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David P. Clark

Molecular Biology

Das Original mit Übersetzungshilfen

Liebe Leserin, lieber Leser,

mittels dieser PDF-Leseprobe möchten wir Ihnen ein erfolgreiches englischsprachiges Molekularbiologie-Lehrbuch, gleichzeitig aber einen völlig neuen Lehrbuchtyp vorstellen, der speziell für die Studiensituation in deutschsprachigen Ländern konzipiert ist.

CLARKs „Molecular Biology“ ist 2005 bei Academic Press erschienen und erobert gerade einen achtbaren Platz in der Riege der großen amerikanischen Lehrbücher der Zell- und Molekularbiologie. Das in flüssigem Stil geschriebene und mit anschaulichen Farbbildern illustrierte Werk zeigt, welche Bedeutung der Molekularbiologie in der genetischen Forschung, aber auch in Medizin, Evolution, Landwirtschaft und Biotechnologie zukommt. Der Autor David P. Clark lehrt an der Southern Illinois University in Carbondale/USA.

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Wesentlicher Zusatznutzen der „Easy Reading“-Ausgabe ist also, das Lesen des englischen Grundtextes zu erleichtern und in die spezielle Wissenschaftsterminologie einzuführen. Biologie wird ja auch in deutschsprachigen Ländern immer öfters auf Englisch unterrichtet.

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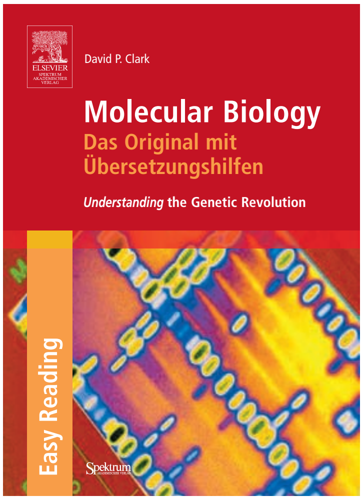
Wir hoffen sehr, dass Ihnen dieses Werk und der neue Lehrbuchtyp gefallen und dass Sie beides Ihren Studenten und Kollegen empfehlen können.

Mit freundlichen Grüßen
Ihr
Dr. Ulrich G. Moltmann

Programmleiter Biologie-, Chemie- und Geowissenschaften



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CHAPTER TWO

Cells and Organisms

What Is Life?

Although there is no definition of life that suits all people, everyone has an idea of what being alive means. Generally, it is accepted that something is alive if it can *grow* and *reproduce*, at least during some stage of its existence. Thus, we still regard adults who are no longer growing and those individuals beyond reproductive age as being alive. We also regard sterile individuals, such as mules or worker bees as being alive, even though they lack the ability to reproduce. Part of the difficulty in defining life is the complication introduced by multicellular organisms. Although a multicellular organism as a whole may not grow or reproduce some of its cells may still retain these abilities.

Perhaps the key factor that characterizes life is the ability to self-replicate. This includes both the **replication** of the genetic information (the genome) and of the structure carrying and protecting it (the cell). Growth and reproduction need both information and energy in order to process raw materials into new living matter, and ultimately to create new organisms identical or, at any rate very similar, to the original organism. This brings us to another characteristic of life, which is that it evolves. Descendents are not identical to their ancestors but gradually accumulate changes in their genetic information over time. Both accurate replication and occasional evolutionary change are due to the properties of the nucleic acid molecules, DNA and RNA, which carry the genetic information. Furthermore, life forms do not merely grow and divide they also respond to stimuli from the environment. Some responses involve such complex structures as the nervous system of higher animals. However, many responses operate at the genetic level and are therefore included in this book.

The basic ingredients needed to sustain life include the following:

Genetic information Biological information is carried by the **nucleic acid** molecules, **deoxyribonucleic acid** (**DNA**) and **ribonucleic acid** (**RNA**). The units of genetic information are known as **genes** and each consists physically of a segment of a nucleic acid molecule. DNA is used for long-term storage of large amounts of genetic information (except by some viruses—see Ch. 17). Whenever genetic information is actually used, working copies of the genes are carried on RNA. The total genetic information possessed by an organism is known as its **genome**. Whenever an organism reproduces, the DNA molecules carrying the genome must be replicated so that the descendents may receive a complete copy of the genetic information.

Mechanism for energy generation By itself, information is useless. Energy is needed to put the genetic information to use. Living creatures must all obtain energy for growth and reproduction. **Metabolism** is the set of processes in which energy is acquired, liberated and used for biosynthesis of cell components.

Machinery for making more living matter Synthesis of new cell components requires chemical machinery. In particular, the **ribosomes** are needed for making proteins, the **macromolecules** that make up the bulk of all living tissue.

A characteristic outward physical form Living creatures all have a material body that is characteristic for each type of life form. This structure contains all the metabolic and biosynthetic machinery for generating energy and making new living matter. It also contains the DNA molecules that carry the genome.

Identity or self All living organisms have what one might call an identity. The term self-replication implies that an organism knows to make a copy of itself—

passend ist
sich fortpflanzen
Maultiere / Arbeiterinnen bei Bienen
fehlt die Fähigkeit
behalten
sich selbst duplizieren
Wachstum
umwandeln / Rohstoffe / lebende Materie / letztlich
sich entwickelt, evolviert / Abkömmlinge / Vorfahren
im Laufe der Zeit
beruhen auf / Eigenschaften
bloß
reagieren / Umwelt
Bestandteile / aufrechterhalten
langfristige Speicherung

Es gibt keine zufrieden stellende fachliche Definition für Leben. Dennoch wissen wir, was Leben ausmacht. In erster Linie bedeutet es ein dynamisches Gleichgewicht zwischen Vervielfältigung und Veränderung.

