used extensively in biological research as a model of the viral life cycle and of viral neuropathy. Due to its broad host range and efficient replication, it has also been developed as a vector for genes encoding vaccines and anti-cancer agents, and as a tool in gene therapy.

Sergei Nikolaievich Winogradsky : He was a Russian microbiologist, ecologist and soil scientist who pioneered the cycle of life concept and discovered the biological process of nitrification, the first known form of chemoautotrophy.

Sergei Nikolaievich Winogradsky

Winogradsky was born in Kiev, in what was then the Russian Empire, and entered the Imperial Conservatoire of Music in St Petersburg in 1875 to study piano. However, after two years of music training, he entered the University of Saint Petersburg in 1877 to study chemistry under Nikolai Menshchutkin and botany under Andrei Sergeevich Famintzin. He took a diploma in 1881 and stayed at the University of St Petersburg to receive a degree of master of science in botany in 1884. In 1885, he began work at the University of Strasbourg under the renowned botanist Anton de Bary; Winogradsky became renowned for his work on sulfur bacteria. In 1888, he relocated to Zurich, where he began investigation into the process of nitrification, identifying the genera *Nitrosomonas* and *Nitrosococcus*, which oxidizes ammonium to nitrite, and *Nitrobacter*, which oxidizes nitrite to nitrate. He returned to St. Petersburg for the period 1891-1905 and there was chief of the division of general microbiology of the Institute of Experimental Medicine; during this period, he identified the obligate anaerobe *Clostridium pastorianum*, which is capable of fixing atmospheric nitrogen. In 1901, he was elected honorary member of the Moscow Society of Natural Science and, in 1902, corresponding member of the French Academy of Sciences. He retired from active scientific work in 1905, dividing his time between his private estate and Switzerland. In 1922, he accepted an invitation to head the division of agricultural bacteriology at the Pasteur Institute at an experimental station at Brie-Comte-Robert, France, about 30 km from Paris. In this period, he worked on a number of topics, among them iron bacteria, nitrifying bacteria, nitrogen fixation by *Azotobacter*, cellulose-decomposing bacteria, and culture methods for soil microorganisms. Winogradsky retired from active life in 1940 and died in Brie-Comte-Robert.

Serovar : It is a group of microorganisms or viruses classified together based on their cell surface antigens. Serovars allow the epidemiologic classification of organisms to the sub-species level. A group of serovars with common antigens is called a serogroup. Serovars may be established based on virulence factors, lipopolysaccharides in Gram-negative bacteria, presence of an exotoxin (pertussis toxin in *Bordetella pertussis*, for example), plasmids, phages, or other characteristics which differentiate two members of the same species.

Serratia marcescens : It is a species of Gram-negative, rod-shaped bacteria in the family Enterobacteriaceae. A human pathogen, *S. marcescens* is involved in nosocomial infections, particularly catheter-associated bacteremia, urinary tract infections and wound infections, and is responsible for 1.4% of nosocomial bacteremia cases in the United States. It is commonly found in the respiratory and urinary tracts of hospitalized adults and in the gastrointestinal system of children.

Due to its ubiquitous presence in the environment, and its preference for damp conditions, *S. marcescens* is commonly found growing in bathrooms (especially on tile grout, shower corners, toilet water line, and basin), where it manifests as a pink

discoloration and slimy film feeding off phosphorous containing materials or fatty substances (such as soap and shampoo residue). Once established, complete eradication of the organism is often difficult, but can be accomplished by application of a bleach-based disinfectant. Rinsing and drying surfaces after use can also prevent the establishment of the bacteria by removing it's food source and making the environment less hospitable.

S. marcescens may also be found in environments such as dirt, supposedly "sterile" places, and the subgingival biofilm of teeth. Due to this, and the fact that *S. marcescens* produces a reddish-orange tripyrrole pigment called prodigiosin, *S. marcescens* may cause extrinsic staining of the teeth. The biochemical pathway illustrating the production of prodigiosin by *S. marcescens* is unknown except for the final two steps. In these steps, a monopyrrole (MAD) and a bipyrrole (MBC) undergo a condensation reaction by way of a condensing enzyme to ultimately form prodigiosin.

Sewage treatment : It is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge suitable for discharge or reuse back into the environment. This material is often inadvertently contaminated with many toxic organic and inorganic compounds.

Sewage can be treated close to where it is created (in septic tanks, biofilters or aerobic treatment systems), or collected and transported via a network of pipes and pump stations to a municipal treatment plant. Sewage collection and treatment is typically subject to local, state and federal regulations and standards. Industrial sources of wastewater often require specialized treatment processes.

Conventional sewage treatment involves three stages, called *primary, secondary* and *tertiary treatment*. First, the solids are separated from the wastewater stream. Then dissolved biological matter is progressively converted into a solid mass by using indigenous, water-borne micro-organisms. Finally, the biological solids are neutralized then disposed of or re-used, and the treated water may be disinfected chemically or physically (for example by lagoons and microfiltration). The final effluent can be discharged into a stream, river, bay, lagoon or wetland, or it can be used for the irrigation of a golf course, green way or park. If it is sufficiently clean, it can also be used for groundwater recharge or agricultural purposes.

Sexual reproduction : It is characterized by processes that pass a combination of genetic material to offspring, resulting in diversity. The main two processes are : meiosis, involving the halving of the number of chromosomes; and fertilization, involving

the fusion of two gametes and the restoration of the original number of chromosomes. During meiosis, the chromosomes of each pair usually cross over to achieve genetic recombination.

The evolution of sexual reproduction is a major puzzle. The first fossilized evidence of sexually reproducing organisms is from eukaryotes of the Stenian period, about 1 to 1.2 billion years ago. Sexual reproduction is the primary method of reproduction for the vast majority of macroscopic organisms, including almost all animals and plants. Bacterial conjugation, the transfer of DNA between two bacteria, is often mistakenly confused with sexual reproduction, because the mechanics are similar.

A major question is why sexual reproduction persists when parthenogenesis appears in some ways to be a superior form of reproduction. Contemporary evolutionary thought proposes some explanations. It may be due to selection pressure on the clade itself—the ability for a population to radiate more rapidly in response to a changing environment through sexual recombination than parthenogenesis allows. Alternatively, sexual reproduction may allow for the "ratcheting" of evolutionary speed as one clade competes with another for a limited resource.

Shiga toxins : These are a family of related toxins with two major groups, Stx1 and Stx2, whose genes are considered to be part of the genome of lambdoid prophages. The toxins are named for Kiyoshi Shiga, who first described the bacterial origin of dysentery caused by *Shigella dysenteriae*. The most common sources for Shiga toxin are the bacteria *S. dysenteriae* and the *Shigatoxigenic group* of *Escherichia coli* (STEC), which includes serotype O157 :H7 and other enterohemorrhagic *E. coli*.

Shiga toxins act to inhibit protein synthesis within target cells by a mechanism similar to that of ricin toxin produced by *Ricinus communis*. After entering a cell, the protein functions as an N-glycosidase, cleaving several nucleobases from the RNA that comprises the ribosome, thereby halting protein synthesis.

The toxin has two subunits—designated A and B—and is one of the AB5 toxins. The B subunit is a pentamer that binds to specific glycolipids on the host cell, specifically globotriaosylceramide (Gb3). Following this, the A subunit is internalised and cleaved into two parts. The A1 component then binds to the ribosome, disrupting protein synthesis. Stx-2 has been found to be approximately 400 times more toxic (as quantified by LD50 in mice) than Stx-1.

Gb3 is, for unknown reasons, present in greater amounts in renal epithelial tissues, to which the renal toxicity of Shiga toxin may be attributed.

The toxin requires highly specific receptors on the cells' surface in order to attach and enter the cell; species such as cattle, swine, and deer which do not carry these

receptors may harbor toxigenic bacteria without any ill effect, shedding them in their feces, from where they may be spread to humans.

Shigella dysenteriae : It is a species of the rod-shaped bacterial genus *Shigella*. Shigella can cause shigellosis (bacillary dysentery). Shigellae are Gram-negative, non-spore-forming, facultatively anaerobic, non-motile bacteria.

S. dysenteriae, spread by contaminated water and food, causes the most severe dysentery because of its potent and deadly Shiga toxin, but other species may also be dysentery agents.

A stool specimen is Gram-stained to show G—ve, rods, with no particular arrangement. Enrichment is performed by growing the organisms on Selenite-F broth. Then, since the specimen is not sterile, the use of selective plates is mandatory. XLD agar, DCA agar, or HE agar are inoculated and colonies are colorless on all of them as the organism is non-lactose fermentor. TSI slant would show a profile of (K/A/H2S-/g-), and SIM would appear (+/-/+).

It's noteworthy that *Shigella flexneri* will produce acid and gas from glucose, and *Shigella sonnei* is mannitol and ornithine positive, and is also late lactose fermentor (ONPG positive). Some *Shigella* species are capable of producing indol.

Shigella : Is a genus of Gram-negative, non-spore forming rod-shaped bacteria closely related to *Escherichia coli* and *Salmonella*. The causative agent of human shigellosis, *Shigella* cause disease in primates, but not in other mammals.

Shigella infection is typically via ingestion (fecal–oral contamination); depending on age and condition of the host as few as ten bacterial cells can be enough to cause an infection. *Shigella* causes dysentery that results in the destruction of the epithelial cells of the intestinal mucosa in the cecum and rectum. Some strains produce enterotoxin and Shiga toxin, similar to the verotoxin of *E. coli* O157 :H7. Both Shiga toxin and verotoxin are associated with causing hemolytic uremic syndrome.

Shigella invade the host through epithelial cells of the large intestine. Using a Type III secretion system acting as a biological syringe, the bacterium injects *IpaD* protein into cell, triggering bacterial invasion and the subsequent lysis of vacuolar membranes using *IpaB* and *IpaC* proteins. It utilizes a mechanism for its motility by which its *IcsA* protein triggers actin polymerization in the host cell (via N-WASP recruitment of Arp2/3 complexes) in a "rocket" propulsion fashion for cell-to-cell spread. to the cell The most common symptoms are diarrhea, fever, nausea, vomiting, stomach cramps, flatulence, and constipation. The stool may contain blood, mucus, or pus. In rare cases, young children may have seizures. Symptoms can take as long as a week to show up, but most often begin two to four days after ingestion. Symptoms usually last for several days but can last for weeks.

Shigella is implicated as one of the pathogenic causes of reactive arthritis worldwide.

Simian immunodeficiency virus (SIV) : Is a retrovirus that is found, in numerous strains, in primates; the specific strains infecting humans are HIV-1 and HIV-2, the viruses that cause AIDS. The origin of HIV is now generally attributed to SIV from African primates. HIV-2 is most closely related to SIVsm, the SIV strain that primarily infects Sooty Mangabeys, while HIV-1 is closely related to the chimpanzee strain of SIV, designated SIVcpz. The most likely route of transmission of HIV-1 to humans involves contact with the blood of chimps that are often hunted for bushmeat in Africa.

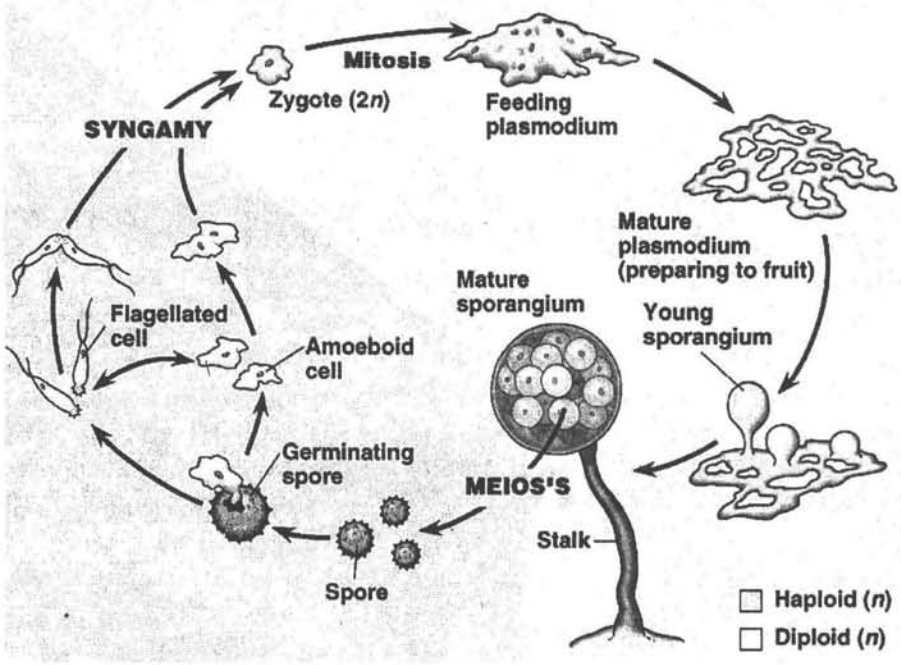
Simian immunodeficiency virus

SIV monkey strains are transmitted sexually and usually do not cause immunodeficiency in their natural hosts, Sooty mangabeys and African Green Monkeys, even when the infected hosts carry large viral loads. SIV strains may cause an AIDS-like immune deficiency known as SAIDS (simian acquired immunodeficiency syndrome) if they cross species boundaries. For example, SIVagm, the SIV strain from African Green Monkeys causes SAIDS in Pig-tailed macaques. Unlike African Green Monkeys, macaques are native to Asia and do not carry their own strain of SIV. Interestingly, yellow and chacma baboons, African monkeys, do not develop SAIDS when they contract SIVagm.

Slime layer : In bacteria is an easily removed, diffuse, unorganised layer of extracellular material that surrounds bacteria cells. Specifically, this consists mostly of exopolysaccharides, glycoproteins, and glycolipids.The slime layer is not to be confused with the S-layer, a separate and highly organised glycoprotein layer surrounding many bacterial cells. The function of the slime layer is to protect the

bacteria cells from environmental dangers such as antibiotics and desiccation. The slime layer also allows bacteria to adhere to smooth surfaces such as prosthetic medical devices and catheters. It may permit bacterial colonies to survive chemical sterilization with chlorine, iodine, and other chemicals, leaving autoclaving or flushing with boiling water as the only certain methods of decontamination.A bacterial capsule is similar, but is a well ordered structure that is resistant to washing off.

Slime mold : Is a broad term describing fungi-like organisms that use spores to reproduce. They were formerly classified as fungi, but are no longer considered part of this group. Their common name refers to part of some of these organism's lifecycles where they can appear gelatinous (hence the name slime). However, this feature is mostly seen with the myxomycetes, which are the only macroscopic slime molds.



Slime mold life cycle

Slime molds have been found all over the world and feed on microorganisms that live in any type of dead plant material. For this reason, these organisms are usually

found in soil, lawns, and on the forest floor, commonly on deciduous logs. However, in tropical areas they are also common on inflorescences, fruits and in aerial situations (e.g., in the canopy of trees). In urban areas, they are found on mulch or even in the leaf mold in gutters. One of the most commonly encountered slime molds, both in nature in forests in the temperate zones of the earth as well as in classrooms and laboratories is the yellow *Physarum polycephalum*.

Most slime mold are smaller than a few centimetres, but the very largest recorded reached an area of up to thirty square metres, making them the largest undivided cells known. Many have striking colours such as yellow, brown and white.

They begin life as amoeba-like cells. These unicellular amoebae are commonly haploid and multiply if they encounter their favorite food, bacteria. These amoebae can mate if they encounter the correct mating type and form zygotes which then grow into plasmodia. These contain many nuclei without cell membranes between them, which can grow to be meters in size. One variety is often seen as a slimy yellow network in and on rotting logs. The amoebae and the plasmodia engulf microorganisms. The plasmodium grows into an interconnected network of protoplasmic strands.

Within each protoplasmic strand the cytoplasmic contents rapidly stream. If one strand is carefully watched for about 50 seconds the cytoplasm can be seen to slow, stop, and then reverse direction. The streaming protoplasm within a plasmodial strand can reach speeds of up to 1.35 mm per second which is the fastest rate recorded for any organism. Migration of the plasmodium is accomplished when more protoplasm streams to advancing areas and protoplasm is withdrawn from rear areas. When the food supply wanes, the plasmodium will migrate to the surface of its substrate and transform into rigid fruiting bodies. The fruiting bodies or sporangia are what we commonly see, they superficially look like fungi or molds but are not related to the true fungi. These sporangia will then release spores which hatch into amoebae to begin the life cycle again.

Smallpox : Is an infectious disease unique to humans, caused by either of two virus variants, *Variola major* and *Variola minor*. The disease is also known by the Latin names *Variola* or *Variola vera*, which is a derivative of the Latin *varius*, meaning spotted, or *varus*, meaning "pimple". The term "smallpox" was first used in Europe in the 15th century to distinguish variola from the "great pox" (syphilis).

Smallpox localizes in small blood vessels of the skin and in the mouth and throat. In the skin, this results in a characteristic maculopapular rash, and later, raised fluid-filled blisters. *V. major* produces a more serious disease and has an overall mortality rate of 30–35%. *V. minor* causes a milder form of disease (also known as alastrim, cottonpox, milkpox, whitepox, and Cuban itch) which kills about 1%

of its victims. Long-term complications of *V. major* infection include characteristic scars, commonly on the face, which occur in 65–85% of survivors. Blindness resulting from corneal ulceration and scarring, and limb deformities due to arthritis and osteomyelitis are less common complications, seen in about 2–5% of cases.

Smallpox is believed to have emerged in human populations about 10,000 BC. The disease killed an estimated 400,000 Europeans each year during the 18th century (including five reigning monarchs), and was responsible for a third of all blindness. Of all those infected, 20–60%—and over 80% of infected children—died from the disease.

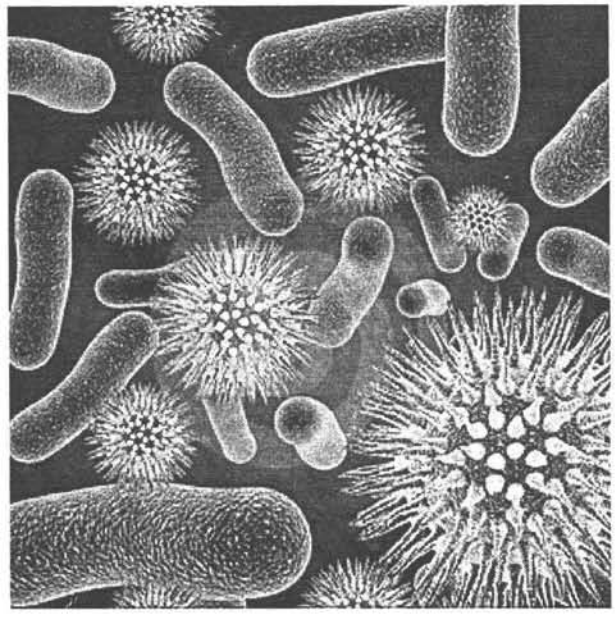
In the early 1950s an estimated 50 million cases of smallpox occurred in the world each year. As recently as 1967, the World Health Organization estimated that 15 million people contracted the disease and that two million died in that year. After successful vaccination campaigns throughout the 19th and 20th centuries, the WHO certified the eradication of smallpox in December 1979. To this day, smallpox is the only human infectious disease to have been completely eradicated.

