Einführung in die Mikrobiologie (WS 19/20)

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Molekulare Mikrobiologie & Bioenergetik
Institut für Molekulare Biowissenschaften

Vorlesung:	**Mittwochs: 10.15 - 12.00**
	Freitags: 9.15 - 11.00
Sprechstunde:	**Nach der Vorlesung oder**
	Dienstags, 10.00 - 12.00
	nach Voranmeldung im Sekretariat
	bitte keine emails!

Was ist Mikrobiologie?

Teilbereich der Biologie, der sich mit mikroskopisch kleinen Organismen befasst:

- Protozoen, Algen, Pilze (Eukaryoten)

- Bakterien, Archaeen (Prokaryoten)

- Viren

Einige Folien sind als downloads verfügbar:

http://www.mikrobiologie-frankfurt.de

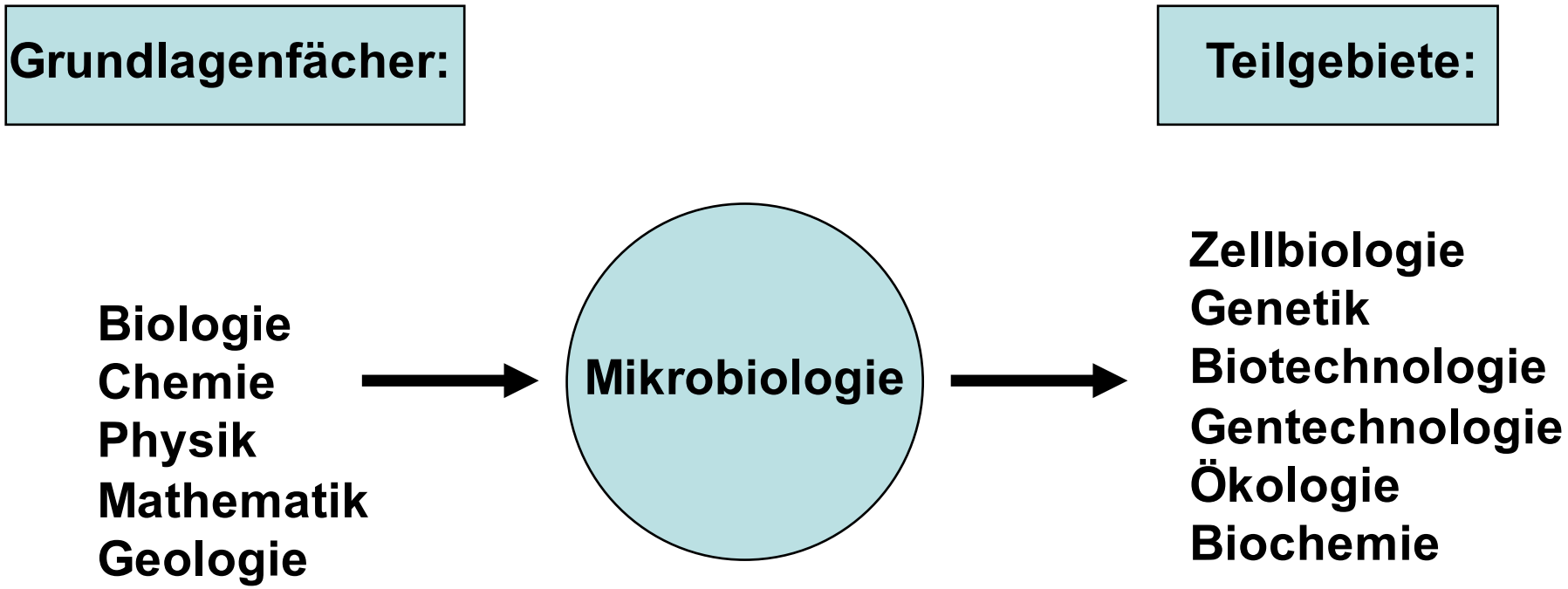
Unter: teaching

Password: mikrobiologie-frankfurt

Für den Inhalt der Folien wird, gerade in Hinblick auf die Klausur, keine Haftung übernommen.