Erzeugung
zur Wirkung zu bringen
erlangt / freigesetzt
Großteil / Gewebe
äußeren
beinhaltet

desoxyribonucleic acid (DNA) Desoxyribonucleinsäure (DNA, DNS); hoch polymeres Kettenmolekül, aus dem die Gene zusammengesetzt sind
gen Gen; Einheit der genetischen Information
genome Genom; die gesamte genetische Information eines Individuums
macromolecule Makromolekül; großes polymeres Molekül mit einer Molekülmasse von einer Million und mehr; in lebenden Zellen vor allem DNA, RNA, Proteine und Polysaccharide
metabolism Stoffwechsel, Metabolismus; Prozesse, durch die Nährstoffmoleküle in der Zelle transportiert und umgewandelt werden; dienen zur Freisetzung von Energie und zum Aufbau von neuem Zellmaterial
nucleic acid Nucleinsäure, Kernsäure; aus Nucleotiden zusammengesetztes Polymer, das die genetische Information trägt
replication Replikation; Verdopplung der DNA vor der Zellteilung
ribonucleic acid (RNA) Ribonucleinsäure (RNA, RNS); Nucleinsäure, die im Gegensatz zu DNA Ribose anstelle von Desoxyribose und Uracil anstelle von Thymin enthält
ribosome Ribosom; Zellorganell, an dem die Proteinsynthese erfolgt

zusammenbauen / wahllos
höchstentwickelt
Krankheit

not merely to assemble random organic material. Living organisms use raw material from the environment to make more of their own selves, ultimately to make complete copies of themselves. This concept of self versus non-self reaches its most sophisticated expression in the immune systems that protect higher animals against disease. But even primitive creatures attempt to preserve their own existence.

Living Creatures Are Made of Cells

bewohnen
Tintenfische / Möwen / Mammutbäume / Faultiere / Schnecken / Sojabohnen
oberflächlich
Einheitlichkeit
Kompartimente
vorgeschlagen
kugelförmig / quaderförmig
verzweigt

Looking around at the living creatures that inhabit this planet, one is first struck by their immense variety: squids, seagulls, sequoias, sharks, sloths, snakes, snails, spiders, strawberries, soybeans, and so forth. Although highly diverse to the eye, the biodiversity represented by these creatures is actually somewhat superficial. The most fascinating thing about life is not its superficial diversity but its *fundamental unity*. All of these creatures, together with microscopic organisms too small to see with the naked eye, are made up of **cells,** structural units or compartments that have more or less the same components.

The idea that living cells are the structural units of life was first proposed by Schleiden and Schwann in the 1830s. Cells are microscopic structures that vary considerably in shape. Many are spherical, cylindrical or roughly cuboidal but many other shapes are found, such as the long branched filaments of nerve cells. Many microscopic life forms consist of a single cell, whereas creatures large enough to see usually contain thousands of millions. Each cell is enclosed by a cell membrane composed of **proteins** and **phospholipids** and contains a complete copy of the genome (at least at the start of its life). Living cells possess the machinery to carry out metabolic reactions and generate energy and are usually able to grow and divide. Moreover, living cells always result from the division of pre-existing cells; they are never assembled from their component parts. This implies that living organisms too can only arise from pre-existing organisms. In the 1860s, Louis Pasteur confirmed experimentally that life cannot arise spontaneously from organic matter. Sterilized nutrient broth did not "spoil" or "go bad" unless it was exposed to microorganisms in the air.

Materie setzt sich aus Atomen zusammen, genetische Information aus Genen und lebende Organismen aus Zellen.

schon vorher bestehend
Nährlösung / verderben

In most multicellular organisms, the cells are specialized in a variety of ways (Fig. 2.01). The development of specialized roles by particular cells or whole tissues is referred to as **differentiation**. For example, the red blood cells of mammals lose their nucleus and the enclosed DNA during development. Once these cells are fully differentiated, they can perform only their specialized role as oxygen carriers and can no longer grow and divide. Some specialized cells remain functional for the life span of the individual organism, whereas others have limited life spans, sometimes lasting only a few days or hours. For multicellular organisms to grow and reproduce, some cells clearly need to keep a complete copy of the genome and retain the ability to grow and divide. In single-celled organisms, such as **bacteria** or protozoa, each individual cell has a complete genome and can grow and reproduce; hence, the complications of having multiple types of cell are largely absent.

bezeichnet als / Säugetiere
erfüllen / Sauerstofftransporter
Lebensdauer
Protozoen, Einzeller
daher

Essential Properties of a Living Cell

At least in the case of unicellular organisms, each cell must possess the characteristics of life as discussed above (Fig. 2.02). Each living cell must generate its own energy and

bacteria Bakterien; relativ einfach gebaute einzellige Organismen ohne Zellkern
cell Zelle; grundlegende Einheit des Lebens; jede Zelle ist von einer Membran umgeben und besitzt in der Regel einen vollständigen Satz an Genen, der sie mit der nötigen Information versorgt, um zu funktionieren
differentiation Differenzierung; fortschreitende Veränderungen der Struktur und Genexpression von Zellen eines Organismus, die zur Bildung von verschiedenen Zelltypen führen
phospholipid Phospholipid; ein Wasser abstoßendes (hydrophobes) Molekül; Bestandteil von Zellmembranen; zusammengesetzt aus einer löslichen Alkoholgruppe und zwei Fettsäuren gebunden an Glycerinphosphat
protein Protein, Eiweiß; aus Aminosäuren zusammengesetztes Polymer, das in der Zelle die meisten Funktionen erfüllt