Snottites : These are colonies of single-celled extremophilic bacteria. They hang from the walls and ceilings of caves and are similar to small stalactites, but have the consistency of "snot", or mucus. The bacteria derive their energy from chemosynthesis of volcanic sulfur compounds and warm-water solution dripping down from above. Because of this, they are highly acidic, some with the corrosive properties of battery acid (sulphuric acid). Snottites were recently brought to attention by researchers Diana Northup and Penny Boston, studying them (and other organisms) in a toxic sulfur cave called Cueva de Villa Luz (*Cave of the Lighted House*), in Tabasco, Mexico. The term "snottite" was originally given to these cave features by Jim Pisarowicz in 1986. Snottites have also been found in the drained mining levels of Parys Mountain in Anglesey, Wales.

Solemyidae : Is a family of protobranch bivalves in the order Solemyoida.Solemyids are remarkable in that their digestive tract is ›ither extremely small or non-existent, and their feeding appendages are too short to reach outside the shell . It has been shown that these clams host sulphur-oxidizing Bacteria intracellularly within their gill filaments. As chemoautotrophs, these bacterial symbionts synthesize organic matter from CO_2 and are the primary source of nutrition for the whole organism . In turn, the animal host provides its symbionts a habitat in which they have access to the substrates of chemoautotrophy. Together, these partners create "animals" with novel metabolic capabilities.

Sorangium cellulosum : Is a soil-dwelling Gram-negative bacteria of the group myxobacteria. It is motile and shows gliding motility. It has an unusually-large genome 12,200,000 base pairs in size. A more recent work sequenced the genome

of *Sorangium cellulosum* So ce56 and put its size at 13,033,779 base pairs making it the largest bacterial genome sequenced to date. Metabolites secreted by Sorangium cellulosum known as epothilones have been noted to have antineoplastic activity. This has led to the development of analogs which mimic its activity. One such analog, known as Ixabepilone is a US FDA approved chemotherapy agent for the treatment of metastatic breast cancer.



Sorangium cellulosum

spheroplast : Is a cell from which the cell wall has been almost completely removed, as by the action of penicillin. The name stems from the fact that after a microbe's cell wall is digested, membrane tension causes the cell to acquire a characteristic spherical shape. Spheroplasts are osmotically fragile, and will lyse if transferred to a hypotonic solution. Specially prepared giant spheroplasts of Gram-negative bacteria can be used to study the function of bacterial ion channels through a technique called patch clamp, which was originally designed for characterizing the behavior of neurons and other excitable cells. To prepare giant spheroplasts, bacteria are grown in a medium containing chemicals that prevent the cells from dividing completely. This causes bacteria to form long "snakes" that share a single membrane and cytoplasm. After a period of time, the cell walls of the "snakes" are digested, and the bacteria collapse into very large spheres surrounded by a

single lipid bilayer. The membrane can then be analyzed on a patch clamp apparatus to determine the phenotype of the ion channels embedded in it. It is also common to overexpress a particular channel to amplify its effect and make it easier to characterize.

Spider mites : Spider mites are members of the Acari (mite) family Tetranychidae, which includes about 1600 species. They generally live on the under sides of leaves of plants, where they may spin protective silk webs, and they can cause damage by puncturing the plant cells to feed.

Spider mites are less than 1 mm in size and vary in color. They lay small, spherical, initially transparent eggs and many species spin silk webbing to help protect the colony from predators; they get the 'spider' part of their common name from this webbing. Hot, dry conditions are often associated with population build-up of spider mites.

The best known member of the group is Tetranychus urticae (the glasshouse red spider mite, or two-spotted spider mite), which is common in tropical and warm temperate zones, and in glasshouses. Other species which can be important pests of commercial plants include Panonychus ulmi (fruit tree red spider mite) and Panonychus citri (citrus red mite).

Spider mites, like hymenopterans and some homopterous insects, are arrhenotochous : females are diploid and males are haploid. When mated, females avoid the fecundation of some eggs to produce males. Fertilized eggs produce diploid females. Unmated, unfertilized females still lay eggs, that originate exclusively haploid males.

Spore : A spore is a reproductive structure that is adapted for dispersal and surviving for extended periods of time in unfavorable conditions. Spores form part of the life cycles of many plants, algae, fungi and some protozoans. A chief difference between spores and seeds as dispersal units is that spores have very little stored food resources compared with seeds.

Spores are usually haploid and unicellular and are produced by meiosis in the sporangium by the sporophyte. Once conditions are favorable, the spore can develop into a new organism using mitotic division, producing a multicellular gametophyte, which eventually goes on to produce gametes.

Two gametes fuse to create a new sporophyte. This cycle is known as alternation of generations, but a better term is "biological life cycle", as there may be more than one phase and so it cannot be a direct alternation. Haploid spores produced by mitosis (known as mitospores) are used by many fungi for asexual reproduction.Many ferns, especially those adapted to dry conditions, produce diploid spores. This form of asexual reproduction is called apogamy. It is a form of apomixis.

Spores are the units of asexual reproduction, because a single spore develops into a new organism. By contrast, gametes are the units of sexual reproduction, as two gametes need to fuse to create a new organism.In common parlance, the difference between a "spore" and a "gamete" (both together called gonites) is that a spore will germinate and develop into a sporeling, while a gamete needs to combine with another gamete before developing further. However, the terms are somewhat interchangeable when referring to gametes.

A chief difference between spores and seeds as dispersal units is that spores have little food storage compared with seeds, and thus require more favorable conditions in order to successfully germinate. (This is not without its exceptions, however : many orchid seeds, although multicellular, are microscopic and lack endosperm, and spores of some fungi in the Glomeromycota commonly exceed 300 μm in diameter.) Seeds, therefore, are more resistant to harsh conditions and require less energy to start mitosis. Spores are produced in large numbers to increase the chance of a spore surviving in a number of notable examples.

Sputum culture : Is a test to detect and identify bacteria or fungi that infect the lungs or breathing passages. Sputum is a thick fluid produced in the lungs and in the adjacent airways. A sample of sputum is placed in a sterile container and sent to the laboratory for testing. Sputum may be expectorated (produced by coughing), induced (saline is sprayed in the lungs to induce sputum production), or taken via an endotracheal tube (commonly used on patiens on respirators) in an intensive care setting.For selected organisms such as Cytomegalovirus or "Pneumocystis jiroveci" in specific clincal settings (immunocompromised patients) a bronchoalveolar lavage might be taken by an experienced pneumologist. If no bacteria or fungi grow, the culture is negative. If organisms that can cause the infection (pathogenic organisms) grow, the culture is positive. The type of bacterium or fungus will be identified by microscopy, colony morphology and biochemical tests of bacterial growth.

If bacteria or fungi that can cause infection grow in the culture, other tests may be done to determine which antimicrobial agent will be most effective in treating the infection. This is called susceptibility or sensitivity testing. In a hospital setting, a sputum culture is most commonly ordered if a patient has a pneumonia. The Infectious Diseases Society of America recommends that sputum cultures be done in pneumonia requiring hospitalization, while the American College of Chest Physicians does not. One reason for such a discrepancy is that normal, healthy lungs have bacteria, and sputum cultures collect both normal bacteria and those which are pathogenic. However, pure cultures of common respiratory pathogens in the absence of upper respiratory flora combined with symptoms of respiratory distress provides strong evdience of the infectious agent, and its significance. Such

pathogens include *Streptococcus pneumoniae, Haemophilus influenzae* and the highly infectious *Mycobacterium tuberculosis* which are transmitted by inhailing aerosols. For this reason, laboratory processing of sputum for respiratory pathogens are performed with the aid of a biological safety cabinet.

Staining : Is an auxiliary technique used in microscopy to enhance contrast in the microscopic image. In biochemistry it involves adding a class-specific (DNA, proteins, lipids, carbohydrates) dye to a substrate to qualify or quantify the presence of a specific compound. It is similar to fluorescent tagging.

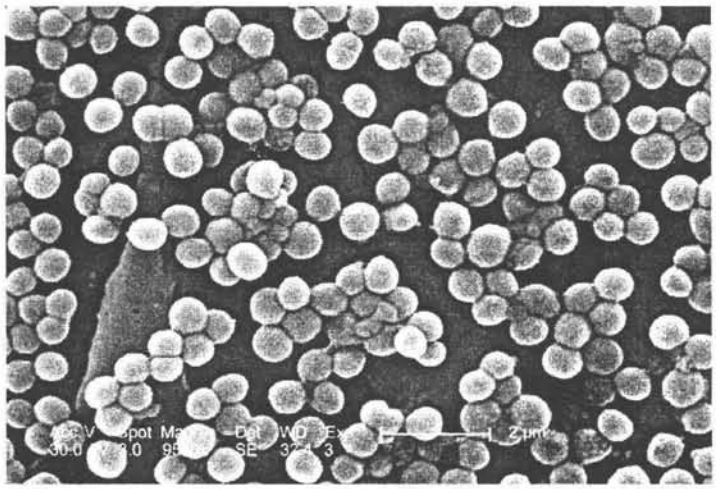
Stains and dyes are frequently used in biology and medicine to highlight structures in biological tissues for viewing, often with the aid of different microscopes. Stains may be used to define and examine bulk tissues (highlighting, for example, muscle fibers or connective tissue), cell populations (classifying different blood cells, for instance), or organelles within individual cells. Biological staining is also used to mark cells in flow cytometry, and to flag proteins or nucleic acids in gel electrophoresis. Staining is not limited to biological materials, it can also be used to study the morphology of other materials for example the lamellar structures of semicrystalline polymers or the domain structures of block copolymers.

Staphylococcus aureus : Is the most common cause of staph infections. It is a spherical bacterium, frequently found in the nose and skin of a person. About 20% of the population are long-term carriers of *S. aureus*. *S. aureus* can cause a range of illnesses from minor skin infections, such as pimples, impetigo (may also be caused by *Streptococcus pyogenes*), boils, cellulitis folliculitis, furuncles, carbuncles, scalded skin syndrome and abscesses, to life-threatening diseases such as pneumonia, meningitis, osteomyelitis, endocarditis, Toxic shock syndrome (TSS), and septicemia. Its incidence is from skin, soft tissue, respiratory, bone, joint, endovascular to wound infections. It is still one of the four most common causes of nosocomial infections, often causing postsurgical wound infections. Abbreviated to *S. aureus* or *Staph aureus* in medical literature, *S. aureus* should not be confused with the similarly named (and also medically relevant) species of the genus *Streptococcus*.

S. aureus was discovered in Aberdeen, Scotland in 1880 by the surgeon Sir Alexander Ogston in pus from surgical abscesses. Each year some 500,000 patients in American hospitals contract a staphylococcal infection.*S. aureus* is a facultatively anaerobic, Gram-positive coccus, which appears as grape-like clusters when viewed through a microscope and has large, round, golden-yellow colonies, often with hemolysis, when grown on blood agar plates. The golden appearance is the etymological root of the bacteria's name : *aureus* means "golden" in Latin.

S. aureus is catalase positive (meaning that it can produce the enzyme "catalase") and able to convert hydrogen peroxide (H_2O_2) to water and oxygen, which makes

the catalase test useful to distinguish staphylococci from enterococci and streptococci.



Staphylococcus aureus

A small percentage of *S. aureus* can be differentiated from most other staphylococci by the coagulase test : *S. aureus* is primarily coagulase-positive (meaning that it can produce "coagulase", a protein product, which is an enzyme) that causes clot formation while most other *Staphylococcus* species are coagulase-negative. However, while the majority of *S. aureus* are coagulase-positive, some may be atypical in that they do not produce coagulase. Incorrect identification of an isolate can impact implementation of effective treatment and/or control measures.

Stealth-adapted virus : Is used to describe cell damaging (cytopathic) viruses that lack genes coding for antigens targeted by the cellular immune system. Infection with stealth-adapted viruses do not evoke the inflammatory reaction typical of most cytopathic viruses. Missing antigenic proteins enable stealth viruses to escape recognition by the immune system. Atypically-structured cell-damaging viruses were initially proposed by W. John Martin, M.D., Ph.D., who introduced the term 'stealth viruses' to highlight their evasion of effective immune recognition. Martin has hypothesized that stealth viruses are contributing to increasingly prevalent diseases, such as autism and learning disorders in children, chronic fatigue syndrome and mental illness in adults, and neurodegenerative illnesses in the elderly. His research has been controversial and has not been accepted by the scientific community.

Sterilization : Refers to any process that effectively kills or eliminates transmissible agents (such as fungi, bacteria, viruses, spore forms, etc.) from a surface, equipment, article of food or medication, or biological culture medium. Sterilization does not, however, remove prions. Sterilization can be achieved through application of heat, chemicals, irradiation, high pressure or filtration.

The first application of sterilization was thorough cooking to effect the partial heat sterilization of foods and water, inventor Nicolas Appert. Cultures that practice heat sterilization of food and water have longer life expectancy and lower rates of disability. Canning of foods by heat sterilization was an extension of the same principle. Ingestion of contaminated food and water remains a leading cause of illness and death in the developing world, particularly for children.

Food sterilization is generally considered a harsher form of Pasteurization, and is carried out through heating, though other methods are available. Food sterilization is commonly a part of canning and is used in combination with or instead of preservatives, refrigeration, and other ways to preserve food.

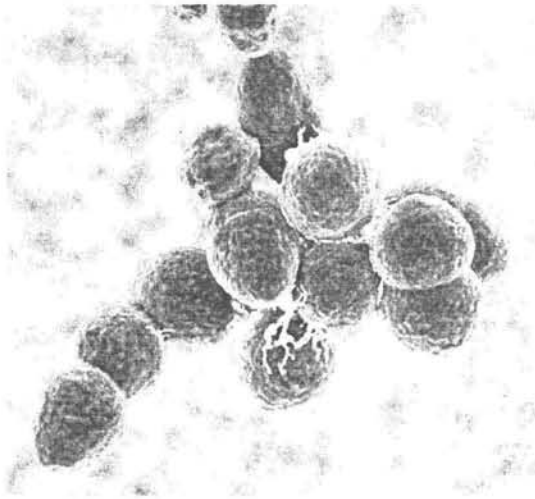
In general, surgical instruments and medications that enter an already sterile part of the body (such as the blood, or beneath the skin) must have a high sterility assurance level. Examples of such instruments include scalpels, hypodermic needles and artificial pacemakers. This is also essential in the manufacture of parenteral pharmaceuticals.

Heat sterilization of medical instruments is known to have been used in Ancient Rome, but it mostly disappeared throughout the Middle Ages resulting in significant increases in disability and death following surgical procedures.

Preparation of injectable medications and intravenous solutions for fluid replacement therapy requires not only a high sterility assurance level, but well-designed containers to prevent entry of adventitious agents after initial sterilization.

Strain 121 : Is a single-celled microbe, of the domain Archaea. First discovered 200 miles (320 km) off Puget Sound in a hydrothermal vent, it is a hyperthermophile, able to survive and reproduce at 121°C (250°F) (hence its name). It is the only known form of life that can tolerate such incredibly high temperatures. 130°C (266°F) is proven to be only bacteriostatic for Strain 121, meaning that although growth is halted, the archaeum remains viable, and can resume reproducing once it has been transferred to a cooler medium. The ability to grow at 121 degrees Celsius is significant because medical equipment is exposed to this temperature for sterilization in an autoclave. Prior to the 2003 discovery of Strain 121, a fifteen-minute exposure to autoclave temperatures was believed to kill all living organisms.

Streptococcus pneumoniae : Is Gram-positive, alpha-hemolytic diplococcus aerotolerant anaerobe and a member of the genus *Streptococcus*. A significant human pathogenic bacterium, *S. pneumoniae* was recognized as a major cause of pneumonia in the late 19th century and is the subject of many humoral immunity studies. Despite the name, the organism causes many types of pneumococcal infection other than pneumonia, including acute sinusitis, otitis media, meningitis, bacteremia, osteomyelitis, septic arthritis, endocarditis, peritonitis, pericarditis, cellulitis, and brain abscess.

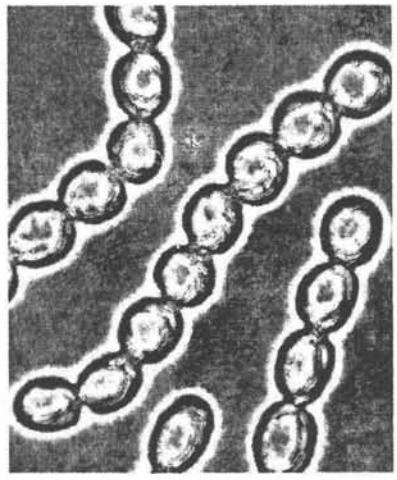


S. pneumoniae

S. pneumoniae is the most common cause of bacterial meningitis in adults and children, and is one of the top two isolates found in ear infection, otitis media. Pneumococcal pneumonia is more common in the very young and the very old. *S. pneumoniae* can be differentiated from *Streptococcus viridans*, which is also alpha hemolytic, using an optochin test, as *S. pneumoniae* is optochin sensitive. The encapsulated, gram-positive coccoid bacteria have a distinctive morphology on gram stain, the so-called, "lancet shape." It has a polysaccharide capsule that acts as a virulence factor for the organism; 91 different capsular types are known, and these types differ in virulence, prevalence, and extent of drug resistance.

Streptococcus pyogenes : Is a spherical gram-positive bacteria that grows in long chains and is the cause of Group A streptococcal infections. *S. pyogenes* displays streptococcal group A antigen on its cell wall. *S. pyogenes* typically produces large zones of beta-hemolysis (the complete disruption of erythrocytes and the release

of hemoglobin) when cultured on blood agar plates and are therefore also called Group A (beta-hemolytic) *Streptococcus*.



Streptococcus pyogenes

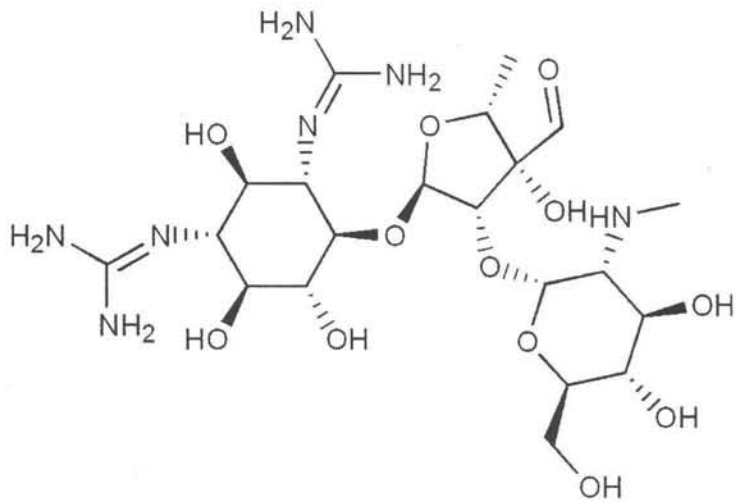
Streptococci are catalase-negative. In ideal conditions, *S. pyogenes* has an incubation period of approximately 10 days. *S. pyogenes* is the cause of many important human diseases ranging from mild superficial skin infections to life-threatening systemic diseases. Infections typically begin in the throat or skin. Examples of mild *S. pyogenes* infections include pharyngitis ("strep throat") and localized skin infection ("impetigo"). Erysipelas and cellulitis are characterized by multiplication and lateral spread of *S. pyogenes* in deep layers of the skin. *S. pyogenes* invasion and multiplication in the fascia can lead to necrotizing fasciitis, a potentially life-threatening condition requiring surgical treatment.