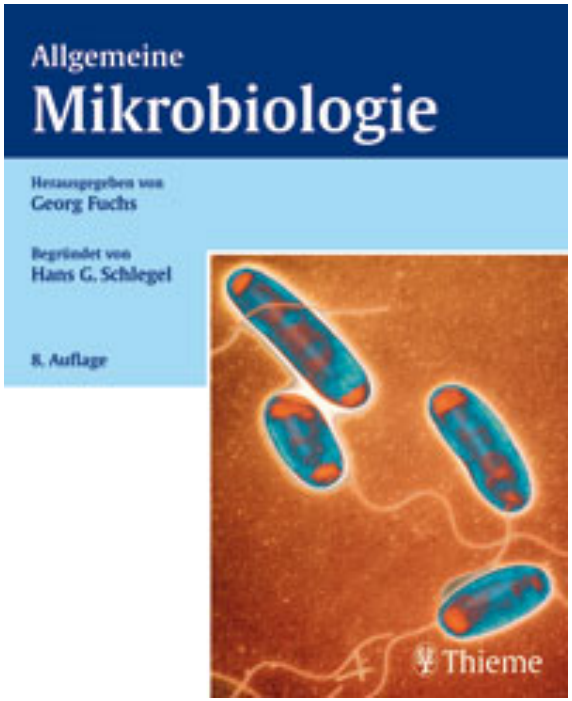
Die Folien ersetzen auf keinen Fall den Besuch der Vorlesung. In der Vorlesung werden darüber Hinausgehende Informationen, aber auch Kommentare und Korrekturen geliefert

Mikrobiologie:
Biologie von Mikroorganismen:



Grundlagen- und angewandte Forschung

Lehrbuch



Georg Fuchs (Hrsg.)