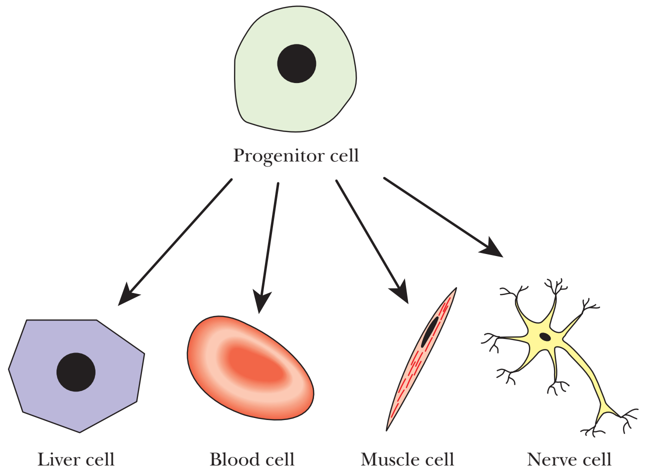

FIGURE 2.01 ***Some Cells Differentiate***

In multicellular organisms, cells differentiate from unspecialized precursor [Vorläufer] cells. Differentiation allows cells to specialize functionally. Their form is related to [steht in Beziehung mit] their function.

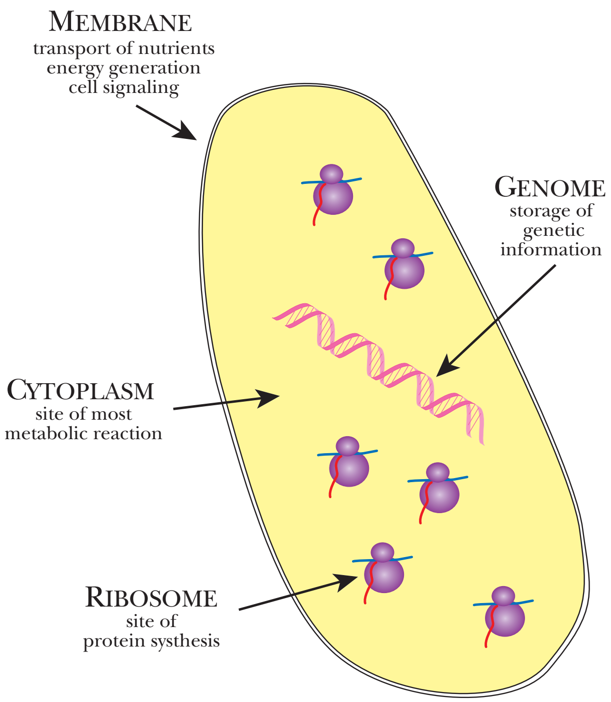

FIGURE 2.02 ***Essential Features of a Living Cell***

Simple cells possess certain elements considered essential to support life. Fundamentals for life include a membrane to separate the inside of the cell (the cytoplasm) from the environment; a means to store genetic information (the genome); and an apparatus (ribosome) to synthesize proteins.

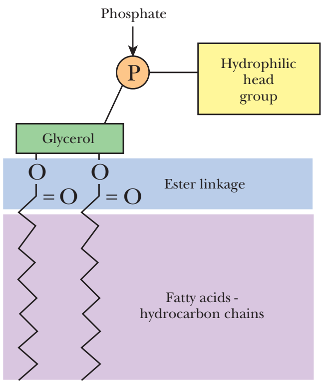

FIGURE 2.04 ***Phospholipid Molecule***

Phospholipid molecules of the kind found in membranes have a hydrophilic head group [hydrophiler Kopf] attached via a phosphate group to glycerol [Glycerin]. Two fatty acids [Fettsäuren] are also attached to the glycerol via ester linkages [Ester-Bindungen].

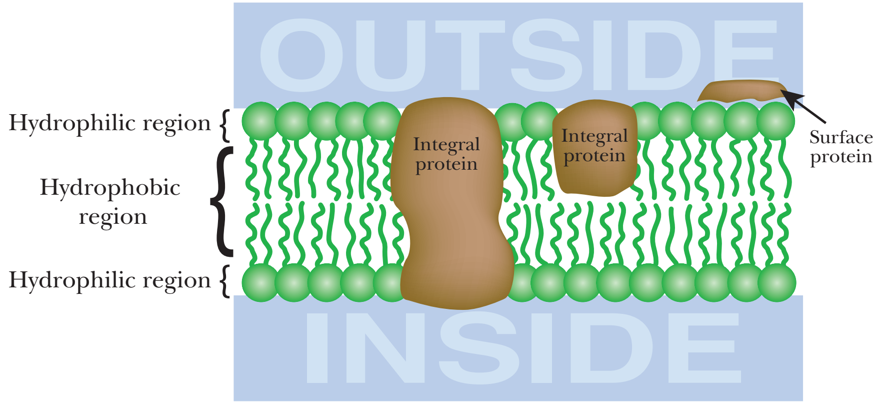

FIGURE 2.03 ***A Biological Membrane***

A biological membrane is formed by phospholipid and protein. The phospholipid layers [Schichten] are oriented with their hydrophobic tails [hydrophobe Enden] inward and their hydrophilic heads outward. Proteins may be within the membrane (integral) or lying on the membrane surfaces.