Infections due to certain strains of *S. pyogenes* can be associated with the release of bacterial toxins. Throat infections associated with release of certain toxins lead to scarlet fever. Other toxigenic *S. pyogenes* infections may lead to streptococcal toxic shock syndrome, which can be life-threatening.

S. pyogenes can also cause disease in the form of post-infectious "non-pyogenic" (not associated with local bacterial multiplication and pus formation) syndromes. These autoimmune-mediated complications follow a small percentage of infections and include rheumatic fever and acute poststreptococcal glomerulonephritis. Both conditions appear several weeks following the initial streptococcal infection. Rheumatic fever is characterised by inflammation of the joints and/or heart

following an episode of Streptococcal pharyngitis. Acute glomerulonephritis, inflammation of the renal glomerulus, can follow Streptococcal pharyngitis or skin infection.

Streptomycin : Is an antibiotic drug, the first of a class of drugs called aminoglycosides to be discovered, and was the first antibiotic remedy for tuberculosis. It is derived from the actinobacterium *Streptomyces griseus*. Streptomycin is a bactericidal antibiotic. It kills sensitive microbes by inhibiting protein synthesis; more specifically, it binds to the 16S rRNA of the bacterial ribosome, interfering with the binding of formyl-methionyl-tRNA to the 30S subunit. This prevents initiation of protein synthesis and leads to death of microbial cells.



Streptomycin : Chemical structure

Humans have structurally different ribosomes from bacteria, thereby allowing the selectivity of this antibiotic for bacteria. However at low concentrations Streptomycin only inhibits growth of the bacteria, this is done by inducing prokaryotic ribosomes to misread mRNA. Streptomycin cannot be given orally, but must be administered by regular intramuscular injection. An adverse effect of this medicine is ototoxicity, which can lead to temporary hearing loss.

subclinical infection : Is the asymptomatic (without apparent sign) carrying of an (infection) by an individual of an agent (microbe, intestinal parasite, or virus) that usually is a pathogen causing illness, at least in some individuals. Many pathogens spread by being silently carried in this way by some of their host population. Such infections occur both in humans and nonhuman animals. An example of an

asymptomatic infection is a mild common cold that is not noticed by the infected individual. Since subclinical infections often occur without eventual overt sign, their existence is only identified by microbiological culture, or DNA techniques such as polymerase chain reaction.

An individual may only develop signs of an infection after a period of subclinical infection, a duration that is called the incubation period. This is the case, for example, for subclinical sexually transmitted diseases such as AIDS and genital warts in women. Individuals with such subclinical infections, and those that never develop overt illness, creates a reserve of individuals that can transmit an infectious agent to infect other individuals. Because such cases of infections do not come to clinical attention, health statistics can often fail to measure the true prevalence of an infection in a population, and this prevents the accurate modeling of its infectious transmission.

Sulfate-reducing bacteria : Comprise several groups of bacteria that use sulfate as an oxidizing agent, reducing it to sulfide. Most sulfate-reducing bacteria can also use other oxidized sulfur compounds such as sulfite and thiosulfate, or elemental sulfur. This type of metabolism is called dissimilatory, since sulfur is not incorporated—assimilated—into any organic compounds. Sulfate-reducing bacteria have been considered as a possible way to deal with acid mine waters that are produced by other bacteria.

Superinfection : Is the process by which a cell, that has previously been infected by one virus, gets coinfected with a different strain of the virus, or another virus at a later point in time. Viral superinfections of serious conditions can lead to resistant strains of the virus, which may prompt a change of treatment. For example, an individual superinfected with two separate strains of the HIV virus may contract a strain that is resistant to antiretroviral treatment. The combined infection has also been shown to reduce the overall effectiveness of the immune response.

Superinfection is an infection following a previous infection, especially when caused by microorganisms that are resistant or have become resistant to the antibiotics used earlier. Superinfection, according to Dorland's illustrated medical dictionary, is a condition produced by sudden growth of a type of bacteria, different from the original offenders in a wound or lesion under treatment. When a cell is a lambda lysogen, another lambda phage that infects is not able to undergo lytic development and produce phage. The incoming phage can inject DNA, however, the DNA is immediately shut down and no transcription/translation of the lambda initiates. Therefore, lambda lysogens are immune to infection by another lambda phage particle. The reason is that the lysogen is continuously producing cI repressor. The amount of cI protein exceeds the amount needed to shut down more than one phage. The extra repressor binds to the superinfecting phage DNA and prevents its transcription.

Swarming motility : Is a rapid (2-10 μm/s.) and coordinated translocation of a bacterial population across solid or semi-solid surfaces. This type of motility is an example of an emerging concept in microbiology : bacterial multicellularity. Swarming motility was first reported by Jorgen Henrichsen and has been mostly studied in genus *Serratia, Salmonella, Aeromonas, Bacillus, Yersinia, Pseudomonas, Proteus, Vibrio* and *Escherichia* .

This multicellular behavior has been mostly observed in controlled laboratory conditions and relies on two critical elements : 1) the nutrient composition and 2) viscosity of culture medium (i.e. % agar). One particular feature of this type of motility is the formation of dendritic fractal-like patterns formed by migrating swarms moving away from an initial location. Although the majority of species can produce tendrils when swarming, some species like *Proteus mirabilis* do form concentric circles motif instead of dendritic patterns.

In some species, swarming motility requires the self-production of biosurfactant to occur. Biosurfactant synthesis is usually under the control of an intercellular communication system called quorum sensing. Biosurfactant molecules are thought to act by lowering surface tension, thus permitting bacteria to move across a surface.

Symbiosis : The term symbiosis commonly describes close and often long-term interactions between different biological species. The term was first used in 1879 by the German mycologist Heinrich Anton de Bary, who defined it as "the living together of unlike organisms." The definition of symbiosis is in flux, and the term has been applied to a wide range of biological interactions. The symbiotic relationship may be categorized as being mutualistic, parasitic, or commensal in nature. Others define it more narrowly, as only those relationships from which both organisms benefit, in which case it would be synonymous with mutualism.

Symbiotic relationships include those associations in which one organism lives on another (ectosymbiosis, such as mistletoe), or where one partner lives inside the other (endosymbiosis, such as lactobacilli and other bacteria in humans or zooxanthelles in corals). Symbiotic relationships may be either obligate, i.e., necessary for the survival of at least one of the organisms involved, or facultative, where the relationship is beneficial but not essential for survival of the organisms.

Symbiotic bacteria : These are bacteria living in symbiosis with another organism or each other. For example, Zoamastogopera, found in the stomach of termites, enable them to digest cellulose.Symbiotic bacteria are able to live in or on plant or animal tissue. In digestive systems, symbiotic bacteria help break down foods that contain fibre. They also help produce vitamins. Symbiotic bacteria can live near hydrothermal vents. They usually have a mutual relationship with other

bacteria. Some live in tube worms. A use for symbiotic bacteria has recently been in paratransgenesis for controlling important vectors for disease, such as the transmission of Chagas disease by Triatome kissing bugs.

Systemic lupus erythematosus (SLE) : Is a chronic autoimmune connective tissue disease that can affect any part of the body. As occurs in other autoimmune diseases, the immune system attacks the body's cells and tissue, resulting in inflammation and tissue damage.

SLE most often harms the heart, joints, skin, lungs, blood vessels, liver, kidneys, and nervous system. The course of the disease is unpredictable, with periods of illness (called *flares*) alternating with remissions. The disease occurs nine times more often in women than in men, especially between the ages of 15 and 50, and is more common in those of non-European descent.

SLE is treatable through addressing its symptoms, mainly with corticosteroids and immunosuppressants; there is currently no cure. SLE can be fatal, although with recent medical advances, fatalities are becoming increasingly rare. Survival for people with SLE in the United States, Canada, and Europe is approximately 95% at five years, 90% at 10 years, and 78% at 20 years.

T

T cells : Belong to a group of white blood cells known as lymphocytes, and play a central role in cell-mediated immunity. They can be distinguished from other lymphocyte types, such as B cells and natural killer cells by the presence of a special receptor on their cell surface called *T cell receptors* (TCR). The abbreviation *T*, in *T cell*, stands for thymus, since this is the principal organ responsible for the T cell's maturation. Several different subsets of T cells have been discovered, each with a distinct function.

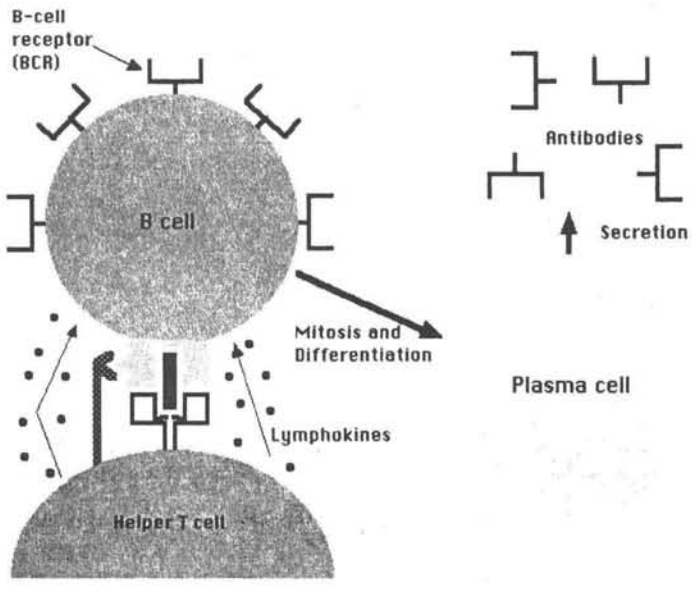
All T cells originate from hematopoietic stem cells in the bone marrow. Hematopoietic progenitors derived from hematopoietic stem cells populate the thymus and expand by cell division to generate a large population of immature thymocytes. The earliest thymocytes express neither CD4 nor CD8, and are therefore classed as *double-negative* ($CD4^-CD8^-$) cells. As they progress through their development they become *double-positive* thymocytes (CD4+CD8+), and finally mature to *single-positive* ($CD4^+CD8^-$ or $CD4^-CD8^+$) thymocytes that are then released from the thymus to peripheral tissues.

About 98% of thymocytes die during the development processes in the thymus by failing either positive selection or negative selection, whereas the other 2% survive and leave the thymus to become mature immunocompetent T cells.

The thymus contributes more naive T cells at younger ages. As the thymus shrinks by about 3% a year throughout middle age, there is a corresponding fall in the thymic production of naive T cells, leaving peripheral T cell expansion to play a greater role in protecting older subjects.

T helper cells : These are a sub-group of lymphocytes that play an important role in establishing and maximizing the capabilities of the immune system. These cells are unusual in that they have no cytotoxic or phagocytic activity; they cannot kill infected host (also known as somatic) cells or pathogens, and without other immune cells they would usually be considered useless against an infection. Th cells are involved in activating and directing other immune cells, and are

particularly important in the immune system. They are essential in determining B cell antibody class switching, in the activation and growth of cytotoxic T cells, and in maximizing bactericidal activity of phagocytes such as macrophages. It is this diversity in function and their role in influencing other cells that gives T helper cells their name.



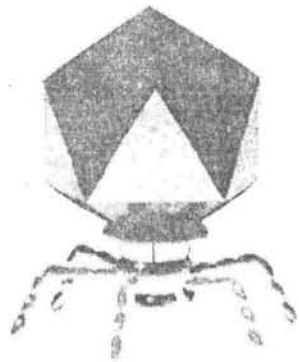
T helper cells

Mature Th cells are believed to always express the surface protein CD4. T cells expressing CD4 are also known as $CD4^+$ T cells. $CD4^+$ T cells are generally treated as having a pre-defined role as helper T cells within the immune system, although there are known rare exceptions. For example, there are sub-groups of regulatory T cells, natural killer T cells, and cytotoxic T cells that are known to express CD4 (although cytotoxic examples have been observed in extremely low numbers in specific disease states, they are usually considered non-existent). All of the latter $CD4^+$ T cell groups are not considered T helper cells, and are beyond the scope of this article.

The importance of helper T cells can be seen from HIV, a virus that infects cells that are $CD4^+$ (including helper T cells). Towards the end of an HIV infection the number of functional $CD4^+$ T cells falls, which leads to the symptomatic stage of infection known as the acquired immune deficiency syndrome (AIDS). There are

also some rare disorders that result in the absence or dysfunction of $CD4^+$ T cells. These disorders produce similar symptoms, and many of these are fatal.

T7 phage : Bacteriophage T7 is a phage capable of infecting susceptible bacterial cells. It infects most strains of *Escherichia coli* (including *E. coli O157 :H7*, a strain of *E. coli* which can cause foodborne illness).



T7 phage

The virus is said to have complex structural symmetry, with a capsid of the phage that is spherical with an inner diameter of 55 nm and a tail 19 nm in diameter and 28.5 nm long attached to the capsid. The head of the phage particle contains the roughly 40 kbp dsDNA genome of T7.

T7 has been used as a model in synthetic biology. Chan *et al.* (2005) "refactored" the genome of T7, replacing approximately 12 kbp of its genome with engineered DNA. The engineered DNA was designed to be easier to work with in a number of ways : individual functional elements were separated by restriction endonuclease sites for simple modification, and overlapping protein coding domains were separated and, where necessary, modified by single base pair silent mutations.

Taq polymerase : Is a thermostable DNA polymerase named after the thermophilic bacterium *Thermus aquaticus* from which it was originally isolated by Thomas D. Brock in 1965. It is often abbreviated to "Taq Pol" (or simply "Taq"), and is frequently used in polymerase chain reaction (PCR), methods for greatly amplifying short segments of DNA.

T. aquaticus is a bacterium that lives in hot springs and hydrothermal vents, and Taq polymerase was identified as an enzyme able to withstand the protein-

denaturing conditions (high temperature) required during PCR. Therefore it replaced the DNA polymerase from E.coli originally used in PCR . Taq's optimum temperature for activity is 75-80°C, with a halflife of 9 minutes at 97.5°C, and can replicate a 1000 base pair strand of DNA in less than 10 seconds at 72°C.

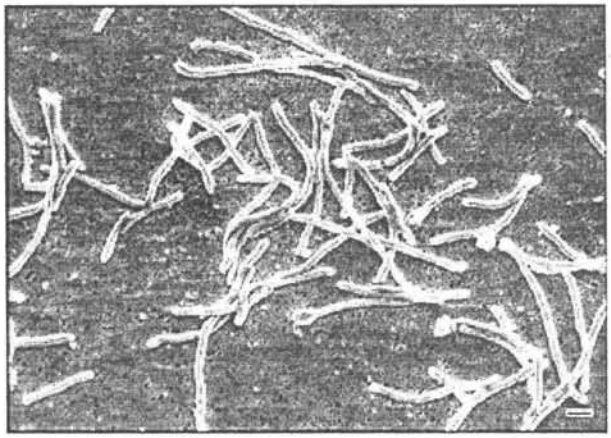
One of Taq's drawbacks is its relatively low replication fidelity. It lacks a 3' to 5' exonuclease proofreading activity, and has an error rate measured at about 1 in 9,000 nucleotides. Some thermostable DNA polymerases have been isolated from other thermophilic bacteria and archaea, such as Pfu DNA polymerase, possessing a proofreading activity, and are being used instead of (or in combination with) Taq for high-fidelity amplification.

Taq makes DNA products that have A (Adenine) overhangs at their 3' ends. This may be useful in TA Cloning, whereby a cloning vector (such as a plasmid) is used which has a T (Thymine) 3' overhang, which complements with the A overhang of the PCR product, thus enabling ligation of the PCR product into the plasmid vector.

Taura syndrome : Is one of the more devastating diseases affecting the shrimp farming industry worldwide. Taura syndrome was first described in Ecuador during the summer of 1992. In March 1993, it returned as a major epidemic and was the object of extensive media coverage. Retrospective studies have suggested that a case of Taura syndrome might have occurred on a shrimp farm in Colombia as early as 1990 and that the virus was already present in Ecuador in mid-1991. Between 1992 and 1997 the disease spread to all major regions of the Americas where *Penaeus vannamei* is cultured. It is estimated that the economic impact of TS in the Americas during that period might have exceeded 2 billion US dollars.

Tectiviridae : Is classified as a class 1 virus under the Boltimore classification scheme.This family of viruses infects Gram-negative bacteria carrying drug resistance plasmids e.g. enterobacteria phage PRD1.*Tectiviridae* have no head-tail structure, but are capable of producing tail-like tubes of ~ 60 x 10 nm upon adsorption or after chloroform treatment. This family of viruses consist of capsids that have apical spikes extending ~20 nm and an unusual internal lipid envelope around the nucleoprotein. The capsid is nonenveloped and has a diameter of 63 nm icosahedron structure. The capsid shells are composed of two layers, inner and outer capsid. The inner capsid shell consist of a 5-6 nm flexible shell made from a lipoprotein vesicle whereas the outer capsid is made up of a smooth, rigid 3 nm thin protein shell. The genome forms a tightly packed coil and the viral genome encodes structural proteins. The virion Mr is ~ 66 x 106 and constitutes 14-15 % of the virion by weight and 15% lipids by weight. This family of viruses have a single molecule of linear double stranded DNA of 150, 000 nucleotide long and the genome is unsegmented. Carbohydrates not detected and no information on antigenic properties.

Thermus aquaticus : Is a species of bacterium that can tolerate high temperatures, one of several thermophilic bacteria that belong to the Deinococcus-Thermus group. It is the source of the heat-resistant enzyme Taq DNA Polymerase, one of the most important enzymes in molecular biology because of its use in the polymerase chain reaction.



Thermus aquaticus

When studies of biological organisms in hot springs began in the 1960s, scientists thought that the life of thermophilic bacteria could not be sustained in temperatures above about 55° Celsius (131° Fahrenheit). Soon, however, it was discovered that many bacteria in different springs not only survived but also thrived in higher temperatures. In 1969, Thomas D. Brock and Hudson Freeze of Indiana University reported a new species of thermophilic bacterium which they named *Thermus aquaticus*. The bacterium was first discovered in the Great Fountain region of Yellowstone National Park, and has since been found in similar thermal habitats around the world.

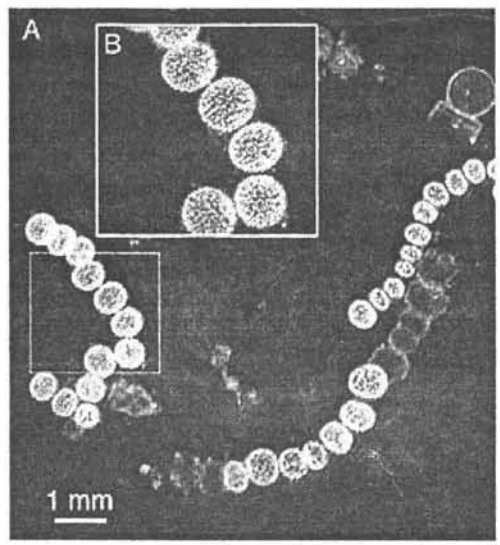
It thrives at 70°C (160°F), but can survive at temperatures of 50°C to 80°C (120°F to 175°F). This bacterium is a chemotroph—it performs chemosynthesis in order to obtain food. However, since its range of temperature overlaps somewhat with that of the photosynthetic cyanobacteria that share its ideal environment, it is sometimes found living in conjuncture with its neighbors, obtaining energy for growth from their photosynthesis.