Allgemeine Mikrobiologie
Begr. v. Hans G. Schlege
lISBN: 9783134446081

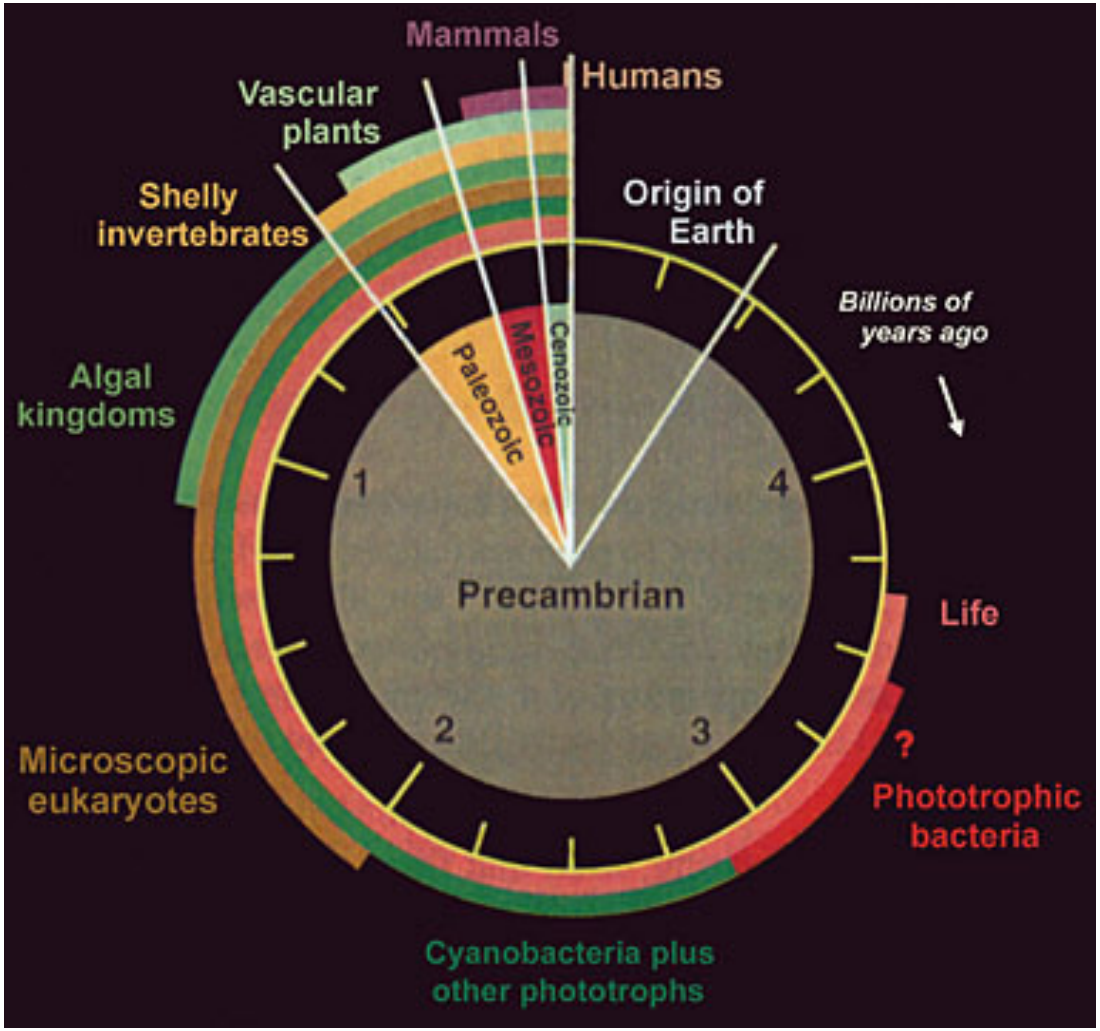
EUR [D] 49,95

Ausreichend Exemplare in der Bibliothek vorhanden!

Meine Aufgabe:	Ihre Aufgabe:
Sie einzuführen in die faszinierende Welt der Mikroben	Ruhe bewahren, damit jeder in den Genuss kommen kann
Wissen zu vermitteln	Mitdenken während der Vorl.
Sie zu motivieren und stimulieren, nachzulesen	Die Vorlesung nachzuarbeiten
Klausur korrigieren	Klausur schreiben

The origin of life: a brief review

"How has life on Earth emerged from non-life sometime between 4.4 billion years ago, when liquid water first flowed on the Earth, and 3.5 billion years ago when the earliest uncontroversial evidence of life is found in the form of molecular biomarkers?"



Many theories

RNA-World theory

Iron sulfur-World theory

Bubble theory

Lipid-World theory

Clay theory

Deep hot biosphere theory

Extraterrestrial theory

Many theories

RNA-World theory

Iron sulfur-World theory

Bubble theory

Lipid-World theory

Clay theory

Deep hot biosphere theory

Extraterrestrial theory

Conflicting theories

chemo(photo)trophic vs. autotrophic

“genes first” vs. “metabolism first”

Conflicting theories

chemo(photo)trophic vs. autotrophic

“genes first” vs. “metabolism first”