synthesize its own macromolecules. Each must have a genome, a set of genes carried on molecules of DNA. [Partial exceptions occur in the case of multicellular organisms, where responsibilities may be distributed among specialized cells and some cells may lack a complete genome.]

teilweise Ausnahmen
fehlt

A cell must also have a surrounding **membrane** that separates the cell interior, the **cytoplasm**, from the outside world. The cell membrane, or cytoplasmic membrane, is made from a double layer of phospholipids together with proteins (Fig. 2.03). [Some single-celled protozoa, such as *Paramecium*, have multiple nuclei within each single cell. In addition, in certain tissues of some multi-cellular organisms several nuclei may share the same cytoplasm and be surrounded by only a single cytoplasmic membrane. Such an arrangement is known as a syncytium when it is derived from multiple fused cells.] Phospholipid molecules consist of a water-soluble head group, including phosphate, found at the surface of the membrane, and a lipid portion consisting of two hydrophobic chains that form the body of the membrane (Fig. 2.04). The phospholipids form a hydrophobic layer that greatly retards the entry and exit of water-soluble molecules. For the cell to grow, it must take up nutrients. For this, transport proteins, which penetrate through the membrane, are necessary. Many of the metabolic reactions involved in the breakdown of nutrients to release energy are catalyzed by soluble enzymes located in the cytoplasm. Other energy-yielding series of reactions, such as the respiratory chain or the photosynthetic system, are located in membranes. The proteins may be within or attached to the membrane surfaces (Fig. 2.03).

Doppelschicht
mehrere Zellkerne
stammt ab von / verschmolzen
wasserlöslich
Ketten
hemmt
Nährstoffe
durchdringen
Abbau
Energie liefernd
Atmungskette

The cytoplasmic membrane is physically weak and flexible. Many cells therefore have a tough structural layer, the cell wall, outside the cell membrane. Most bacterial and plant cells have hard cell walls, though animal cells usually do not. Thus a cell wall is not an essential part of a living cell.

schwach
fest

Membranen trennen nicht nur lebendes Gewebe vom nicht belebten Äußeren, an ihnen finden auch viele biosynthetische und Energie liefernde Reaktionen statt.

Soluble enzymes located in the cytoplasm catalyze biosynthesis of the low molecular weight precursors to protein and nucleic acids. However, assembly of proteins requires a special organelle, the ribosome (Fig. 2.05). This is a subcellular machine that consists of several molecules of RNA and around 50 proteins. It uses information that is carried from the genome into the cytoplasm by special RNA molecules, known as **messenger RNA**. The ribosome decodes the nucleic acid-encoded genetic information on the messenger RNA to make protein molecules.

Vorstufen / Aufbau
entschlüsselt / in Nucleinsäuren codierte

cytoplasm Cytoplasma, Zellplasma; der innerhalb der Zellmembran liegende und den Zellkern umgebende Bereich der Zelle
membrane Zellmembran; alle Zellen umgebende dünne, flexible Schicht aus Proteinen und Phospholipiden
messenger RNA (mRNA) messenger-RNA (mRNA), Boten-RNA; jene Gruppe von RNA-Molekülen, welche die genetische Information von den Genen zum Rest der Zelle transportieren

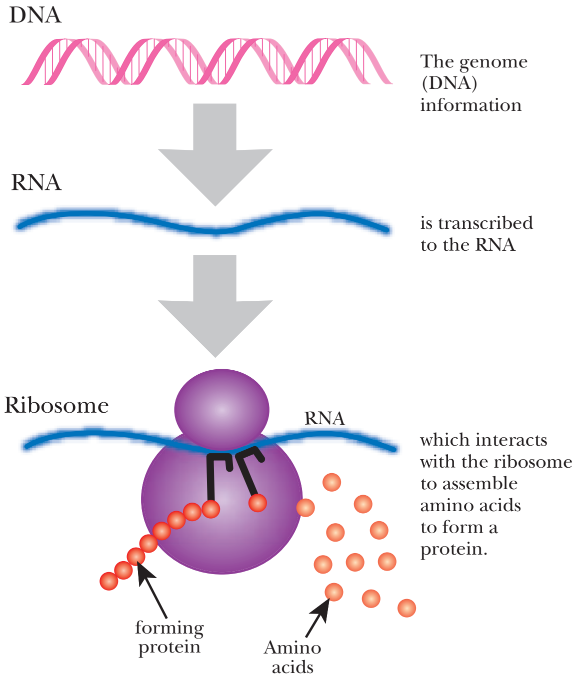

FIGURE 2.05 ***Ribosomes Make Protein***

The information stored in DNA is transported to the ribosome where proteins are synthesized from components known as amino acids.

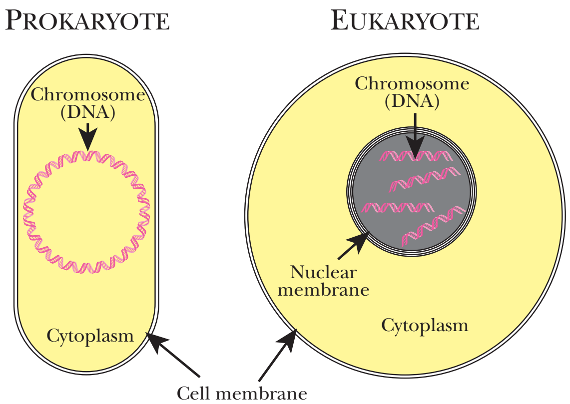

FIGURE 2.06 ***Prokaryotic and Eukaryotic Cells***

A comparison of prokaryotic and eukaryotic cells shows that the eukaryotes have a separate compartment called the nucleus that contains their DNA.