Thienamycin : One of the most potent naturally-produced antibiotics known thus far, was discovered in *Streptomyces cattleya* in 1976. Thienamycin has excellent activity against both Gram-positive and Gram-negative bacteria and is resistant to bacterial ß-lactamase enzymes. Thienamycin is a zwitterion at pH 7. In 1976, fermentation

broths obtained from the soil bacteria *Streptomyces cattleya* were found to be active in screens for inhibitors of peptidoglycan biosynthesis. Initial attempts to isolate the active species proved difficult due to the chemical instability of that component. After many attempts and extensive purification, the material was finally isolated in >90% purity, allowing for the structural elucidation of thienamycin in 1979.

Thienamycin was the first among the naturally-occurring class of carbapenem antibiotics to be discovered and isolated. Carbapenems are similar in structure to their antibiotic "cousins" the penicillins. Like penicillins, carbapenems contain a ß-lactam ring (cyclic amide) fused to a five-membered ring. Carbapenems differ in structure from penicillins in that within the five-membered ring a sulfur is replaced by a carbon atom (C1) and an unsaturation is present between C2 and C3 in the five-membered ring.

Thiomargarita namibiensis : *Thiomargarita namibiensis* is a gram-negative coccoid Proteobacterium, found in the ocean sediments of the continental shelf of Namibia. It is the largest bacterium ever discovered, generally 0.1—0.3 mm (100—300 μm) wide, but sometimes up to 0.75 mm (750 μm).



Thiomargarita namibiensis

The species was discovered by Heide N. Schulz and others in 1999, in the coastal sediments of Walvis Bay (Namibia). In 2005, a closely related strain was discovered in the Gulf of Mexico. There are no other species in the genus *Thiomargarita*.

The bacterium is chemolithotrophic, and is capable of using nitrate as the terminal electron acceptor in the electron transport chain. The organism will oxidize hydrogen sulfide (H_2S) into elemental sulfur (S). This is deposited as granules in its cytoplasm and is highly refractile and opalescent, making the organism look like a pearl.

While the sulfide is available in the surrounding sediment, produced by other bacteria from dead microalgae that sank down to the sea bottom, the nitrate comes from the water above. Since the bacterium is sessile, and the concentration of available nitrate fluctuates considerably over time, it stores nitrate at high concentration (up to 800 millimolar) in a large vacuole, which is responsible for some 80% of its size. When nitrate concentrations in the environment are low, the bacteria use the contents of the vacuole for respiration. Recent research has also indicated that the bacteria may be facultatively anaerobic rather than obligately anaerobic, and thus capable of respiring with oxygen if it is plentiful.

Three-domain system : The three-domain system is a biological classification introduced by Carl Woese in 1990 that divides cellular life forms into archaea, bacteria, and eukaryote domains. In particular, it emphasizes the separation of prokaryotes into two groups, originally called *Eubacteria* and *Archaebacteria*. Woese argued that, on the basis of differences in 16S rRNA genes, these two groups and the eukaryotes each arose separately from an ancestor with poorly developed genetic machinery, often called a progenote. To reflect these primary lines of descent, he treated each as a domain, divided into several different kingdoms.

Each of the three cell types tends to fit into recurring specialties or roles. Bacteria tend to be the most prolific reproducers, at least in moderate environments. Archaeans tend to adapt quickly to extreme environments, such as high temperatures, high acids, high sulfur, etc. This includes adapting to use a wide variety of food sources. Eukaryotes are the most flexible with regard to forming cooperative colonies, such as in multi-cellular organisms, including humans. In fact, the structure of a Eukaryote is likely to have derived from a joining of different cell types, forming organelles.

Tissue culture : Is the growth of tissues and/or cells separate from the organism. This is typically facilitated via use of a liquid, semi-solid, or solid growth media, such as broth or agar. Tissue culture commonly refers to the culture of animal cells and tissues, while the more specific term plant tissue culture is used for plants.

In 1885 Wilhelm Roux removed a portion of the medullary plate of an embryonic chicken and maintained it in a warm saline solution for several days, establishing the basic principle of tissue culture.

In 1907 the zoologist Ross Granville Harrison demonstrated the growth of frog nerve cell processes in a medium of clotted lymph.

In modern usage, "tissue culture" generally refers to the growth of eukaryotic cells *in vitro*. It is often used interchangeably with *cell culture* to specifically describe the *in vitro* culturing of sperm donor cells. However, "tissue culture" can also be used to refer to the culturing of tissue pieces, i.e. explant culture or whole organs, i.e. organ culture. It is a tool for the study of animal cell biology in vitro model of cell growth to allow a highly selective environment which is easily manipulated (used to optimize cell signaling pathways).

Tobacco mosaic virus (TMV) : Is an RNA virus that infects plants, especially tobacco and other members of the family Solanaceae. The infection causes characteristic patterns (mottling and discoloration) on the leaves (thence the name). TMV was the first virus to be discovered. Although it was known from the late 19th century that an infectious disease was damaging tobacco crops, it was not until 1930 that the infectious agent was determined to be a virus.

Tobacco mosaic virus

Tobacco mosaic virus has a rod-like appearance. Its capsid is made from 2130 molecules of coat protein and one molecule of genomic RNA 6400 bases long. The coat protein self-assembles into the rod like helical structure (16.3 proteins per helix turn) around the RNA which forms a hairpin loop structure. The protein monomer consists of 158 amino acids which are assembled into four main alpha-helices, which are joined by a prominent loop proximal to the axis of the virion. Virions are ~300 nm in length and ~18 nm in diameter. Negatively stained electron microphotographs show a distinct inner channel of ~4 nm. The RNA is located at a radius of ~6 nm and is protected from the action of cellular enzymes by the coat protein. There are three RNA nucleotides per protein monomer. TMV is a thermostable virus. On a dried leaf, it can withstand up to 120 degrees Fahrenheit (50°C) for 30 minutes.

Toxoplasmosis : Is a parasitic disease caused by the protozoan *Toxoplasma gondii*. The parasite infects most genera of warm-blooded animals, including humans, but the primary host is the felid (cat) family. Animals are infected by eating infected meat, by ingestion of feces of a cat that has itself recently been infected, or by transmission from mother to fetus. Cats have been shown as a major reservoir of this infection.

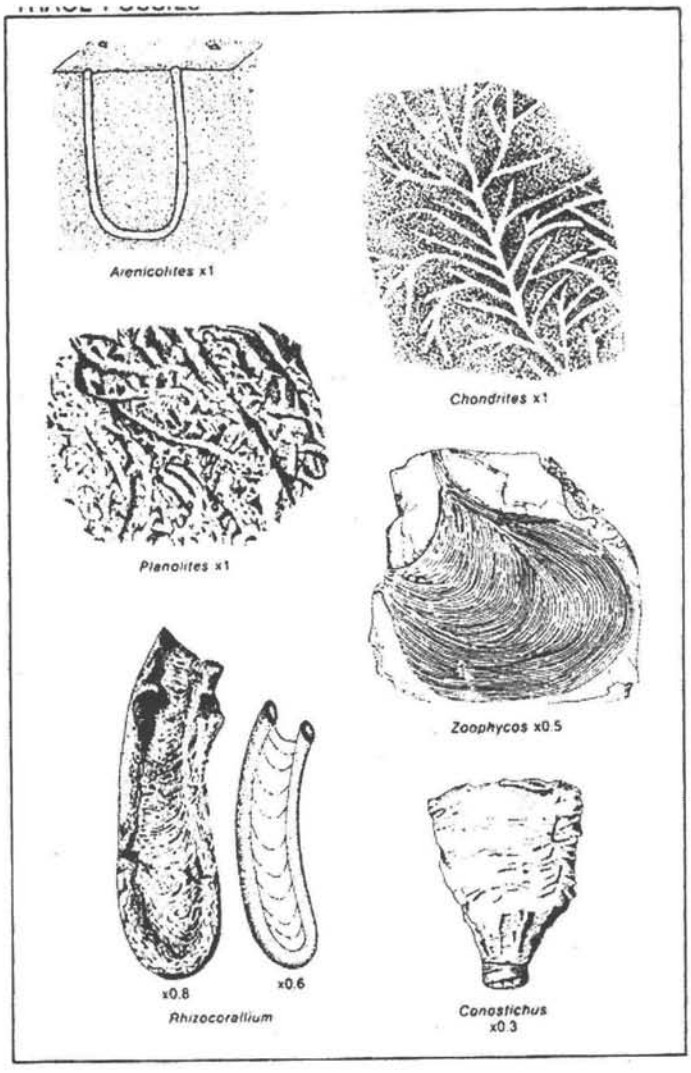
Up to one third of the world's population is estimated to carry a Toxoplasma infection. The Centers for Disease Control and Prevention notes that overall seroprevalence in the United States as determined with specimens collected by the National Health and Nutritional Assessment Survey (NHANES) between 1999 and 2004 was found to be 10.8%, with seroprevalence among women of childbearing age (15 to 44 years) of 11%.

During the first few weeks, the infection typically causes a mild flu-like illness or no illness. After the first few weeks of infection have passed, the parasite rarely causes any symptoms in otherwise healthy adults. However, people with a weakened immune system, such as those infected with HIV or pregnant, may become seriously ill, and it can occasionally be fatal. The parasite can cause encephalitis (inflammation of the brain) and neurologic diseases and can affect the heart, liver, and eyes (chorioretinitis).

Trace fossils : Also called ichnofossils, are geological records of biological activity. Trace fossils may be impressions made on the substrate by an organism : for example, burrows, borings (bioerosion), footprints and feeding marks, and root cavities. The term in its broadest sense also includes the remains of other organic material produced by an organism—for example coprolites (fossilized droppings) or chemical markers—or sedimentological structures produced by biological means—for example, stromatolites. Trace fossils contrast with body fossils, which are the fossilised remains of parts of organisms' bodies, usually altered by later chemical activity or mineralisation.

Sedimentary structures, for example those produced by empty shells rolling along the sea floor, are not produced through the behaviour of an organism and not considered trace fossils.

The study of traces is called ichnology, which is divided into *paleoichnology*, or the study of trace fossils, and *neoichnology*, the study of modern traces. This science is challenging, as most traces reflect the behaviour—not the biological affinity—of their makers. As such, trace fossils are categorised into form genera, based upon their appearance and the implied behaviour of their makers.



Trace fossils

Transduction : Transduction is the process by which DNA is transferred from one bacterium to another by a virus. It also refers to the process whereby foreign DNA is introduced into another cell via a viral vector. This is a common tool used by molecular biologists to stably introduce a foreign gene into a host cell's genome. When bacteriophages (viruses that infect bacteria) infect a bacterial cell, their normal mode of reproduction is to harness the replicational, transcriptional, and translation machinery of the host bacterial cell to make numerous virions, or complete viral particles, including the viral DNA or RNA and the protein coat. Transduction happens through either the lytic cycle or the lysogenic cycle. If the

lysogenic cycle is adopted, the phage chromosome is integrated into the bacterial chromosome, where it can remain dormant for thousands of generations. If the lysogen is induced (by UV light for example), the phage genome is excised from the bacterial chromosome and initiates the lytic cycle, which culminates in lysis of the cell and the release of phage particles. The lytic cycle leads to the production of new phage particles which are released by lysis of the host. However, the packaging of bacteriophage DNA has low fidelity and small pieces of bacterial DNA, together with the bacteriophage genome, may become packaged into the bacteriophage genome. At the same time, some phage genes are left behind in the bacterial chromosome. There are generally two types of recombination events that can lead to this incorporation of bacterial DNA into the viral DNA, leading to two modes of recombination.

Generalised transduction may occur in two main ways, recombination and headful packaging. If bacteriophages undertake the lytic cycle of infection upon entering a bacterium, the virus will take control of the cell's machinery for use in replicating its own viral DNA. If by chance bacterial chromosomal DNA is inserted into the viral capsid used to contain the viral DNA, while this lytic pathway is proceeding, the mistake will lead to *generalized transduction*. If the virus replicates using 'headful packaging', it attempts to fill the nucleocapsid with genetic material. If the viral genome results in spare capacity, viral packaging mechanisms may incorporate bacterial genetic material into the new virion. The new virus capsule now loaded with part bacterial DNA continues to infect another bacterial cell. This bacterial material may become recombined into another bacterium upon infection. Viruses with RNA genomes are not able to package DNA and so do not usually make this mistake. Upon lysis of the host cell, the mispackaged virions containing bacterial DNA can attach to other bacterial cells and inject the DNA they have packaged, thus transferring bacterial DNA from one cell to another. This DNA can become part of the new bacterium's genome and thus be stably inherited. More generally, transduction is the process by which genetic material, e.g. DNA or siRNA, is inserted into a cell. Common techniques in molecular biology are the use of viral vectors (including bacteriophages), electroporation, or chemical reagents that increase cell permeability. Transfection and transformation are more common terms, although these sometimes imply expression of the genetic material as well.

Transformation : Transformation is the genetic alteration of a cell resulting from the uptake, genomic incorporation, and expression of foreign genetic material (DNA). Separate terms are used for genetic alterations resulting from introduction of DNA by viruses ("transduction") or by cell-cell contact between bacteria ("conjugation"). Transformation of eukaryotic cells in tissue culture is usually called transfection. RNA may also be transferred into cells using similar methods, but this does not

normally produce heritable change and so is not true transformation. Genetic material taken in from the environment is added to a part of the bacterial DNA. The DNA may also replace an existing gene or part of it from the genome of the bacteria, thus resulting in loss of the activity of that gene.

Transformation was first demonstrated in 1928 by Frederick Griffith, an English bacteriologist searching for a vaccine against bacterial pneumonia. Griffith discovered that a non-virulent strain of *Streptococcus pneumoniae* could be transformed into a virulent one by exposure to strains of virulent *S. pneumoniae* that had been killed with heat. In 1944 it was demonstrated that the transforming factor was genetic, when Oswald Avery, Colin MacLeod, and Maclyn McCarty showed gene transfer in *S. pneumoniae*. Avery, Macleod and McCarty called the uptake and incorporation of DNA by bacteria "transformation."

Bacteria transformation may be referred to as a stable genetic change brought about by taking up naked DNA (DNA without associated cells or proteins), and competence refers to the state of being able to take up exogenous DNA from the environment. Two different forms of competence should be distinguished : natural and artificial.

Some bacteria (around 1% of all species) are naturally capable of taking up DNA under laboratory conditions; many more may be able to take it up in their natural environments. Such species carry sets of genes specifying the cause of the machinery for bringing DNA across the cell's membrane or membranes. Artificial competence is not encoded in the cell's genes. Instead it is induced by laboratory procedures in which cells are passively made permeable to DNA, using conditions that do not normally occur in nature. Chilling cells in the presence of divalent cations such as Ca^{2+} (in $CaCl_2$) prepares the cell membrane to become permeable to plasmid DNA. Cells are incubated on ice with the DNA and then briefly heat shocked (eg 42°C for 30–120 seconds), which causes the DNA to enter the cell. This method works very well for circular plasmid DNAs. An excellent preparation of competent cells will give ~108 colonies per microgram of plasmid. A poor preparation will be about 104/μg or less. Good non-commercial preps should give 105 to 106 transformants per microgram of plasmid. The method usually does not work well for linear molecules such as fragments of chromosomal DNA, probably because exonuclease enzymes in the cell rapidly degrade linear DNA. However, cells that are naturally competent are usually transformed more efficiently with linear DNA than with plasmids.

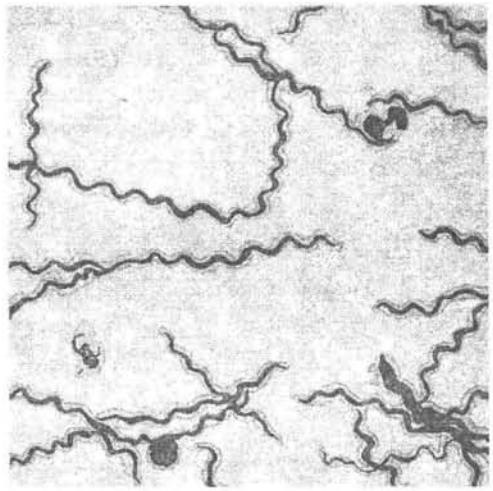
Electroporation is another way to make holes in bacterial (and other) cells, by briefly shocking them with an electric field of 10-20kV/cm. Plasmid DNA can enter the cell through these holes. This method is amenable to use with large plasmid DNA. Natural membrane-repair mechanisms will rapidly close these holes after the shock.

Transmissible spongiform encephalopathies (TSEs) : These are a group of progressive conditions that affect the brain and nervous system of many animals, including humans. According to the most widespread hypothesis they are transmitted by prions, though some other data suggest an involvement of a *Spiroplasma* infection. Mental and physical abilities deteriorate and myriad tiny holes appear in the cortex causing it to appear like a sponge (hence 'spongiform') when brain tissue obtained at autopsy is examined under a microscope. The disorders cause impairment of brain function, including memory changes, personality changes and problems with movement that worsen over time. Prion diseases of humans include classic Creutzfeldt-Jakob disease, new variant Creutzfeldt-Jakob disease (a human disorder related to mad cow disease), Gerstmann-Sträussler-Scheinker syndrome, fatal familial insomnia and kuru. These conditions form a spectrum of diseases with overlapping signs and symptoms.

Unlike other kinds of infectious disease which are spread by microbes, the infectious agent in TSEs is a specific protein called prion protein. Misshaped prion proteins carry the disease between individuals and cause deterioration of the brain. TSEs are unique diseases in that their aetiology may be genetic, sporadic or infectious via ingestion of infected foodstuffs and via iatrogenic means (e.g. blood transfusion). Most TSEs are sporadic and occur in an animal with no prion protein mutation. Inherited TSE occurs in animals carrying a rare mutant prion allele, which expresses prion proteins that contort by themselves into the disease-causing conformation. Transmission occurs when healthy animals consume tainted tissues from others with the disease. In recent times a type of TSE called bovine spongiform encephalopathy (BSE) spread in cattle in an epidemic fashion. This occurred because cattle were fed the processed remains of other cattle, a practice now banned in many countries. The epidemic could have begun with just one cow with sporadic disease. Prions cannot be transmitted through the air or through touching or most other forms of casual contact. However, they may be transmitted through contact with infected tissue, body fluids, or contaminated medical instruments. Normal sterilization procedures such as boiling or irradiating materials fail to render prions non-infective.

Treponema denticola : Is a motile and highly proteolytic bacterium. The Gram-negative oral spirochete is associated with the incidence and severity of human periodontal disease. *Treponema denticola* levels in the mouth are elevated in patients with periodontal diseases and the species is considered one of the main etiological agents of periodontitis. *T. denticola* dwells in a complex and diverse microbial community in the oral cavity and is highly specialized to survive in this environment. *T. denticola* is related to the syphilis-causing obligate human pathogen, *Treponema pallidum* subsp. *pallidum*. Periodontal disease is an infection and inflammation of the gingiva resulting in destruction of the surrounding tissues and alveolar bone.

It occurs in 15% of adults at some time in their lives and can lead to bleeding on brushing, halitosis, tooth mobility and loss. Severe forms include aggressive periodontitis and necrotizing periodontitis which can cause rapid bone resorption and tooth loss along with ulceration of the gingiva and considerable pain.