RNA-World

Iron sulfur-World

RNA-World theory

Hypothesis 1: Abiotic synthesis of organic molecules

Miller-Urey in 1953

NO oxygen present

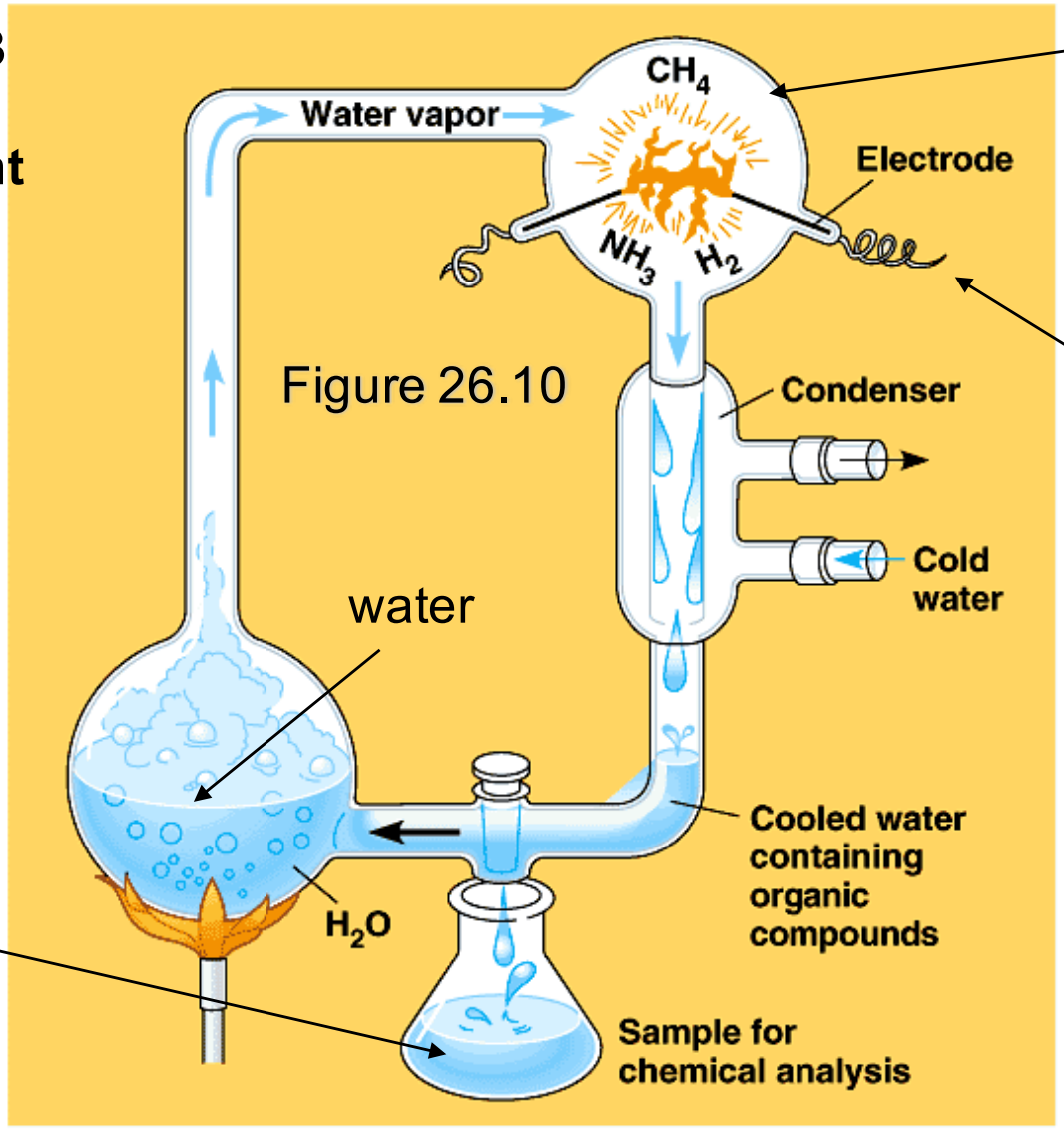
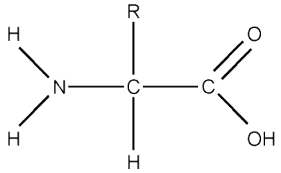


Figure 26.10

A "reducing" atmosphere of inorganic molecules

Electric sparks → lightning

This combination produced organic molecules including amino acids



This *could* have been the origin of life **or** organic molecules could have originated from space **or**…