Kompartimentierung

Pilze / Protisten, Einzeller

Based on differences in compartmentalization, living cells may be divided into two types, the simpler **prokaryotic** cell and the more complex **eukaryotic** cell. By definition, prokaryotes are those organisms whose cells are not subdivided by membranes into a separate **nucleus** and cytoplasm. All prokaryote cell components are located together in the same compartment. In contrast, the larger and more complicated cells of higher organisms (animals, fungi, plants and protists) are subdivided into separate compartments and are called eukaryotic cells. Figure 2.06 compares the design of prokaryotic and eukaryotic cells.

eukaryote Eukaryot; Organismus mit höher entwickelten Zellen, die mehr als ein Chromosom in einem Zellkern aufweisen
nucleus Zellkern, Nucleus; von einer Kernmembran umschlossenes inneres Zellkompariment, das die Chromosomen enthält; nur die Zellen höherer Organismen haben Kerne (Nuclei)
prokaryote Prokaryot; aus einem primitiveren Zelltypus bestehender niederer Organismus, der ein einzelnes Chromosom aber keinen Zellkern besitzt, z. B. ein Bakterium

Zellen sind von ihrer Umgebung durch Membranen abgegrenzt. In den komplexeren Zellen von Eukaryoten ist das Genom durch eine weitere Membran vom Rest der Zelle separiert.

Prokaryotic Cells Lack a Nucleus

Bacteria (singular, bacterium) are the simplest living cells and are classified as prokaryotes. By definition, prokaryotes lack a nucleus and their DNA is therefore in the same compartment as the cytoplasm. Bacterial cells (Fig. 2.07) are always surrounded [umgeben] by a membrane (the cell or cytoplasmic membrane) and usually also by a cell wall. Like all cells, they contain all the essential chemical and structural components necessary for life. Typically, each bacterial cell has a single **chromosome** carrying a full set of genes providing it with [das sie ausstattet mit] the genetic information necessary to operate as a living organism. [Occasional bacteria are known that have more than one chromosome, however this is relatively uncommon [ungewöhnlich].] Typically, bacteria have 3,000–4,000 genes, although some have as few as 500. The minimum number of genes to allow the survival of a living cell is uncertain. Experiments are presently in progress to successively delete [entfernen] genes from certain very small bacterial genomes in an attempt [Versuch] to create a truly minimal cell.

A typical bacterial cell, such as ***Escherichia coli***, is rod shaped [stäbchenförmig] and about two or three micrometers long and a micrometer wide. A micrometer (μm), also known as a micron, is a millionth of a meter (i.e., 10^{-6} meter). Bacteria are not limited to a rod shape (Fig. 2.08); spherical, filamentous or spirally twisted [fadenförmig / gewunden] bacteria are also found. Occasional giant bacteria occur, such as *Epulopiscium fishelsoni*, which inhabits the surgeonfish [Doktorfisch] and measures a colossal 50 microns by 500 microns—an organism visible to the naked eye. Typical eukaryotic cells are 10 to 100 microns in diameter [Durchmesser].

A smaller cell has a larger surface-to-volume ratio [Verhältnis Oberfläche/Volumen]. Smaller cells transport nutrients relatively faster, per unit mass of cytoplasm (i.e., cell contents), and so can grow more rapidly than larger cells. Because bacteria are less structurally complex than animals and plants, they are often referred to as "lower organisms." However, it is important to remember that present-day bacteria are at least as well adapted to modern conditions as animals and plants, and are just as highly evolved as so-called "higher organisms." In many ways, bacteria are not so much "primitive" as specialized for growing more efficiently in many environments than larger and more complex organisms.

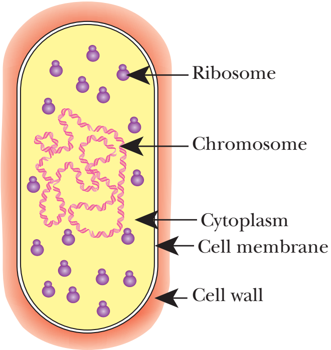

FIGURE 2.07 *Typical Bacterium*

The components of a bacterium are depicted [eingezeichnet].