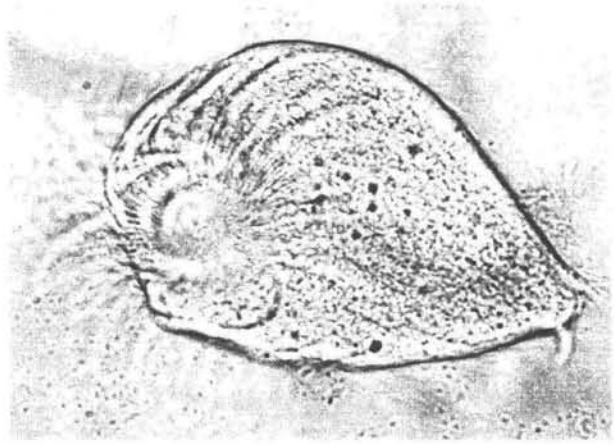


Treponema denticola

Treatment involves removal of plaque and calculus on the root surfaces by scaling and root planing using various periodontal currettes. If the periodontal disease does not resolve, given at least 8–12 weeks for healing, the area is retreated. Periodontal surgery to raise a flap and root plane the affected teeth may be undertaken along with antibiotic therapy (systemic or local).

Trichonympha : Is a genus of parabasalian protists that live in the intestines of many, if not most, termite species. They are important symbiotes, in that they break down the cellulose in the wood and plant fibers their hosts eat. *Trichonympha* resembles teardrops or pears that are wearing wigs. They are extremely motile, and feed by engulfing wood and plant fibers through phagocytosis, which always occurs at the broad ends of their bodies. As beguiling as a relationship between a wood-eating insect (xylophagus) and its wood-digesting symbiote may seem, further investigations of *Trichonympha* reveals even more mind-boggling situations.

By itself, *Trichonympha* lacks the ability to produce cellulase, it requires bacterial endosymbiotes to produce the cellulase to digest its food. It also has spirochete ectosymbiotes embedded in its cell membrane, together with its flagella these symbiotes give their host its characteristic "wiggy" appearance to grant it motility.



Trichonympha

The relationship with the spirochetes is particularly intriguing, as researchers are unsure whether the spirochetes move their host around, in the manner a group of excited dogs drag around their dog-walker, or if *Trichonympha* "commands" them to move it around, much like a charioteer controls the horses of his chariot.

Tropical ulcer : Is a lesion occurring in cutaneous leishmaniasis It is caused by a variety of microorganisms, including mycobacteria. It is common in Nigeria.Ulcers occur on exposed parts of the body, primarily on anterolateral aspect of the lower limbs and may erode muscles and tendons, and sometimes, the bones. These lesions may frequently develop on preexisting abrasions or sores sometimes beginning from a mere scratch.

The vast majority of the tropical ulcers occur below the knee, usually around the ankle. They are often initiated by minor trauma, and subjects with poor nutrition are at higher risk. Once developed, the ulcer may become chronic and stable, but also it can run a destructive course with deep tissue invasion, osteitis, and risk of amputation. Unlike Buruli ulcer, tropical ulcers are very painful. Lesions begin with inflammatory papules that progress into vesicles and rupture with the formation of an ulcer.

Tuberculosis : Tuberculosis (abbreviated as TB for *tubercle bacillus* or Tuberculosis) is a common and often deadly infectious disease caused by mycobacteria, in humans mainly *Mycobacterium tuberculosis* . Tuberculosis usually attacks the lungs (as pulmonary TB) but can also affect the central nervous system, the lymphatic system, the circulatory system, the genitourinary system, the gastrointestinal system, bones, joints, and even the skin. Other mycobacteria such as

Mycobacterium bovis, *Mycobacterium africanum*, *Mycobacterium canetti*, and *Mycobacterium microti* also cause tuberculosis, but these species are less common in humans.The classic symptoms of tuberculosis are a chronic cough with blood-tinged sputum, fever, night sweats, and weight loss. Infection of other organs causes a wide range of symptoms. The diagnosis relies on radiology (commonly chest X-rays), a tuberculin skin test, blood tests, as well as microscopic examination and microbiological culture of bodily fluids. Tuberculosis treatment is difficult and requires long courses of multiple antibiotics. Contacts are also screened and treated if necessary. Antibiotic resistance is a growing problem in (extensively) multi-drug-resistant tuberculosis. Prevention relies on screening programs and vaccination, usually with Bacillus Calmette-Guérin (BCG vaccine).

Tuberculosis is spread through the air, when people who have the disease cough, sneeze, or spit. One–third of the world's current population has been infected with *M. tuberculosis*, and new infections occur at a rate of one per second. However, most of these cases will not develop the full-blown disease; asymptomatic, latent infection is most common. About one in ten of these latent infections will eventually progress to active disease, which, if left untreated, kills more than half of its victims. The proportion of people in the general population who become sick with tuberculosis each year is stable or falling worldwide but, because of population growth, the absolute number of new cases is still increasing. In 2004, mortality and morbidity statistics included 14.6 million chronic active cases, 8.9 million new cases, and 1.6 million deaths, mostly in developing countries. In addition, a rising number of people in the developed world are contracting tuberculosis because their immune systems are compromised by immunosuppressive drugs, substance abuse, or AIDS. The distribution of tuberculosis is not uniform across the globe with about 80% of the population in many Asian and African countries testing positive in tuberculin tests, while only 5-10% of the US population test positive. It is estimated that the US has 25,000 new cases of tuberculosis each year, 40% of which occur in immigrants from countries where tuberculosis is endemic.

Tumor : Is the name for a swelling or lesion formed by an abnormal growth of cells (termed *neoplastic*). *Tumor* is not synonymous with cancer. A tumor can be benign, pre-malignant or malignant, whereas cancer is by definition malignant.

The term tumor is derived, via the Old French *tumour*, from the Latin *tumor* "swelling". It originally meant an abnormal swelling of the flesh. In contemporary English, tumor is synonymous with solid neoplasm, all other forms of swelling being called swelling. This usage is common also in medical literature, where the nouns tumefaction and tumescence, derived from the adjective tumefied, are the current medical terms for non-neoplastic swelling.

A neoplasm is an abnormal proliferation of tissues, usually caused by genetic mutations. Most neoplasms cause a tumor, with a few exceptions like leukemia or carcinoma in situ. Tumors may be benign, pre-malignant or malignant. The nature of the tumor is determined by a pathologist after examination of the tumor tissues from a [biopsy] or a surgical excision specimen.

Turbidostat : Is a continuous culture device, similar to a chemostat or an auxostat, which has feedback between the turbidity of the culture vessel and the dilution rate. The theoretical relationship between growth in a chemostat and growth in a turbidostat is somewhat complex, in part because it is similar. A chemostat technically has a fixed volume and flow rate—thus a fixed dilution rate. When the cells are uniform and at equilibrium, operation of a chemostat and turbidostat should be identical. It is only when classical chemostat assumptions are violated (for instance, out of equilibrium; or the cells are mutating) that a turbidostat is functionally different. One case may be while cells are growing at their maximum growth rate, in which case it is difficult to set a chemostat to the appropriate constant dilution rate .While most turbidostats use a spectrophotometer/ turbidometer to measure the optical density for control purposes, there exist other options, such as electrical conductivity .

Tyndallization : Is an old process for sterilizing food.A simple, effective, modern sterilizing method is to heat the thing being sterilized to 121° C for 15 minutes in a pressure cooker. If a pressure cooker is unavailable and sterilization proceeds instead using unpressurized heating to 100° C, the heat will kill the bacterial cells but the viability of bacterial spores may survive. In this latter case the Tyndallization process can be used to destroy the spores. The process is named after its inventor, the 19th century scientist John Tyndall. It essentially consists of boiling the thing for 15 minutes for three days in a row. On the second day most of the spores that survived the first day will have germinated into bacterial cells, which will be killed by the second day's heating. The third day kills bacterial cells from late-germinating spores. During the waiting periods over the three days the temperature is kept near 37° C, a temperature that is conducive to germination. Germination also requires a moist environment. When the environment is conducive to the formation of cells from spores, the formation of spores from cells does not occur. Although the Tyndallization process is generally effective it is not considered 100% reliable. It is not often used today, but has application in sterilizing some things that cannot withstand pressurized heating.

Typhoid fever : Also known as enteric fever,Salmonella Typhi or commonly just typhoid, is an illness caused by the bacterium *Salmonella enterica* serovar Typhi. Common worldwide, it is transmitted by the ingestion of food or water contaminated with feces from an infected person. The bacteria then perforate

through the intestinal wall and are phagocytosed by macrophages. Salmonella Typhi then alters its structure to resist destruction and allow them to exist within the macrophage. This renders them resistant to damage by PMN's, complement and the immune response. The organism is then spread via the lymphatics while inside the macrophages. This gives them access to the reticuloendothelial system and then to the different organs throughout the body. The organism is a Gram-negative short bacillus that is motile due to its peritrichous flagella. The bacteria grows best at 37°C/99°F—human body temperature.

U

Ultra-heat treatment (UHT) : Is the partial sterilization of food by heating it for a short time, around 1–2 seconds, at a temperature exceeding 135°C (275°F), which is the temperature required to kill spores in milk. The high temperature also reduces the processing time, thereby reducing the spoiling of nutrients. The most common UHT product is milk, but the process is also used for fruit juices, cream, yogurt, wine, soups, and stews.UHT milk was invented in the 1960s, and became generally available for consumption in 1970s.

High heat during the UHT process can cause Maillard browning and change the taste and smell of dairy products. UHT milk has a typical shelf life of six to nine months, until opened. It can be contrasted with HTST pasteurization (high temperature/short time), in which the milk is heated to 72°C (161.6°F) for at least 15 seconds.

Ultramicrobacteria : These are bacteria that are considerably smaller than normal bacterial cells and are 0.3 to 0.2 micrometres in diameter. This term was first used in 1981, to refer to cocci in seawater that were less than 0.3 μm in diameter. These cells have also been recovered from soil and appeared to be a mixture of Gram-positive and negative species. Many, if not all, these small bacteria are dormant forms of larger cells that allow survival under starvation conditions. In this process cells downregulate their metabolism, stop growing and stabilize their DNA, creating dormant non-growing cells that can remain viable for many years. These starvation forms may be the most common type of ultramicrobacteria in seawater. These small living bacterial cells are distinct from the purported "nanobacteria" or "calcifying nanoparticles", which were proposed to be living organisms that were 0.1 μm in diameter. These structures are now thought to be non-living, and are probably precipitated particles of inorganic material.

Ultraviolet (UV) : UV light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than x-rays, in the range 10 nm to 400 nm, and

energies from 3 eV to 124 eV. It is so named because the spectrum consists of electromagnetic waves with frequencies higher than those that humans identify as the color violet.UV light is found in sunlight and is emitted by electric arcs and specialized lights such as black lights. As an ionizing radiation it can cause chemical reactions, and causes many substances to glow or fluoresce. Most people are aware of the effects of UV through the painful condition of sunburn, but the UV spectrum has many other effects, both beneficial and damaging, on human health.

The discovery of UV radiation was intimately associated with the observation that silver salts darken when exposed to sunlight. In 1801 the German physicist Johann Wilhelm Ritter made the hallmark observation that invisible rays just beyond the violet end of the visible spectrum were especially effective at darkening silver chloride-soaked paper. He called them "de-oxidizing rays" to emphasize their chemical reactivity and to distinguish them from "heat rays" at the other end of the visible spectrum. The simpler term "chemical rays" was adopted shortly thereafter, and it remained popular throughout the 19th century. The terms chemical and heat rays were eventually dropped in favor of ultraviolet and infrared radiation, respectively.

Urinary tract infection (UTI) : Is a bacterial infection that affects any part of the urinary tract. Although urine contains a variety of fluids, salts, and waste products, it usually does not have bacteria in it. When bacteria get into the bladder or kidney and multiply in the urine, they cause a UTI. The most common type of UTI is a bladder infection which is also often called cystitis. Another kind of UTI is a kidney infection, known as pyelonephritis, and is much more serious. Although they cause discomfort, urinary tract infections can usually be quickly and easily treated with a short course of antibiotics.

Most uncomplicated UTIs can be treated with oral antibiotics such as trimethoprim, cephalosporins, nitrofurantoin, or a fluoroquinolone (*e.g.*, ciprofloxacin or levofloxacin). Trimethoprim is one widely used antibiotic for UTIs and is usually taken for seven days. It is often recommended that trimethoprim be taken at night to ensure maximal urinary concentrations to increase its effectiveness. Trimethoprim/sulfamethoxazole was previously internationally used (and continues to be used in the U.S. and Canada); the addition of the sulfonamide gave little additional benefit compared to the trimethoprim component alone. However it is responsible for a high incidence of mild allergic reactions and rare but serious complications. A three-day treatment of trimethoprim/ sulfamethoxazole or ciprofloxacin is usually all that is needed.

V

Vaccine : Is a biological preparation that improves immunity to a particular disease. A vaccine typically contains a small amount of an agent that resembles a microorganism. The agent stimulates the body's immune system to recognize the agent as foreign, destroy it, and "remember" it, so that the immune system can more easily recognize and destroy any of these microorganisms that it later encounters. Vaccines can be prophylactic (e.g. to prevent or ameliorate the effects of a future infection by any natural or "wild" pathogen), or therapeutic (e.g. vaccines against cancer are also being investigated).

The term *vaccine* derives from Edward Jenner's 1796 use of the term *cow pox* (Latin *variolæ vaccinæ,* adapted from the Latin *vaccin-us,* from *vacca* cow), which, when administered to humans, provided them protection against smallpox. Vaccines are dead or inactivated organisms or purified products derived from them. There are several types of vaccines currently in use. These represent different strategies used to try to reduce risk of illness, while retaining the ability to induce a beneficial immune response. Vaccines containing killed microorganisms—these are previously virulent micro-organisms which have been killed with chemicals or heat. Examples are vaccines against flu, cholera, bubonic plague, polio and hepatitis A.

Vaccine trial : Is a clinical trial that aims at establishing the safety and efficacy of a vaccine prior to it being licensed.A basic vaccine trial might involve forming two groups from a random sample of the target population. One group receives the vaccine while the control group receives a placebo, an adjuvant-containing cocktail, or a different vaccine which might be intended to protect against a different pathogen. Data on antibody production and immunity to the disease in question is collected from both groups some time after the administration of the vaccine or placebo, and a statistical test is performed on these two sets of data to determine whether or not there is any statistically significant difference between them. If the vaccine produces no statistically significant results, then it is rejected. Side effects of the vaccine are also noted, and these too contribute to the decision on whether to license it.

Vaccine trials may take months or years to complete, since a sufficient time period must elapse for the subjects to react to the vaccine and develop the required antibodies.

Vaginal flora : The human vaginal region has a higher concentration of bacteria than any other part of the body other than the colon. The bacteria of the vaginal flora were discovered by the German gynecologist Albert Döderlein in 1892. Primarily, these bacteria consist of lactobacilli , and are collectively referred to as the vaginal flora. The amount and type of bacteria present have significant implications for a woman's overall health. These bacteria and the lactic acid they produce, in combination with fluids secreted during sexual arousal, are greatly responsible for the characteristic odor associated with the vaginal area.

A healthy vaginal flora aids in the prevention of yeast infections and other possible problems by occupying the chemical resources otherwise utilized by pathogen organisms. However, harmful bacteria or an imbalance in bacteria can lead to infection. One method of reducing the risk of infection in the local area of the urethra is to urinate immediately after sex. Additionally, exclusive use of sterile contraceptives can assist in prevention of infection.

Vaporized hydrogen peroxide (VHP) : Is a gaseous form of hydrogen peroxide with applications as a low-temperature antimicrobial gas used to decontaminate enclosed and sealed areas such as laboratory workstations, isolation and pass-through rooms, and even aircraft interiors. It is registered by the U.S. Environmental Protection Agency as a *sterilant*, which the EPA defines as "a substance that destroys or eliminates all forms of microbial life in the inanimate environment, including all forms of vegetative bacteria, bacterial spores, fungi, fungal spores, and viruses". As a sterilant, VHP is one of the chemicals approved for decontamination of anthrax spores from contaminated buildings, such as occurred during the 2001 anthrax attacks in the U.S. It has also been shown to be effective in removing exotic animal viruses, such as avian influenza and Newcastle disease from equipment and surfaces.

VHP is produced from a solution of liquid hydrogen peroxide and water, by generators specifically designed for the purpose. These generators initially dehumidify the ambient air, then produce VHP by passing aqueous hydrogen peroxide over a vaporizer, and circulate the vapor at a programmed concentration in the air, typically from 140 ppm to 1400ppm depending on the infectious agent to be cleared. By comparison, a concentration of 75ppm is considered to be "Immediately Dangerous to Life or Health" in humans. After the VHP has circulated in the enclosed space for a pre-defined period of time, it is circulated back through the generator, where it is broken down into water and oxygen by a catalytic converter, until concentrations of VHP fall to safe levels (typically <1

ppm). Alternatively, the VHP is vented to the outside air, in cases where recapturing of the VHP is not needed.

Variola caprina : Is a contagious viral disease caused by the pox virus which affects goats. The virus usually spreads via the respiratory route or sometimes through abraded skin and is most likely to occur in crowded stock. Sources of the virus include Cutaneous lesions, Saliva , Nasal Secretions and Faeces. There are two types of the disease; the Papulo-vesicular form and Nodular form ('stone pox'). The incubation period is usually between 8-13 days but may be as short as 4 days. It is thought the same virus spreads Sheep pox. European sheep breeds are highly susceptible to Sheep Pox. In dried scabs the virus may be present for up to 6 months. In endemic areas morbidity rate 70-90% and Mortalitiy rate 5-10% (but may reach nearly 100% in imported animals). Resistant animals may show only a mild form of the disease, which may be missed as only a few lesions are present, usually around the ears or the tail.

Venenivibrio stagnispumantis strain CP.B2 : Is the first microorganisms isolated from the terrestrial hot spring Champagne Pool (75°C, pH 5.5) in Waiotapu, New Zealand. The cells are motile and slightly curved rods (1.04 to 1.56 μm long and 0.33 to 0.41 μm wide). The novel bacterium is an obligate chemolithotroph capable of utilizing H_2 as electron donor, O_2 as corresponding electron acceptor and CO_2 as carbon source. *Venenivibrio stagnispumantis* gains metabolic energy using the "Knallgas" reaction $H_2 + ½\ O_2 \rightarrow H_2O$. For growth either elemental sulphur (S0) or thiosulfate ($S_2O_3^{2-}$) is required. Growth is observed under thermophilic conditions between 45°C and 75°C (optimum 70°C), under moderate acidophilic conditions between pH 4.8 and 5.8 (optimum pH 5.4) and under microaerophilic conditions between 1.0% and 10.0% (v/v) O_2 (optimum between 4.0% and 8.0% (v/v) O_2).

Phylogenetic analysis based on 16S rDNA sequences indicate that strain CP.B2 belongs to the order *Aquificales* and represents the type strain of a novel species of a new genus within the family *Hydrogenothermaceae*. The 16S rRNA gene sequence for strain $CP.B_2$ is deposited in the GenBank nucleotide sequence database under accession number DQ989208. The G+C content of the genomic DNA is 29.3 mol% which is the lowest G+C content reported for a species of the order *Aquificales*.

Venezuelan equine encephalitis virus : Is a mosquito-borne viral pathogen that causes Venezuelan equine encephalitis or encephalomyelitis (VEE). VEE can affect all equine species, such as horses, donkeys, and zebras. After infection, equines may suddenly die or show progressive central nervous system disorders. Humans also can contract this disease. Healthy adults who become infected by the virus may experience flu-like symptoms, such as high fevers and headaches. People with

weakened immune systems and the young and the elderly can become severely ill or die from this disease.