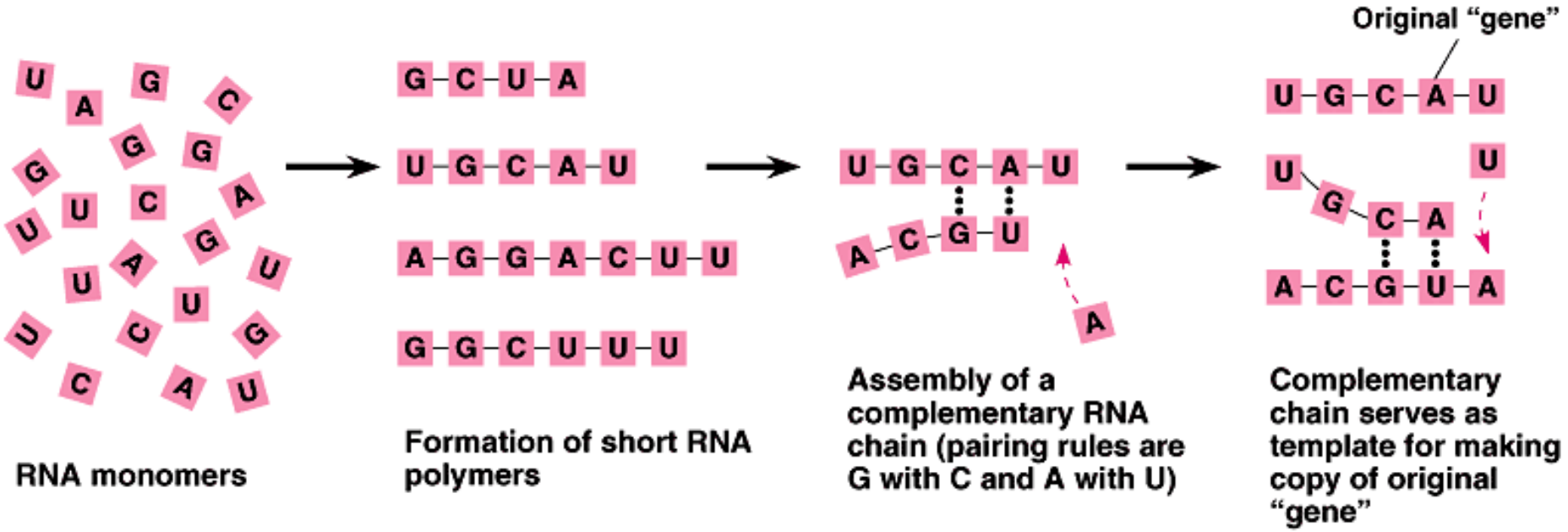
RNA-World theory

Hypothesis 2: Abiotic joining of small molecules into polymers

Polypeptides can be formed from individual amino acids that are splashed onto hot rock, clay or sand (causing the loss of water – dehydration synthesis)

RNA-World theory

Hypothesis 3: Abiotic replication of molecules

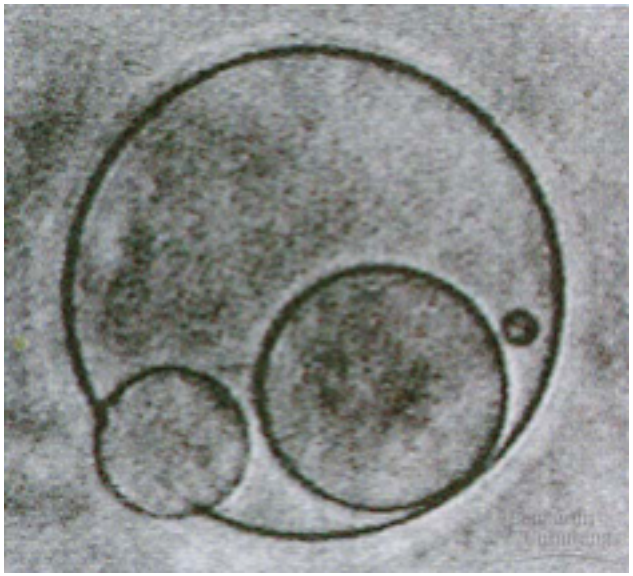


Ribonucleic Acid (RNA)

- *Probably* first hereditary material
- Can form spontanously (following base-pairing rules)
- Has catalytic activity (ribozymes)

RNA-World theory

Hypothesis 4: Self-assembly of protobionts



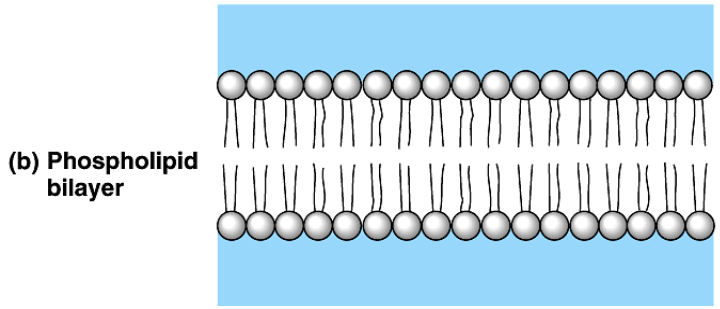
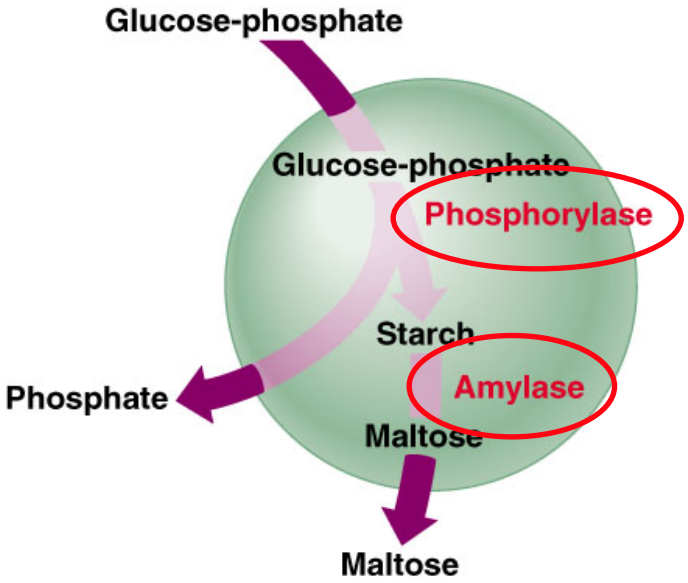