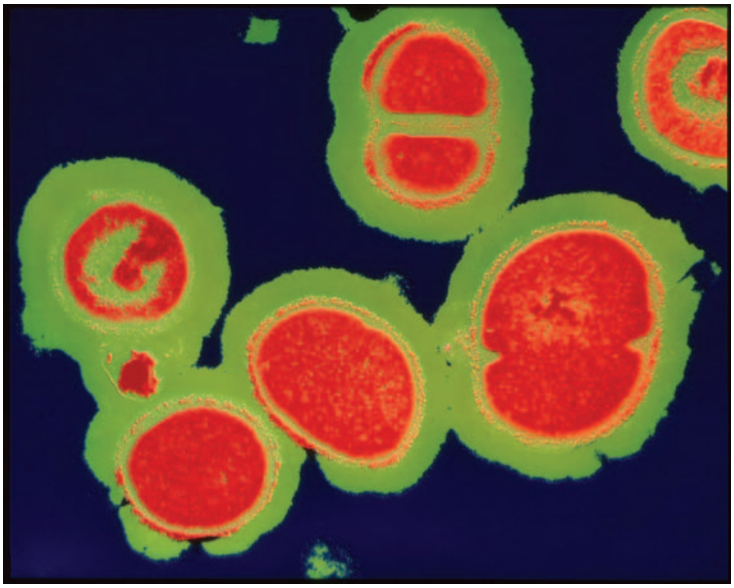

FIGURE 2.08 *False Color TEM of Staphylococcus aureus*

Colored transmission electron micrograph [angefärbtes transmissions-elektronenmikroskopisches Bild] (TEM) of a cluster [Anhäufung] of *Staphylococcus aureus* seen dividing. *S. aureus* may cause boils [Furunkel], usually by entering the skin through a hair follicle or a cut. They are also responsible for internal abscesses and most types of acute suppurative [eitrig] infection. Magnification: ×24,000. Provided by Dr Kari Lounatmaa, Science Photo Library.

chromosome Chromosom; Struktur, die die Gene einer Zelle enthält und aus einem einzelnen DNA-Molekül besteht
Escherichia coli (E. coli) *Escherichia coli (E. coli);* ein in der molekularbiologischen Forschung häufig verwendetes Bakterium

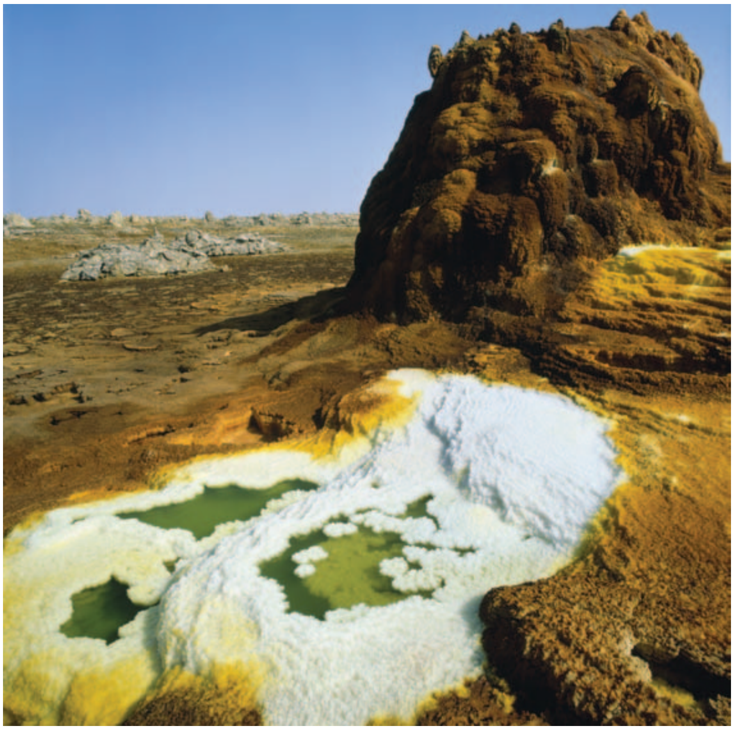

FIGURE 2.09 ***Hot spring in Ethiopia***

Hot springs [Thermalquellen] are good sites to find archaebacteria. These springs are in the Dallol area of the Danakil Depression [Danakilsenke], 120 metres below sea level. The Danakil Depression of Ethiopia is part of the East African Rift Valley [Ostafrikanischer Grabenbruch]. Hot water flows from underground to form these pools. The water is heated by volcanic activity and is at high pressure [Druck], causing minerals in the rock to dissolve [sich lösen] in the water. The minerals precipitate out [fallen aus (chem.)] as the water cools at the surface, forming the deposits [Ablagerungen] seen here. Provided by Bernhard Edmaier, Science Photo Library.

Eubacteria and Archaebacteria Are Genetically Distinct

There are two distinct types of prokaryotes, the **eubacteria** and **archaebacteria**, which are no more genetically related to each other than either group is to the eukaryotes. Both eubacteria and archaebacteria show the typical prokaryotic structure—in other words, they both lack a nucleus and other internal membranes. Thus, cell structure is of little use for distinguishing these two groups. The eubacteria include most well known bacteria, including all those that cause disease. When first discovered, the archaebacteria were regarded as strange and primitive. This was largely because most are found in extreme environments (Fig. 2.09) and/or possessed unusual metabolic pathways. Some grow at very high temperatures, others in very acidic conditions and others in very high salt. The only major group of archaebacteria found under "normal" conditions are the methane bacteria, which, however, have a very strange metabolism. They contain unique enzymes and cofactors that allow the formation of methane by a pathway found in no other group of organisms. Despite this, the **transcription** and **translation** machinery of archaebacteria resembles that of eukaryotes, so they turned out to be neither fundamentally strange nor truly primitive when further analyzed.

verschieden
verwandt mit
um zu unterscheiden
Stoffwechselwege
sauer (chem.)

Als grundlegende Klassifikation der Organismen haben die drei Domänen Bacteria, Archaea und Eucarya (beziehungsweise Eubacteria, Archaebacteria und Eukaryota) die bisherige Einteilung in Tier- und Pflanzenreich abgelöst.