The virus that causes VEE is transmitted primarily by mosquitoes that bite an infected animal and then bite and feed on another animal or human. The speed with which the disease spreads depends on the subtype of the VEE virus and the density of mosquito populations. Enzootic subtypes of VEE are diseases endemic to certain areas. Generally these serotypes do not spread to other localities. Enzootic subtypes are associated with the rodent-mosquito transmission cycle. These forms of the virus can cause human illness but generally do not affect equine health.

Verrucomicrobia : Is a recently described phylum of bacteria. This phylum contains only a few described species (*Verrucomicrobia spinosum,* is an example, the phylum is named after this). The species identified have been isolated from fresh water and soil environments and human feces. A number of as-yet uncultivated species have been identified in association with eukaryotic hosts including extrusive explosive ectosymbionts of protists and endosymbionts of nematodes residing in their gametes. It is the cause of verucae on the feet and hands.

Evidence suggests that verrucomicrobia are abundant within the environment, and important (especially to soil cultures). This phylum is considered to have two sister phyla: Chlamydiae and Lentisphaerae.

Cavalier-Smith has postulated that the Verrucomicrobia belong in the clade Planctobacteria in the larger clade Gracilicutes. 16S rRNA data corroborate that view. Recently the whole genome of *Methylacidiphilum infernorum* was sequenced (2.3 Mbp). On the single circular chromosome, 2473 predicted proteins were found, 731 of which had no detectable homologs. Many homologies with Proteobacteria became also apparent.

Vesicular stomatitis virus (VSV) : Is a virus in the family Rhabdoviridae; the well-known *Rabies virus* belongs to the same family. VSV can infect insects and mammals. It has particular importance to farmers in certain regions of the world where it can infect cattle. It is also a common laboratory virus used to study the properties of viruses in the Rhabdoviridae family, as well as to study viral evolution.

VSV is an arbovirus : natural VSV infections encompass two steps, cytolytic infections of mammalian hosts and transmission by insects. In insects, infections are non-cytolytic persistent.

Vesicular stomatitis virus (VSV) is the prototypic member of the Vesiculovirus genera of the Rhabdovirus family. The genome of the virus is a single molecule of negative-sense RNA that encodes five major proteins : glycoprotein (G), large protein (L), phosphoprotein, matrix protein (M) and nucleoprotein.

The VSVG protein enables viral entry. It mediates virus attachment to the host cell, where it is endocytosed. It then mediates fusion of the viral envelope with the endosomal membrane. The VSVL protein is encoded by half the genome, and combines with the phosphoprotein to catalyze replication of the mRNA.

The VSVM protein is encoded by an mRNA that is 831 nucleotides long and translates to a 229 amino acid-protein. The predicted M protein sequence does not contain any long hydrophobic or nonpolar domains that might promote membrane association. The protein is rich in basic amino acids and contains a highly basic amino terminal domain.

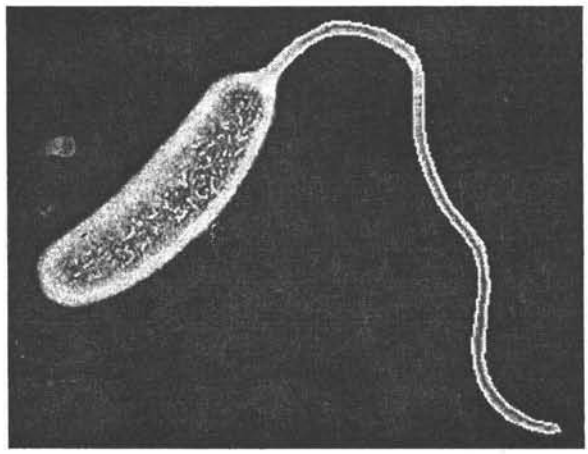
Veterinary pathologists : These are doctors of veterinary medicine who specialise in the diagnosis of diseases through the examination of animal tissue and body fluids. Like for medical pathology, veterinary pathology is divided in two branches, anatomical pathology and clinical pathology. Veterinary pathologists are critical participants in the drug development process.

Anatomical pathology (*Commonwealth*) or *Anatomic pathology* (*U.S.*) is concerned with the diagnosis of disease based on the gross, microscopic, and molecular examination of organs, tissues, and whole bodies (autopsy). The American College of Veterinary Pathologists certifies veterinary pathologists through a certifying exam. This consists of four parts—gross pathology, microscopic pathology, veterinary pathology (a review of the current literature), and general pathology. Only the general pathology section is shared between the anatomic and clinical pathology examinations. Anatomic pathologists are employed in a number of different positions, including diagnostics, teaching, research, and the pharmaceutical industry.

Vibrio cholerae : Is a motile gram negative curved-rod shaped bacterium with a polar flagellum that causes cholera in humans. *V. cholerae* and other species of the genus *Vibrio* belong to the gamma subdivision of the Proteobacteria. There are two major strains of *V. cholerae*, classic and El Tor, and numerous other serogroups.

V. cholerae was first isolated as the cause of cholera by Italian anatomist Filippo Pacini in 1854, but his discovery was not widely known until Robert Koch, working independently thirty years later, publicized the knowledge and the means of fighting the disease. *V. cholerae* occurs naturally in the plankton of fresh, brackish, and salt water, attached primarily to copepods in the zooplankton. Coastal cholera outbreaks typically follow zooplankton blooms. This makes cholera a typical zoonosis

V. cholerae colonizes the gastrointestinal tract, where it adheres to villi. It produces a protease called mucinase and an amylase referred to as chitinase. Chitinase is responsible for the ability of *Vibrio cholerae* to enter copepods. Mucinase is a non-specific protease that assists entry into the human gastro-intestinal tract.



Vibrio cholerae

Vibrio cholerae produces what is called a ZOT, termed as "Zona Occludens Toxin". This toxin specifically attacks the zona occludans or "tight" junctions joining epithelial cells.

Vibriocins : These are a group of bacteriocins produced by, and active against, gram-negative bacteria in the genus *Vibrio*. They were first revealed in 1962, considerably after the original bacteriocins, the colicins, which were discovered in 1925.

Like other bacteriocins, vibriocins are protein toxins. They can kill bacteria beyond the genus Vibrio, including other proteobacteria . They have been used for abortive classification schemes of the vibrio, particularly to type various kinds of cholera, against which they were thought to have potential as antibiotics. Their mode of action, genetics and regulation have all been studied, for at least one example. In all likelihood, however, they are as common and as diverse as the colicins, making it very unlikely that these initial experiments have fully explored the range of mechanisms and forms that the vibriocins take.

In the 1970's, they were investigated, along with some colicins, as potential chemotherapeutic agents. The mode of action appears to be nuclease activity resulting in the induction of apoptosis. The research itself was the result of observing unexpected interactions between the vibriocins and eukaryotic cells.

Viral entry : Is the earliest stage of infection in the viral life cycle, as the virus comes into contact with the host cell and introduces viral material into the cell. The major steps involved in viral entry are shown below. Despite the variation among viruses, the generalities are quite similar. However, the specifics are varied.

A virus floating around an enclosed space with possible host cells faces a large hurdle, the thermodynamics of diffusion. Because neutrally charged objects do not naturally clump around each other, the virus must find a way to move even near a host cell. It does this by attachment—or adsorption—onto a susceptible cell; a cell which holds a receptor that the virus can bind to. The receptors on the viral envelope effectively become connected to complementary receptors on the cell membrane. This attachment causes the two membranes to remain in mutual proximity, favoring further interactions between surface proteins. This is also the first requisite that must be satisfied before a cell can become infected. Satisfaction of this requisite makes the cell susceptible. Viruses that exhibit this behavior include many enveloped viruses such as HIV, Herpes simplex virus or influenza.

This basic idea extends to viruses that do not contain an envelope. Well studied examples are the viruses that infect bacteria, known as bacteriophages or simply phages. They have long tails on which to attach to receptors the bacterial surface.

Viral envelopes : The envelopes are typically derived from portions of the host cell membranes (phospholipids and proteins), but include some viral glycoproteins. Functionally, viral envelopes are used to help viruses enter host cells. Glycoproteins on the surface of the envelope serve to identify and bind to receptor sites on the host's membrane. The viral envelope then fuses with the host's membrane, allowing the capsid and viral genome to enter and infect the host.

Usually, the cell from which the virus itself buds from goes on to survive, and shed more viral particles for an extended period. The lipid bilayer envelope of these viruses is relatively sensitive to desiccation, heat and detergents, and so these viruses are easier to sterilize than non-enveloped viruses—in other words they cannot survive outside host environment and must transfer directly from host to host.

Viral evolution : Is a subfield of evolutionary biology that is specifically concerned with the evolution of viruses. Many viruses, in particular RNA viruses, have short generation times and relatively high mutation rates (on the order of one point mutation or more per genome per round of replication for RNA viruses). This elevated mutation rate, when combined with natural selection, allows viruses to quickly adapt to changes in their host environment.

Viral evolution is an important aspect of the epidemiology of viral diseases such as influenza, HIV, and hepatitis. It also causes problems in the development of successful vaccines and antiviral drugs, as resistant mutations often appear within weeks or months after the beginning of the treatment.

RNA viruses are also used as a model system to study evolution in the laboratory. One of the main theoretical models to study viral evolution is the quasispecies model, as the viral quasispecies.

In evolutionary virology and to an extent in the wider field of pathology, inter-host evolution is considered to represent the geological, i.e. visible or detectable, evolution of a virus while intra-host evolution represents the invisible evolution of a virus. Adaptive changes acquired by inter-host evolution are rarely lost once acquired. Changes acquired by intra-host evolution may be lost if the evolutionary landscape changes, for example : a population of viruses may become resistant to an antiviral drug while the host (patient) takes it, but rapidly revert to wild-type if treatment ceases.

Viral hemorrhagic septicemia (VHS) : Is a deadly infectious fish disease caused by the *Viral hemorrhagic septicemia virus* (VHSV, or VHSv). It afflicts over 50 species of freshwater and marine fish in several parts of the northern hemisphere. VHS is caused by the viral hemorrhagic septicemia virus (VHSV), different strains of which occur in different regions, and affect different species. There are no signs that the disease affects human health. VHS is also known as "Egtved disease," and VHSV as "Egtved virus."

Historically, VHS was associated mostly with freshwater salmonids in western Europe, documented as a pathogenic disease among cultured salmonids since the 1950s. It was first discovered in the US in 1988 among salmon returning from the Pacific in Washington State. This North American genotype was identified as a distinct, more marine-stable strain than the European genotype. VHS has since been found afflicting marine fish in the northeastern Pacific Ocean, the North Sea, and the Baltic Sea. Since 2005, massive die-offs have occurred amongst a wide variety of freshwater species in the Great Lakes region of North America.

Viral plaque : Is a visible structure formed within a cell culture, such as bacterial cultures within some nutrient medium (e.g. agar). The bacteriophage viruses replicate and spread, thus generating regions of cell destructions known as plaques. These plaques can sometimes be detected visually using colony counters, in much the same way as bacterial colonies are counted; however, they are not always visible to the naked eye, and sometimes can only be seen through a microscope, or using techniques such as staining or immunofluorescence. Special computer systems have been designed with the ability to scan samples in batches.

Viral processing : The main idea behind viral processing is to stop the viruses in a given sample from infecting the desired product. The two most widely used methods of viral processing are viral removal and viral inactivation. The former is a method in which all viruses are simply removed from the sample completely. The latter method is one in which the viruses may remain in the final product, but in a non-infective form. These techniques are used widely in the food and blood plasma industries, as those products can be harmed by the presence of viral particles.

Some of the more common viruses removed by these methods are the HIV-1 and HIV-2 viruses; hepatitis A, B, and C; and parvoviruses. The methods used in the plasma industry have been summarized (Horowitz B., Minor P., Morgenthaler J. J., Burnouf T., McIntosh R., Padilla A., Thorpe R. and van Aken W. G. Who Expert Committee on Biological Standardization. World Health Organ Tech Rep Ser. 924 : 1-232, 2004.) In some cases, however, it is the virus *itself* that is the desired product, as is often the case with the HIV. In many cases, researchers may be trying to extract the viruses from the blood for study, not specifically for blood purification. It is also common to use these types of techniques to remove particles produced as a result of viral infection.

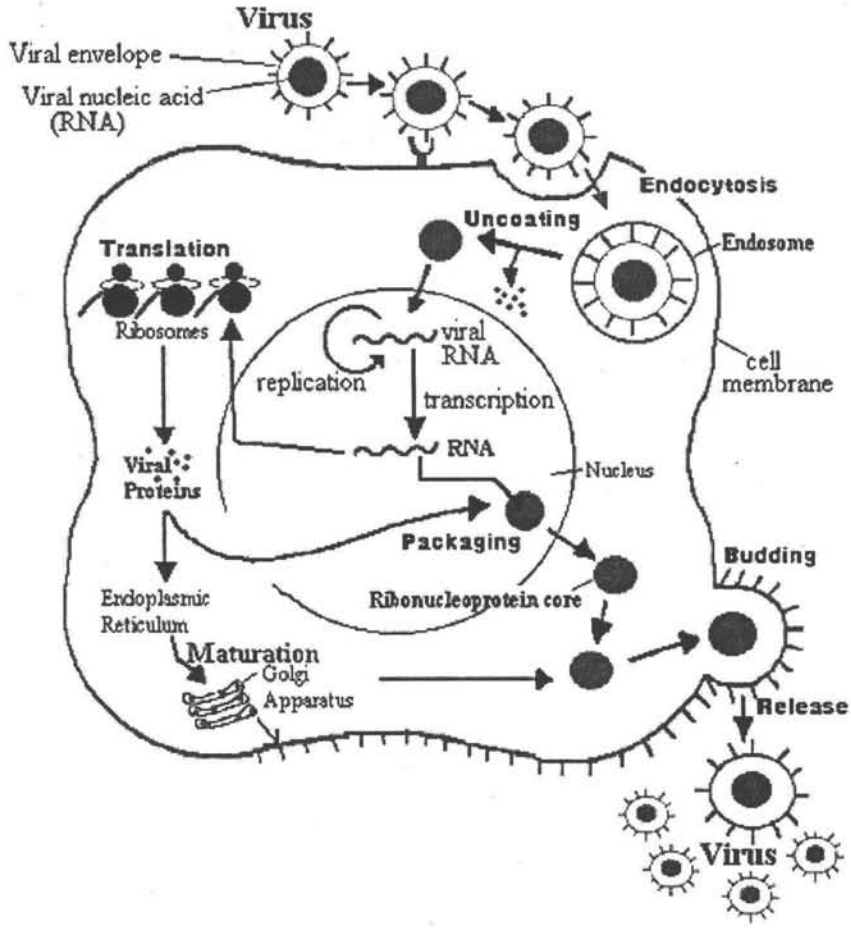
Viral quasispecies : Is a group of viruses related by a similar mutation or mutations, competing within a highly mutagenic environment. The theory predicts that a viral quasispecies at a low but evolutionarily neutral and highly connected (that is, flat) region in the fitness landscape will outcompete a quasispecies located at a higher but narrower fitness peak in which the surrounding mutants are unfit. This phenomenon has been called 'the quasispecies effect' or, more recently, the 'survival of the flattest'.

Originally used by Manfred Eigen to model the evolution of the first macromolecules on earth, the quasispecies concept has been applied to populations of a virus within its host. The quasispecies model is deemed to be relevant to RNA viruses because they have high mutation rates in the order of one per round of replication, and viral populations, while not infinite, are extremely large. Thus the practical conditions for quasispecies formation are thought to exist.

The significance of the quasispecies model for virology is that, if the mutation rate is sufficiently high, selection acts on clouds of mutants rather than individual sequences. Therefore, the evolutionary trajectory of the viral infection cannot be predicted solely from the characteristics of the fittest sequence.

The importance of quasispecies concepts in virology has been the subject of some discussion. Significantly, it has been shown that there is no necessary conflict between a quasispecies model of intra-host evolution and traditional population genetics. Instead, viral quasispecies can be considered as cases of coupled mutation-selection balance models for haploid organisms. It may be useful to understand the etymology of the term. Quasispecies are clouds of related elements that behave almost (quasi) like a single type of molecule (species). There is no suggestion that a viral quasispecies resembles a traditional biological species.

Viral replication : Is the term used by virologists to describe the formation of biological viruses during the infection process in the target host cells. Viruses must first get into the cell before viral replication can occur. From the perspective of the virus, the purpose of viral replication is to allow production and survival of its kind.

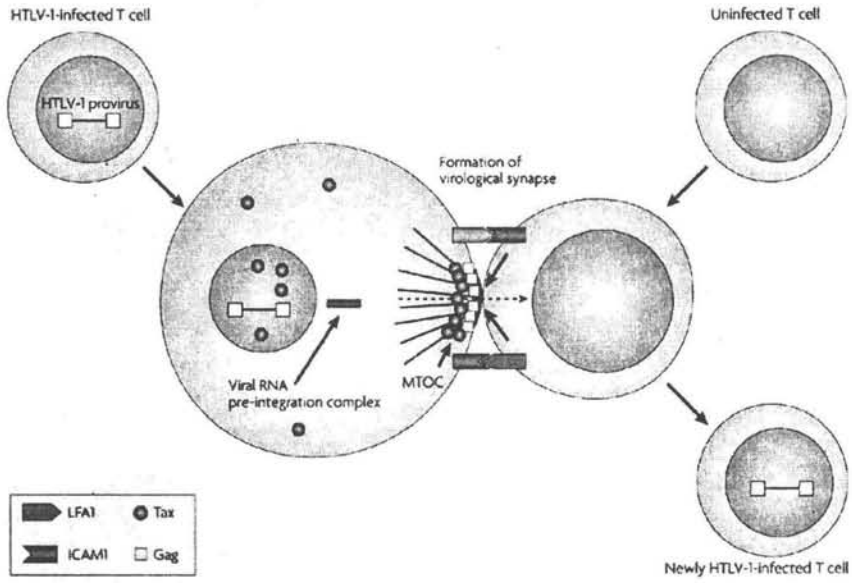


Viral replication

By generating abundant copies of its genome and packaging these copies into viruses, the virus is able to continue infecting new hosts. Replication between viruses is greatly varied and depends on the type of genes involved.

Viral shedding : Refers to the successful reproduction, expulsion, and host-cell infection caused by virus progeny. Once replication has been completed and the host cell is exhausted of all resources in making viral progeny, the viruses may begin to leave the cell by several methods.The term is used to refer to shedding from a single cell, shedding from one part of the body into another part of the body, and shedding from bodies into the environment where the viruses may infect other bodies.

Viral transformation : Most commonly refers to the virus-induced malignant transformation of an animal cell in a body or cell culture. In molecular biology, the term may also refer to the transfection of DNA into a host cell using a viral vector. Viral transformation can impose characteristically determinable features upon a cell. Typical phenotypic changes include : high saturation density, anchorage-independent growth, loss of contact inhibition, loss of orientated growth, immortalisation, disruption of the cell's cytoskeleton.



Viral transformation

Epidemiological studies suggest that malignant transformion of cells by viruses occurs via multiple steps. This involves initiation, promotion and progression events. Viruses act along with other factors to transform cells. The persistence of at least part of the viral genome within the cell is required for cell transformation. This is accompanied by the continual expression from a number of viral genes. These genes interfere with a cell's signaling pathway causing the observed phenotypic changes of the cell. The end result is a transformed cell showing increased cell division, which is favorable to the virus.

Viremia : Is a medical condition where viruses enter the bloodstream and hence have access to the rest of the body. It is similar to *bacteremia*, a condition where bacteria enter the bloodstream.