Biochemically, there are major differences between the eubacterial and archaebacterial cells. In all cells, the cell membrane is made of phospholipids, but the nature and linkage of the lipid portion is quite different in the eubacteria and archaebacteria (Fig. 2.10). The cell wall of eubacteria is always made of peptidoglycan, a molecule unique to this group of organisms. Archaebacteria often have cell walls, but these are made of a variety of materials in different **species**, but peptidoglycan is never

ähnelt
Bindung (chem.)
Peptidoglykan

Archaebacteria (Archaea) Archaea, Archaebakterien; Bakterientyp, der eine genetisch eigenständige Domäne des Lebens bildet; darunter finden sich viele Arten, die unter extremen Umweltbedingungen leben
Eubacteria Bakterien, Eubakterien; die "echten" Bakterien im Gegensatz zu den Archaebakterien (Archaea)
species Art, Spezies; eine Gruppe nahe verwandter Organismen mit einem gemeinsamen Vorfahren in jüngerer Vergangenheit; bei Tieren sind Arten Populationen, die sich untereinander, nicht jedoch mit Individuen anderer Populationen fortpflanzen; für Bakterien und andere Organismen, die sich nicht sexuell fortpflanzen, gibt es keine zufrieden stellende Artdefinition
transcription Transkription; Vorgang, bei dem Information der DNA in ihr RNA-Äquivalent umgesetzt wird
translation Translation; Vorgang, bei dem ein Protein dazu gebracht wird, die von der messenger-RNA bereitgestellte Information zu nutzen

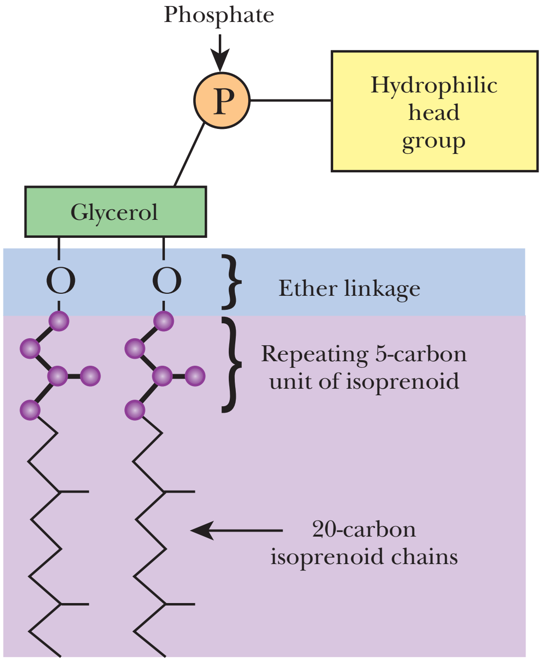

FIGURE 2.10 ***Lipids of Archaebacteria***

In eubacteria and eukaryotes, the fatty acids of phospholipids are esterified [verestert] to the glycerol [Glycerin]. In archaebacteria, the lipid portion consists of branched isoprenoid hydrocarbon chains [Kohlenwasserstoffketten] joined to the glycerol by ether linkages [Ether-Bindungen] (as shown here). Such lipids are much more resistant to extremes of pH, temperature and ionic composition [Ionenzusammensetzung].

present. Thus the only real cellular structures possessed by prokaryotes, the cell membrane and cell wall, are in fact chemically different in these two groups of prokaryotes. The genetic differences will be discussed later when molecular evolution is considered (see Ch. 20).

betrachtet

Bacteria Were Used for Fundamental Studies of Cell Function

Most of the early experiments providing the basis for modern day molecular biology were performed using bacteria such as *Escherichia coli* (see below), because they are relatively simple to analyze. Some advantages of using bacteria to study cell function are:

Bakterienkultur
aufgrund des Fehlens
einigermaßen / vielfältige
in Gegensatz zu
exprimiert

1. Bacteria are single-celled microorganisms. Furthermore, a bacterial culture consists of many identical cells due to lack of sexual recombination during cell division. In contrast, in multi-cellular organisms, even an individual tissue or organ contains many different cell types. All the cells in a bacterial culture respond in a reasonably similar way, whereas those from a higher organism will give a variety of responses, making analysis much more difficult.
2. The most commonly used bacteria have about 4,000 genes as opposed to higher organisms, which have up to 50,000. Furthermore, different selections of genes are expressed in the different cell types of a single multicellular organism.
3. Bacteria are **haploid**, having only a single copy of most genes, whereas higher organisms are **diploid**, possessing at least two copies of each gene. As discussed in Ch. 1, the multiple gene copies may differ in a variety of ways, making research results more complex.

diploid diploid; zwei identische Exemplare jedes Gens enthaltend
haploid haploid; nur ein Exemplar jedes Gens enthaltend

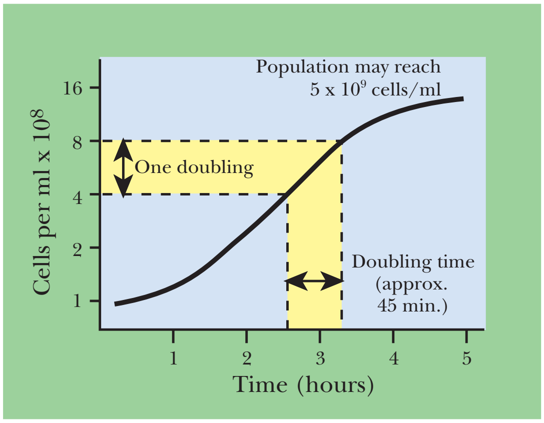

FIGURE 2.11 ***Graph of Exponential Growth of Bacterial Culture***

The number of bacteria in this culture is doubling approximately [in etwa] every 45 minutes. This is typical for fast growing bacteria such as *Escherichia coli* that are widely used in laboratory research. The bacterial population may reach 5×10^9 cells per ml or more in only a few hours under ideal conditions.