- Primary viremia refers to the initial spread of virus in the blood from the first site of infection.
- Secondary viremia occurs when primary viremia has resulted in infection of additional tissues via bloodstream, in which the virus has replicated and once more entered the circulation.

Usually secondary viremia results in higher viral shedding and viral loads within the bloodstream due to the possibility that the virus is able to reach its natural host cell from the bloodstream and replicate more efficiently than the initial site. An excellent example to profile this distinction is the rabies virus. Usually the virus will replicate briefly within the first site of say the bite of a rabid dog, within the muscle tissues. Viral replication then leads to viremia and the virus spreads to its secondary site of infection, the CNS. Upon infection of the CNS, secondary viremia results and symptoms usually begin. Vaccination at this point is useless, as the spread to the brain, leading to death, is unstoppable (the only clinical exception is Jeanna Giese). Hence vaccination must be done before secondary viremia takes place for the individual to be saved.

Virkon : Is a brand name for a powerful, multi-purpose disinfectant. The solution is used in many areas, including hospitals, laboratories, nursing homes, funeral homes, medical, dental and veterinary facilities, and anywhere else where control of pathogens is required. It is typically used for cleaning up hazardous spills, disinfecting surfaces and soaking equipment.

Virkon has a remarkable spectrum of activity against viruses, fungi, and bacteria.,It is also effective against SARS surrogate and Avian influenza. For full effectiveness it must be sprayed liberally on a surface and allowed to sit for at least two (and up to ten) minutes before being wiped off. The disinfecting agents and detergents work synergistically to attack pathogens.

Virokine : Is a protein encoded by certain viruses that acts as a competitive inhibitor of a host cytokines. As cytokines act as an essential part of a hosts immune system, virokines are used by viruses for immunomoduation and subverting host immune responses. The word "virokine" was originally coined by Dr. Bernard Moss. It is used to designate viral proteins that interfere with immune response by reducing cytokine levels or effectiveness. They may do so by suppressing cytokine secretion, competing for cytokine receptors, interfering with cytokine signalling pathways, or otherwise antagonizing cytokines of the host organism. Many virokines are similar to host cytokines and may have been acquired by gene transfer from the host and subsequently modified.

Virology : Virology is the study of viruses and virus-like agents : their structure, classification and evolution, their ways to infect and exploit cells for virus reproduction, the diseases they cause, the techniques to isolate and culture them,

and their use in research and therapy. Virology is often considered a part of microbiology or of pathology. A major branch of virology is virus classification. Viruses can be classified according to the host cell they infect : animal viruses, plant viruses, fungal viruses, and bacteriophages (viruses infecting bacteria, which include the most complex viruses). Another classification uses the geometrical shape of their capsid (often a helix or an icosahedron) or the virus's structure (e.g. presence or absence of a lipid envelope). Viruses range in size from about 30 nm to about 450 nm, which means that most of them cannot be seen with light microscopes. The shape and structure of viruses can be studied with electron microscopy, with NMR spectroscopy, and most importantly with X-ray crystallography.

One main motivation for the study of viruses is the fact that they cause many important infectious diseases, among them the common cold, influenza, rabies, measles, many forms of diarrhea, hepatitis, yellow fever, polio, smallpox and AIDS. Herpes simplex causes cold sores and genital herpes and is under investigation as a possible factor in Alzheimer's. Some viruses, known as oncoviruses, contribute to certain forms of cancer; the best studied example is the association between Human papillomavirus and cervical cancer : it is now acknowledged that almost all cases of cervical cancer are caused by certain strains of this sexually transmitted virus. Some subviral particles also cause disease : Kuru and Creutzfeldt-Jakob disease are caused by prions, and hepatitis D is due to a satellite virus.

Virulence : Is the degree of pathogenicity of an organism, or in other words the relative ability of a pathogen to cause disease. The word *virulent*, which is the adjective for virulence, derives from the Latin word *virulentus*, which means "full of poison." From an ecological point of view, virulence can be defined as the host's parasite-induced loss of fitness. Virulence can be understood in terms of proximate causes—those specific traits of the pathogen that help make the host ill—and ultimate causes—the evolutionary pressures that lead to virulent traits occurring in a pathogen strain.

The ability of bacteria to cause disease is described in terms of the number of infecting bacteria, the route of entry into the body, the effects of host defense mechanisms, and intrinsic characteristics of the bacteria called virulence factors. Host-mediated pathogenesis is often important because the host can respond aggressively to infection with the result that host defense mechanisms do damage to host tissues while the infection is being countered.

The virulence factors of bacteria are typically proteins or other molecules that are synthesized by protein enzymes. These proteins are coded for by genes in chromosomal DNA, bacteriophage DNA or plasmids. Bacteria use quorum sensing to synchronise release of the molecules. These are all proximate causes of morbidity in the host.

Virulence factors : These are molecules produced by a pathogen that specifically cause disease, or that influence their host's function to allow the pathogen to thrive. Factors that are used in general life processes, such as metabolism or bacterial cell structural components, may be vital to the pathogen's ability to thrive in the host, but are not considered virulence factors since they lack specific function to directly influence the host.Examples of virulence factors for *Staphylococcus aureus* are hyaluronidase, protease, coagulase, lipases, deoxyribonucleases and enterotoxins

Some examples of virulence factors for *Streptococcus pyogenes* are M protein, lipoteichoic acid, hyaluronic acid capsul, invasins such as streptokinase, streptodornase, hyaluronidase, spenceronic, dorsettonic, and streptolysins, and excotoxins some other virulence factors are adhesion factors, biofilms, extracellular enzymes, toxins and antiphagocytic factors.

Virus : Is a sub-microscopic infectious agent that is unable to grow or reproduce outside a host cell. Viruses infect all types of cellular life. The first known virus, tobacco mosaic virus, was discovered by Martinus Beijerinck in 1898, and now more than 5,000 types of virus have been described in detail, although most types of virus remain undiscovered. Viruses infect all forms of life, are found in almost every ecosystem on Earth, and are the most abundant type of biological entity on the planet. The study of viruses is known as virology, and is a branch of microbiology.

Viruses consist of two or three parts : all viruses have genes made from either DNA or RNA, long molecules that carry genetic information; all have a protein coat that protects these genes; and some have an envelope of fat that surrounds them when they are outside a cell. Viruses vary in shape from simple helical and icosahedral shapes, to more complex structures. They are about 1/100th the size of bacteria. The origins of viruses are unclear : some may have evolved from plasmids—pieces of DNA that can move between cells—others may have evolved from bacteria. In evolution, viruses are an important means of horizontal gene transfer.

Viruses spread in many ways; plant viruses are often transmitted from plant to plant by insects that feed on sap, such as aphids, while animal viruses can be carried by blood-sucking insects. These disease-bearing organisms are known as *vectors*. Influenza viruses are spread by coughing and sneezing, and others such as norovirus, are transmitted by the faecal-oral route, when they contaminate hands, food or water. Rotaviruses are often spread by direct contact with infected children. HIV is one of several viruses that are transmitted through sex.

Not all viruses cause disease, as many viruses reproduce without causing any obvious harm to the infected organism. Some viruses such as hepatitis B can cause life-long or chronic infections, and the viruses continue to replicate in the body despite the hosts' defence mechanisms. However, viral infections in animals usually cause an immune response, which can completely eliminate a virus. These

immune responses can also be produced by vaccines that give lifelong immunity to a viral infection. Microorganisms such as bacteria also have defences against viral infection, such as restriction modification systems. Antibiotics have no effect on viruses, but antiviral drugs have been developed to treat life-threatening and more minor infections.

Virus latency : It is the ability of a pathogenic virus to lie dormant within a cell, denoted as the lysogenic part of the viral life cycle. A latent viral infection is a type of persistent viral infection which is distinguished from a chronic viral infection. A latent infection is a phase in certain viruses' life cycles in which after initial infection, virus production ceases. However, the virus genome is not fully eradicated. The result of this is that the virus can reactivate and begin producing large amounts of viral progeny without the host being infected by new outside virus, denoted as the lytic part of the viral life cycle, and stays within the host indefinitely. Virus latency is not to be confused with clinical latency during the incubation period when a virus is not dormant.

Virus like particles (VLPs) : Consist of viral protein(s) derived from the structural proteins of a virus. In some cases these proteins are embedded within a lipid bilayer. These particles resemble the virus from which they were derived but lack viral nucleic acid, meaning that they are not infectious. VLPs used as vaccines are often very effective at eliciting both T cell and B cell immune responses. The human papillomavirus and Hepatitis B vaccines are the first virus-like particle based vaccines approved by the Food and Drug Administration (FDA).

Many fungi contain mycoviruses that can not be classified as true viruses as they lack the ability to be transmitted in cell free preparations. This essentially means they are non-infectious. However, they are normally associated with a genome often consisting of double stranded RNA. In these instances they too are referred to as virus like particles. They are very important in phytopathology, as they have been shown to cause hypovirulence in some species of phytopathogenic fungi.

New research suggests that VLP vaccines could provide stronger and longer-lasting protection against flu viruses than conventional vaccines. They can be produced without an actual sample of the agent, and grown in several ways, including in cell cultures or in plants. Production can take as little as 12 weeks, compared to 9 months for traditional vaccines. In early clinical trials, VLP vaccines appeared to provide complete protection against both the H5N1 avian influenza virus and the 1918 Spanish influenza virus.

Visna virus : Also known as Visna-Maedi virus, Maedi-Visna virus or ovine lentivirus from the genus lentivirinae and subfamily Orthoretrovirinae, is a "prototype" retrovirus that causes encephalitis and chronic pneumonitis in sheep. It is known as visna when found in the brain, and maedi when infecting the lungs. Life-long,

persistent infections in sheep occur in the lungs, lymph nodes, spleen, joints, central nervous system, and mammary glands; The condition is sometimes known as "ovine progressive pneumonia", particularly in the United States, or "Montana Sheep Disease". White blood cells of the monocyte/macrophage lineage are the main target of Visna virus.

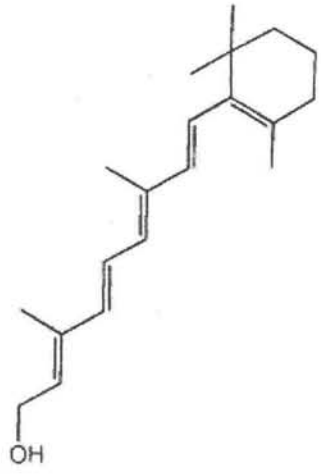
First described in 1954 by Bjorn Sigurdsson in Iceland, Maedi-Visna virus was the first lentivirus to be isolated and characterized, accomplished in 1957 by Sigurdsson. "Maedi", Icelandic for dyspnoea, and "visna", Icelandic for "wasting" or "shrinking" of the spinal cord, refer to endemic sheep herd conditions that were only found to be related after Sigurdsson's work.

Visna infection may progress to total paralysis leading to death via inanition; however, if helped to obtain water and food, animals may survive for long periods of time, sometimes greater than ten years. Viral replication is almost exclusively associated macrophages in infected tissues, however replication is restricted in these cells—the majority of cells containing viral RNA do not produce infectious virus.

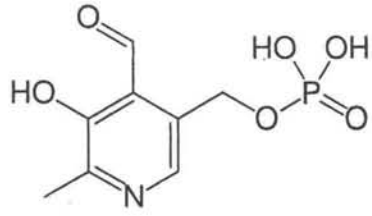
The disease was introduced to Iceland following an import of Karakul sheep from Germany in 1933. The susceptability of Maedi-Visna infection varies across sheep breeds, with coarse-wool breeds apparently more susceptible than fine-wool sheep. Attempts at vaccination against Maedi-Visna virus failed to induce immunity, occasionally causing increased viremia and more severe disease. Eradication programs have been established in countries worldwide.

Vitamin : Is an organic compound required as a nutrient in tiny amounts by an organism. A compound is called a vitamin when it cannot be synthesized in sufficient quantities by an organism, and must be obtained from the diet. Thus, the term is conditional both on the circumstances and the particular organism. For example, ascorbic acid functions as vitamin C for some animals but not others, and vitamins D and K are required in the hur an diet only in certain circumstances. The term *vitamin* does not include other essential nutrients such as dietary minerals, essential fatty acids, or essential amino acids, nor does it encompass the large number of other nutrients that promote health but are otherwise required less often.

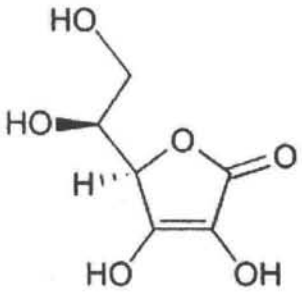
Vitamins are classified by their biological and chemical activity, not their structure. Thus, each "vitamin" may refer to several *vitamer* compounds that all show the biological activity associated with a particular vitamin. Such a set of chemicals are grouped under an alphabetized vitamin "generic descriptor" title, such as "vitamin A," which includes the compounds retinal, retinol, and many carotenoids. Vitamers are often inter-converted in the body.



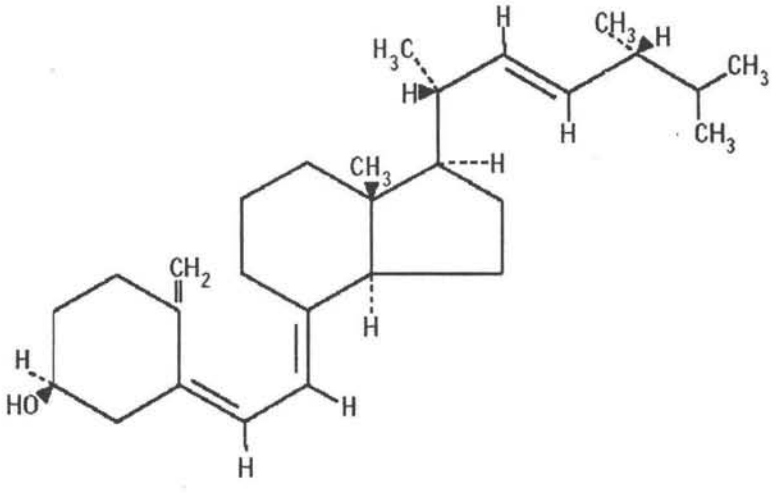
Vitamin A



Vitamin B6



Vitamin C



Vitamin D

Vitamins have diverse biochemical functions, including function as hormones (e.g. vitamin D), antioxidants (e.g. vitamin E), and mediators of cell signaling and regulators of cell and tissue growth and differentiation (e.g. vitamin A). The largest number of vitamins (e.g. B complex vitamins) function as precursors for enzyme

cofactor bio-molecules (coenzymes), that help act as catalysts and substrates in metabolism. When acting as part of a catalyst, vitamins are bound to enzymes and are called prosthetic groups. For example, biotin is part of enzymes involved in making fatty acids. Vitamins also act as coenzymes to carry chemical groups between enzymes. For example, folic acid carries various forms of carbon group—methyl, formyl and methylene—in the cell. Although these roles in assisting enzyme reactions are vitamins' best-known function, the other vitamin functions are equally important.

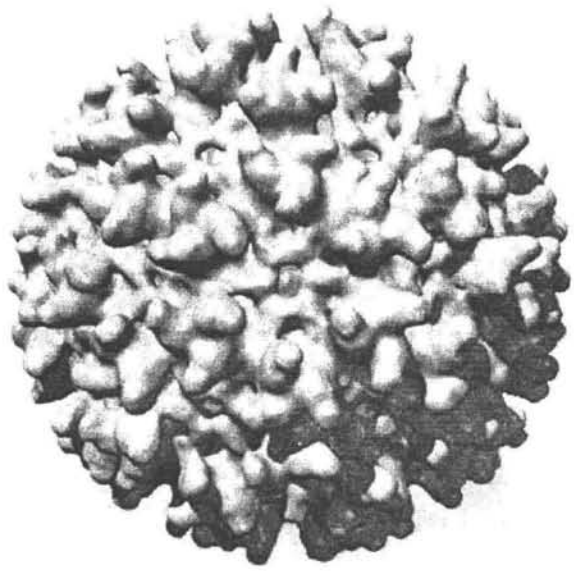
Until the 1900s, vitamins were obtained solely through food intake, and changes in diet (which, for example, could occur during a particular growing season) can alter the types and amounts of vitamins ingested. Vitamins have been produced as commodity chemicals and made widely available as inexpensive pills for several decades, allowing supplementation of the dietary intake.

W

Waterborne diseases : These are caused by pathogenic microorganisms which are directly transmitted when contaminated fresh water is consumed. Contaminated fresh water, used in the preparation of food, can be the source of foodborne disease through consumption of the same microorganisms. According to the World Health Organization, diarrheal disease accounts for an estimated 4.1% of the total DALY global burden of disease and is responsible for the deaths of 1.8 million people every year. It was estimated that 88% of that burden is attributable to unsafe water supply, sanitation and hygiene, and is mostly concentrated in children in developing countries.Waterborne disease can be caused by protozoa, viruses, or bacteria, many of which are intestinal parasites.

Wayson stain : Is a modified methylene blue stain, originally used for diagnosing Bubonic plague. With this stain, *Yersinia pestis* appears purple with a characteristic safety-pin appearance, which is due to the presence of a central vacuole. It is used along with the Giemsa and Wright's stains to rapidly detect potential biowarfare attacks It has also been investigated as a possible cheaper and faster way to detect Melioidosis. It is a useful alternative to the Gram or Loeffler's Methylene Blue stains, especially for detecting Yersinia Entercoliteiea which is often found in contaminated food

Western equine encephalitis virus : Is the causative agent of relatively uncommon viral disease *Western equine encephalitis* (WEE). An Alphavirus of the family Togaviridae, the WEE virus is an arbovirus (arthropod-borne virus) transmitted by mosquitoes of the genera *Culex* and *Culiseta*. There have been under 700 confirmed cases in the U.S. since 1964. In the U.S. WEE is seen primarily in states west of the Mississippi River. The disease is also seen in countries of South America. WEE is commonly a subclinical infection; symptomatic infections are uncommon. However, the disease can cause serious sequellae in infants and children. Unlike Eastern equine encephalitis, the overall mortality of WEE is low (approximately 4%) and is associated mostly with infection in the elderly. There is no vaccine for WEE and there are no licensed therapeutic drugs in the U.S. for this infection.

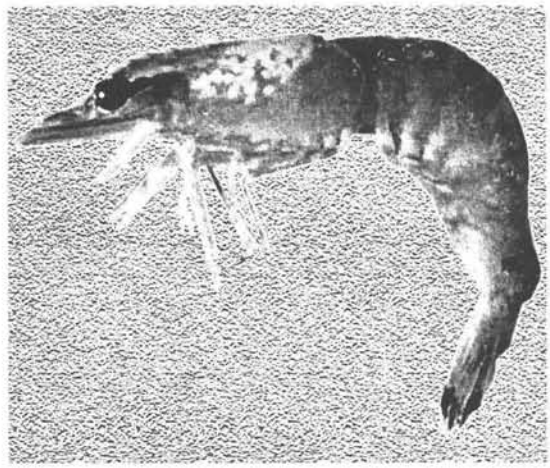


Western equine encephalitis virus

White spot syndrome (WSS) : Is a viral infection of penaeid shrimp. The disease is highly lethal and contagious, killing shrimps quickly. Outbreaks of this disease have wiped out within a few days the entire populations of many shrimp farms throughout the world.The disease is caused by a family of related viruses subsumed as the White Spot Syndrome Baculovirus Complex (WSSV) and the disease caused by them as white spot syndrome (WSS) .