aggressive Stämme
Diarrhoe, Durchfall
Giftstoff / Dysenterie, Ruhr (med.)
berüchtigt
tödlich
Hackfleisch
Rückrufaktionen
Fabrik

E. coli is normally harmless, although occasional rogue strains occur. Even these few **pathogenic** *E. coli* strains mostly just cause diarrhea, by secreting a mild form of a toxin related to that found in cholera and dysentery bacteria. However, the notorious *E. coli* O157:H7 carries two extra toxins and causes bloody diarrhea that may be fatal, especially in children or the elderly. In outbreaks of *E. coli*, the bacteria typically contaminate ground meat used in making hamburgers. Several massive recalls of frozen meat harboring *E. coli* O157:H7 have occurred in the late 1990's. For example, in 1997 the Hudson Foods plant in Columbus, Nebraska was forced to shut down and 25 million pounds of ground beef were recalled.

sich teilen
in geeigneter Weise
Auftauen / nehmen wieder auf

4. Bacteria can be grown under strictly controlled conditions and many will grow in a chemically defined culture medium containing mineral salts and a simple organic nutrient such as glucose.
5. Bacteria grow fast and may divide in as little as 20 minutes, whereas higher organisms often take days or years for each generation (Fig. 2.11).
6. A bacterial culture contains around 10^9 cells per ml. Consequently genetic experiments that need to analyze large numbers of cells can be done conveniently.
7. Bacteria can be conveniently stored for short periods (a couple of weeks) by placing them in the refrigerator and for longer periods (20 years or more) in low temperature freezers at –70°C. Upon thawing, the bacteria resume growth. Thus it is not necessary to keep hundreds of cultures of bacterial mutants constantly growing just to keep them alive.

Flüssigsuspension
Agarschicht / Petri-Schalen
Meeresalgen / aushärtet
Anforderungen / selten / Dichte

In practice, bacteria are usually cultured by growing them as a suspension in liquid inside tubes, flasks or bottles. They can also be grown as colonies (visible clusters of cells) on the surface of an agar layer in flat dishes, known as Petri dishes (Fig. 2.12). Agar is a carbohydrate polymer extracted from seaweed that sets, or solidifies, like gelatin.

It should be noted that the convenient properties noted above apply to commonly grown laboratory bacteria. In contrast, many bacterial species found in the wild are difficult or, by present techniques impossible, to culture in the laboratory. Many others have specialized growth requirements and most rarely grow to the density observed with the bacteria favored by laboratory researchers.

pathogenic pathogen, krankheitserregend

FIGURE 2.12 ***Bacterial Colonies in a Petri Dish***

A Petri dish showing colonies of *Escherichia coli* 0157:H7 growing on nutrient agar medium [Agar-Nährmedium]. This strain sometimes causes food-borne illness [von der Nahrung herrührende Erkrankung]. It may cause bloody diarrhoea and occasionally kidney failure [Nierenversagen], particularly in the elderly or very young. This *E. coli* strain originates from the intestines of cattle [Darm von Rindern] and spreads to contaminate beef [Rindfleisch] and milk. Provided by TEK Image, Science Photo Library.

Stamm
Fruchtbarkeit
genetische Kreuzungsversuche
beschränkt auf
sich paaren

The famous K-12 laboratory strain of *E. coli* was chosen as a research tool because of its fertility. In 1946, Joshua Lederberg was attempting to carry out genetic crosses with bacteria. Until then, no mechanisms for gene transfer had been demonstrated in bacteria, and genetic crosses were therefore thought to be restricted to higher organisms. Lederberg was lucky, as most bacterial strains, including most strains of *E. coli*, do not mate. But among those he tested was one strain (K-12) of *E. coli* that happened to give positive results. Mating in *E. coli* K-12 is actually due to a **plasmid**, an extra circular molecule of DNA within the bacterium that is separate from the chromosome. Because the plasmid carries the genes for fertility, it was named the **F-plasmid**.

Der Entdecker des Operons (siehe Kapitel 9), Jaques Monod, meinte: „Was für E. coli gilt, gilt auch für den Elefanten."

Escherichia coli (E. coli) Is a Model Bacterium

stäbchenförmig
Lebensraum / Grimmdarm (Colon)
Dickdarm / Säugetiere
entwirren

Although many different types of bacteria are used in laboratory investigations, the bacterium used most often in molecular biology research is *Escherichia coli*. *E. coli* is a rod-shaped bacterium of approximately 1 by 2.5 microns. Its natural habitat is the colon (hence "coli"), the lower part of the large intestine of mammals, including humans. The knowledge derived by examining *E. coli* has been used to untangle the genetic operation of other organisms. In addition, bacteria, together with their viruses and plasmids, have been used experimentally during the genetic analysis of higher organisms.

F-plasmid F-Faktor; Fertilitätsplasmid; spezielles Plasmid, das die Fähigkeit zur Konjugation auf seinen bakteriellen Wirt *Escherichia coli* überträgt
plasmid Plasmid; ringförmiges Molekül aus doppelsträngiger DNA, das sich unabhängig von den Chromosomen der Wirtszelle replizieren kann; selten kommen auch lineare Plasmide vor