The first reported epidemic due to this virus is from Taiwan in 1992 , however, reports of losses due to white spot disease came from China in 1993 , where it led to a virtual collapse of the shrimp farming industry. This was followed by outbreaks in Japan and Korea in the same year, Thailand, India and Malaysia in 1994 and by 1996 it had severely affected East Asia and South Asia. In late 1995, it was reported in the USA, 1998 in Central and South America, 1999 in Mexico and in 2000 in the Philippines. Currently, it is known to be present in all shrimp growing regions except Australia.

The virus has a wide host range and is highly virulent and leads to mortality rates of 100% within days in the case of cultured penaeid shrimps. Most of the cultured penaeid shrimps (*Penaeus monodon, Marsupenaeus japonicus, Litopenaeus vannamei, Fenneropenaeus indicus, etc.*) are natural hosts of the virus.



White spot syndrome

Several non-penaeid shrimps were also found to be severely infected during experimental challenges. Many crustaceans like crabs (*Scylla spp., Portunus spp.*), spiny lobsters (*Panulirus spp.*), crayfish (*Astacus spp., Cherax spp., etc.*) and freshwater prawn (*Macrobrachium spp.*) are reported to get infected with variable severities depending on the life stage of the host and presence of external stressors (temperature, salinity, bacterial diseases, pollutants, *etc.*).

Winemaking : Is the production of wine, starting with selection of the grapes or other produce and ending with bottling the finished wine. Although most wine is made from grapes, it may also be made from other fruit or non-toxic plant material. Mead is a wine that is made with honey being the primary ingredient after water. Winemaking can be divided into two general categories : still wine production (without carbonation) and sparkling wine production (with carbonation).

After the harvest, the grapes are crushed and allowed to ferment. Red wine is made from the must (pulp) of red or black grapes that undergo fermentation together with the grape skins, while white wine is usually made by fermenting juice pressed from white grapes, but can also be made from must extracted from red grapes with minimal contact with the grapes' skins. Rosé wines are made from red grapes where the juice is allowed to stay in contact with the dark skins long enough to pick up a pinkish color, but little of the tannins contained in the skins.

During this primary fermentation, which often takes between one and two weeks, yeast converts most of the sugars in the grape juice into ethanol (alcohol) and carbon dioxide. After the primary fermentation, the liquid is transferred to vessels

for the secondary fermentation. Here, the remaining sugars are slowly converted into alcohol and the wine becomes clear. Some wines are then allowed to age in oak barrels before bottling, which add extra aromas to the wine, while others are bottled directly. Still others may be aged in stainless steel tanks or glass carboys. The time from harvest to drinking can vary from a few months for Beaujolais nouveau wines to over twenty years for top wines. However, only about 10% of all red and 5% of white wine will taste better after five years than it will after just one year. Depending on the quality of grape and the target wine style, some of these steps may be combined or omitted to achieve the particular goals of the winemaker. Many wines of comparable quality are produced using similar but distinctly different approaches to their production; quality is dictated by the attributes of the starting material and not necessarily the steps taken during vinification.

X

Xanthomonas campestris : Is a bacterial species which causes a variety of plant diseases. Available from the NCPPB,and other international Culture collections such as ICMP, ATCC, and LMG in a purified form, it is used in the commercial production of a high molecular weight polysaccharide, xanthan gum, that is an efficient viscosifier of water and that has many important uses, especially in the food industry.

Xenotransplantation : Is the transplantation of living cells, tissues or organs from one species to another such as from pigs to humans Such cells, tissues or organs are called xenografts or xenotransplants. The term allotransplantation refers to a same-species transplant. Human xenotransplantation offers a potential treatment for end-stage organ failure, a significant health problem in parts of the industrialized world. It also raises many novel medical, legal and ethical issues. A continuing concern is that pigs have different lifespans than humans and their tissues age at a different rate. Disease transmission (xenozoonosis) and permanent alteration to the genetic code of animals are also a cause for concern.

Because there is a worldwide shortage of organs for clinical implantation, about 60% of patients awaiting replacement organs die on the waiting list. Recent advances in understanding the mechanisms of transplant organ rejection have brought science to a stage where it is reasonable to consider that organs from other species, probably pigs, may soon be engineered to minimize the risk of serious rejection and used as an alternative to human tissues, possibly ending organ shortages.

Other procedures, some of which are being carefully investigated in early clinical trials, aim to use cells or tissues from other species to treat life-threatening and debilitating illnesses such as cancer, diabetes, liver failure and Parkinson's disease. If vitrification can be perfected it could allow for long-term storage of xenogenic cells, tissues and organs so they would be more readily available for transplant

Xerophiles : These are extremophilic organisms that can grow and reproduce in conditions with a low availability of water, also known as water activity. Water

activity (aw) is a measure of the amount of water within a substrate that an organism can use to support growth. Xerophiles are often said to be "xerotolerant", meaning tolerant of dry conditions. They can survive in environments with water activity below 0.8. Endoliths and halophiles are often xerotolerant. The common food preservation method of reducing water activities may not prevent the growth of xerophilic organisms, often resulting in food spoilage. Many mold and yeast species are xerophilic. Mold growth on bread is an example of food spoilage by xerophilic organisms. This naming comes from the Greek *xeros* meaning dry, and *philos* meaning "loving."

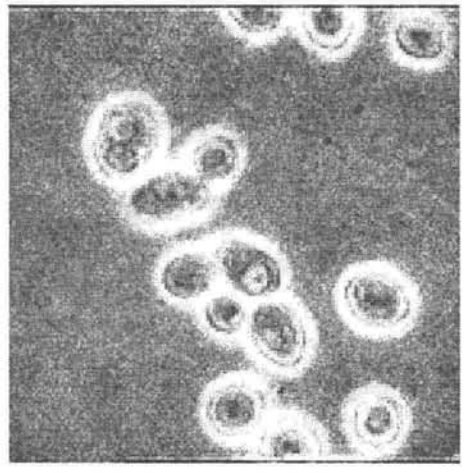
xerophyte : Is a plant which is able to survive in an environment with little available water or moisture, usually in environments where potential evapotranspiration exceeds precipitation for all or part of the growing season. Plants like the cacti and other succulents are typically found in deserts where low rainfall amounts are the norm, but xerophytes such as the bromeliads can also be found in moist habitats such as tropical forests, exploiting niches where water supplies are limited or too intermittent for mesophytic plants. Plants that live under arctic conditions may also have a need for xerophytic adaptations, as water is unavailable for uptake when the ground is frozen. Their leaves are covered with silvery hairs (creates wind break & light reflective surface).

Xylella fastidiosa : Is a Gamma Proteobacteria that is an important plant pathogen, causing several plant diseases including phoney peach disease in the southern United States, oleander leaf scorch and Pierce's disease in California and Texas, and citrus X disease in Brazil. It was named after Newton Barris Pierce (b. 1856, d. 1916; became 60 years old), California's first professional plant pathologist.

Xylose lysine deoxycholate agar (XLD agar) : Is a selective growth medium used in the isolation of *Salmonella* and *Shigella* species from clinical samples and from food. It has a pH of approximately 7.4, leaving it with a bright pink or red appearance due to the indicator phenol red. Sugar fermentation lowers the pH and the phenol red indicator registers this by changing to yellow. Most gut bacteria, including *Salmonella,* can ferment the sugar xylose to produce acid; *Shigella* colonies cannot do this and therefore remain red. After exhausting the xylose supply *Salmonella* colonies will decarboxylate lysine, increasing the pH once again to alkaline and mimicking the red *Shigella* colonies. Salmonellae metabolise thiosulfate to produce hydrogen sulfide, which leads to the formation of colonies with black centers and allows them to be differentiated from the similarly coloured *Shigella* colonies. Other Enterobacteria such as *E. coli* will ferment the lactose and sucrose present in the medium to an extent that will prevent pH reversion by decarboxylation and acidify the medium turning it yellow.

Y

Yeasts : Yeasts are eukaryotic microorganisms classified in the kingdom Fungi, with about 1,500 species currently described; they dominate fungal diversity in the oceans. Most reproduce asexually by budding, although a few do so by binary fission. Yeasts are unicellular, although some species with yeast forms may become multicellular through the formation of a string of connected budding cells known as *pseudohyphae*, or *false hyphae* as seen in most molds. Yeast size can vary greatly depending on the species, typically measuring 3–4 μm in diameter, although some yeasts can reach over 40 μm.



Yeasts

The yeast species *Saccharomyces cerevisiae* has been used in baking and fermenting alcoholic beverages for thousands of years. It is also extremely important as a model organism in modern cell biology research, and is one of the most thoroughly researched eukaryotic microorganism. Researchers have used it to gather

information into the biology of the eukaryotic cell and ultimately human biology. Other species of yeast, such as *Candida albicans*, are opportunistic pathogens and can cause infection in humans. Yeasts have recently been used to generate electricity in microbial fuel cells, and produce ethanol for the biofuel industry.

Yeasts do not form a specific taxonomic or phylogenetic grouping. At present it is estimated that only 1% of all yeast species have been described. The term *"yeast"* is often taken as a synonym for *S. cerevisiae*, but the phylogenetic diversity of yeasts is shown by their placement in both divisions Ascomycota and Basidiomycota. The budding yeasts ("true yeasts") are classified in the order Saccharomycetales.

Yeast flocculation : Typically refers to the clumping together (flocculation) of brewing yeast once the sugar in a beer brew has been fermented into ethyl alcohol. In the case of "top-fermenting" ale yeast (*Saccharomyces cerevisiae*), the yeast sinks to the bottom of an open tank; as it does with "bottom-fermenting" lager yeast (*Saccharomyces pastorianus*).

Cell aggregation occurs throughout microbiology, in bacteria, filamentous algae, fungi and yeast. Yeast are capable of forming three aggregates; mating aggregates, for DNA exchange; chain formation, for development and differentiation; and flocs as a survival strategy in adverse conditions. Brewing strains are polyploid so mating aggregates do not occur. Therefore only chain formation and flocculation are of relevance to the brewing industry.

Yeast flocculation is distinct from agglomeration ('grit' formation), which is irreversible and occurs most commonly in bakers yeast when strains fail to separate when resuspended. Agglomeration only occurs following the pressing and rehydration of yeast cakes and both flocculent and non-flocculent yeast strains have been shown to demonstrate agglomeration. It is also distinct from the formation of biofilms, which occur on a solid substrate.

Louis Pasteur first described flocculation of brewer s yeast in 1876 which has since been the subject of many reviews. Flocculation has been defined as the reversible, non-sexual aggregation of yeast cells that may be dispersed by specific sugars. The addition of nutrients other than sugars has been demonstrated not to reverse flocculation. This is as opposed to mating aggregates formed as a prelude to sexual fusion between complementary yeast cells.

Yellow fever : Also called *yellow jack* or sometimes *black vomit* or *American Plague* is an acute viral disease. It is an important cause of hemorrhagic illness in many African and South American countries despite existence of an effective vaccine. The *yellow* refers to the jaundice symptoms that affect some patients.

Yellow fever has been a source of several devastating epidemics. Yellow fever epidemics broke out in the 1700s and 1900s in Italy, France, Spain, England, and

the United States. Three hundred thousand people are believed to have died from yellow fever in Spain during the 19th century. French soldiers were attacked by yellow fever during the 1802 Haitian Revolution; more than half of the army perished from the disease. Outbreaks followed by thousands of deaths occurred periodically in other Western Hemisphere locations until research, which included human volunteers (some of whom died), led to an understanding of the method of transmission to humans (primarily by mosquitos) and development of a vaccine and other preventive efforts in the early 20th century.

Despite the breakthrough research of Cuban physician Carlos Finlay, American physician Walter Reed, and many others over 100 years ago, non-vaccinated populations in many developing nations in Africa and Central/South America continue to be at risk. As of 2001[update], the World Health Organization (WHO) estimates that yellow fever causes 200,000 illnesses and 30,000 deaths every year in unvaccinated populations.

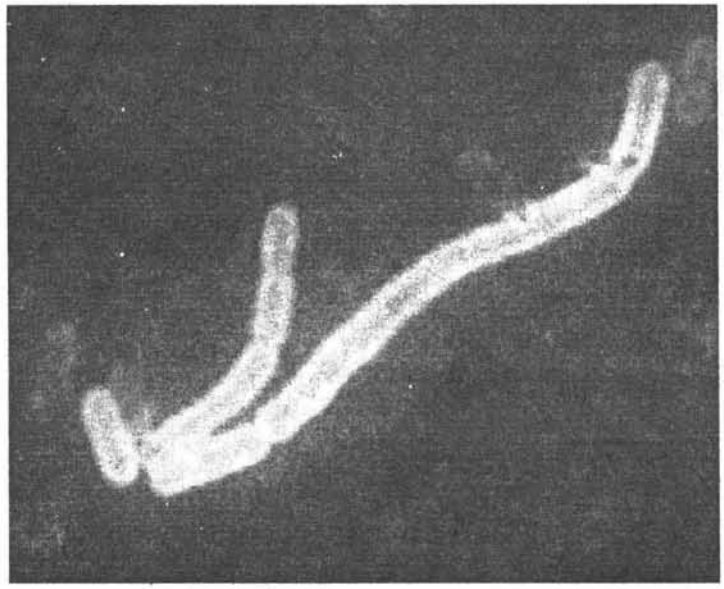
Yellowhead disease (YHD) : Is a viral infection of shrimp and prawn, in particular of the giant tiger prawn (*Penaeus monodon*), one of the two major species of farmed shrimp. The disease is highly lethal and contagious, killing shrimp quickly. Outbreaks of this disease have wiped out in a matter of days the entire populations of many shrimp farms that cultivated P. monodon, i.e. particularly Southeast Asian farms. In Thai, the disease is called Hua leung.

The disease is caused by the yellowhead virus (YHV), a positive-sense single-stranded RNA virus related to coronaviruses and arteriviruses. A closely related virus is the gill-associated virus (GAV), which is the type species of the genus Okavirus. The cephalothorax of infected shrimp turns yellow after a period of unusually high feeding activity ending abruptly, and the then moribund shrimps congregate near the surface of their pond before dying. YHD leads to death of the animals within two to four days. YHD had been reported first from Thailand in 1990, the closely related GAV has been discovered in 1995 during a yellowhead-like disease in Australian shrimp farms

Yersinia : Is a genus of bacteria in the family Enterobacteriaceae. *Yersinia* are Gram-negative rod shaped bacteria, a few micrometers long and fractions of a micrometer in diameter, and are facultative anaerobes. Some members of *Yersinia* are pathogenic in humans. Rodents are the natural reservoirs of *Yersinia*; less frequently other mammals serve as the host. Infection may occur either through blood (in the case of *Y. pestis*) or in an alimentary fashion, occasionally via consumption of food products (especially vegetables, milk-derived products and meat) contaminated with infected urine or feces.

Speculations exist as to whether or not certain *Yersinia* can also be spread via protozoonotic mechanisms, since *Yersinia* are known to be facultative intracellular

parasites; studies and discussions of the possibility of amoeba-vectored (through the cyst form of the protozoan) Yersinia propagation and proliferation are now in progress.



Yersinia

Yoghurt : Is a dairy product produced by bacterial fermentation of milk. Fermentation of the milk sugar (lactose) produces lactic acid, which acts on milk protein to give yoghurt its texture and its characteristic tang. Soy yoghurt, a non-dairy yoghurt alternative, is made from soy milk. It is nutritionally rich in protein, calcium, riboflavin, vitamin B_6 and vitamin B_{12}.

Yoghurt has nutritional benefits beyond those of milk : people who are moderately lactose-intolerant can enjoy yoghurt without ill effects, because the lactose in the milk precursor is converted to lactic acid by the bacterial culture. The reduction of lactose bypasses the affected individuals' need to process the milk sugar themselves. Yoghurt also has medical uses, in particular for a variety of gastrointestinal conditions, and in preventing antibiotic-associated diarrhea. One study suggests that eating yoghurt containing *L. acidophilus* helps prevent vulvovaginal candidiasis, though the evidence is not conclusive.

Z

Zoo blot : A zoo blot or garden blot is a type of Southern blot that demonstrates the similarity between specific, usually protein-coding, DNA sequences of different species. A zoo blot compares animal species while a garden blot compares plant species. In order to understand the degree to which a particular gene is similar from species to species, DNA preparations from a set of species is isolated and spread over a surface. The sequence of interest is labeled and allowed to hybridize to the prepared DNA. Usually, the labeled DNA is marked with a radioactive isotope of phosphorus. The hybridization is a process that happens spontaneously : DNA pairs with complementary strands. The hybridization, however, is not perfect. The hybridization of two strands will happen even when the strands are similar but not identical. This procedure is used to detect similar or exact relationships between the DNA in question and other organisms, so the technique takes advantage of non-exact hybridization. It also allows you judge the locations of introns and exons as the latter will be far more conserved than the former.

Zygosaccharomyces : Zygosaccharomyces is a genus of yeast in the family Saccharomycetaceae. It was first described under the Saccharomyces genus but in 1983 it was reclassified to its current name in the work by Barnett et al. The yeast has a long history as a spoilage yeast within the food industry. This is mainly because it is tolerant to many of the common food preservation methods. The biochemical properties it possesses to achieve this includes high sugar tolerance (50-60%), high ethanol tolerance (up to 18%), high acetic acid tolerance (2.0-2.5%), very high sorbic and benzoic acid tolerance (up to 800-1000mg/L), very high molecular SO_2 tolerance (greater than 3mg/L) and high xerotolerance

Zymography : Is an electrophoretic technique, based on SDS-PAGE, that includes a substrate copolymerized with the polyacrylamide gel, for the detection of enzyme activity. Samples are prepared in the standard SDS-PAGE treatment buffer but without boiling, and without a reducing agent. Following electrophoresis, the SDS is removed from the gel (or zymogram) by incubation in unbuffered Triton X-100, followed by incubation in an appropriate digestion buffer, for an optimized

length of time at 37°C. The zymogram is subsequently stained (commonly with Amido Black or Coomassie Brilliant Blue), and areas of digestion appear as clear bands against a darkly stained background where the substrate has been degraded by the enzyme. These protocols, however, are subject to much adjustment. For instance, *D. melanogaster* digestive glycosidases generally survive reducing conditions (i.e. the presence of 2-mercaptoethanol or DTT) and to an extent heating. Indeed, the separations following heating to 50 deg. C tend to exhibit a substantial increase in band resolution, without appreciable loss of activity. Gelatin is the most commonly used substrate, and is useful for demonstrating the activity of gelatin-degrading proteases, but zymography has been applied to a variety of enzymes, including xylanases, proteases, lipases, chitinases, etc.

Zymomonas mobilis : Is a bacterium belonging to the genus Zymomonas. It is notable for its bioethanol-producing capabilities, which surpass yeast in some aspects. It was originally isolated from alcoholic beverages like the African palm wine, the Mexican pulque, and also as a contaminant of cider and beer in European countries.

Z. mobilis degrades sugars to pyruvate using the Entner-Doudoroff pathway. The pyruvate is then fermentated to produce ethanol and carbon dioxide as the only products (analogous to yeast). An interesting characteristic of *Z. mobilis* is that its plasma membrane contains hopanoids, pentacyclic compounds similar to eukaryotic sterols. This allows it to have an extraordinary tolerance to ethanol in its environment, around 13%.