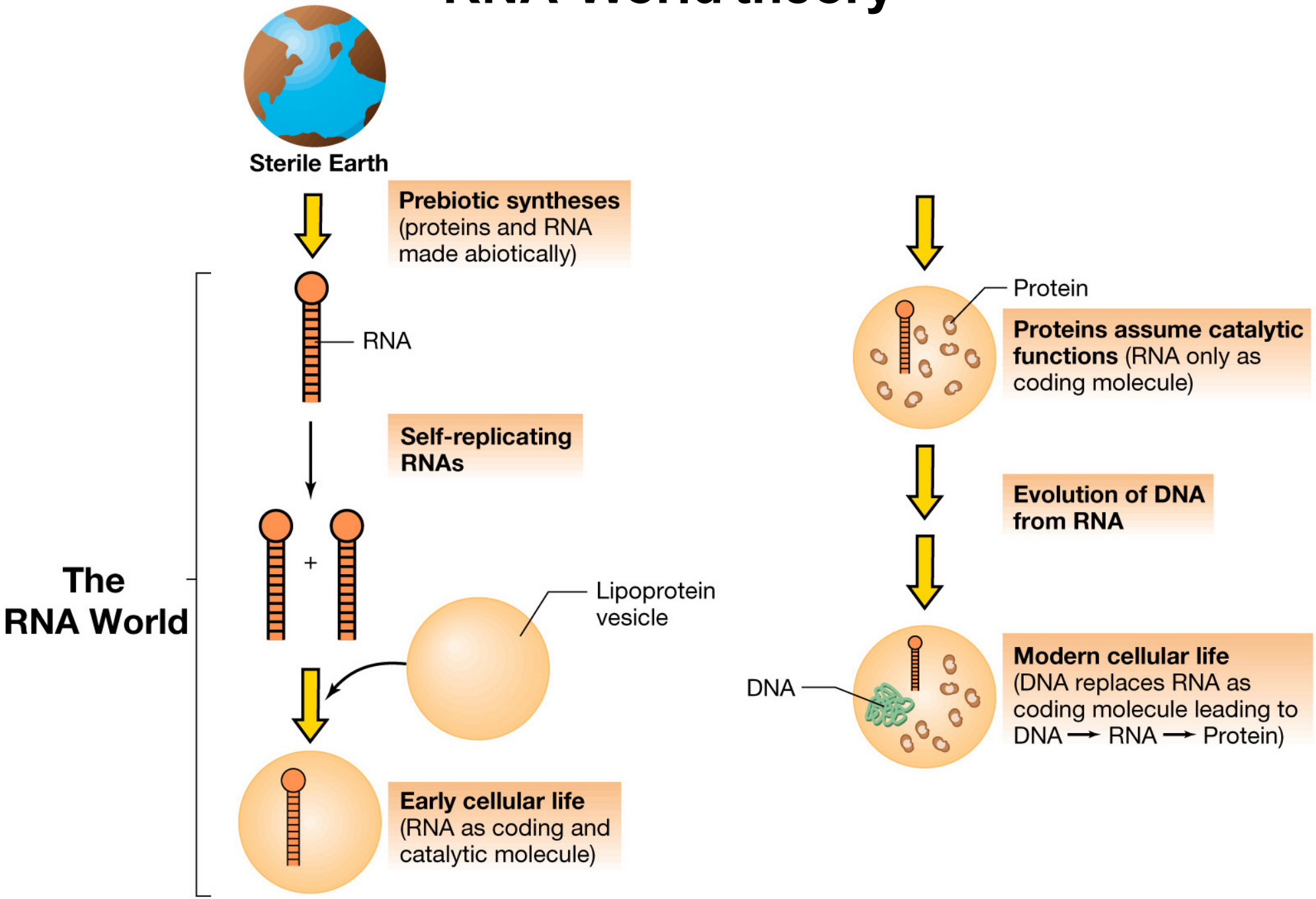
Figure 5.13

Liposome: lipids that self-organize into a bilayer



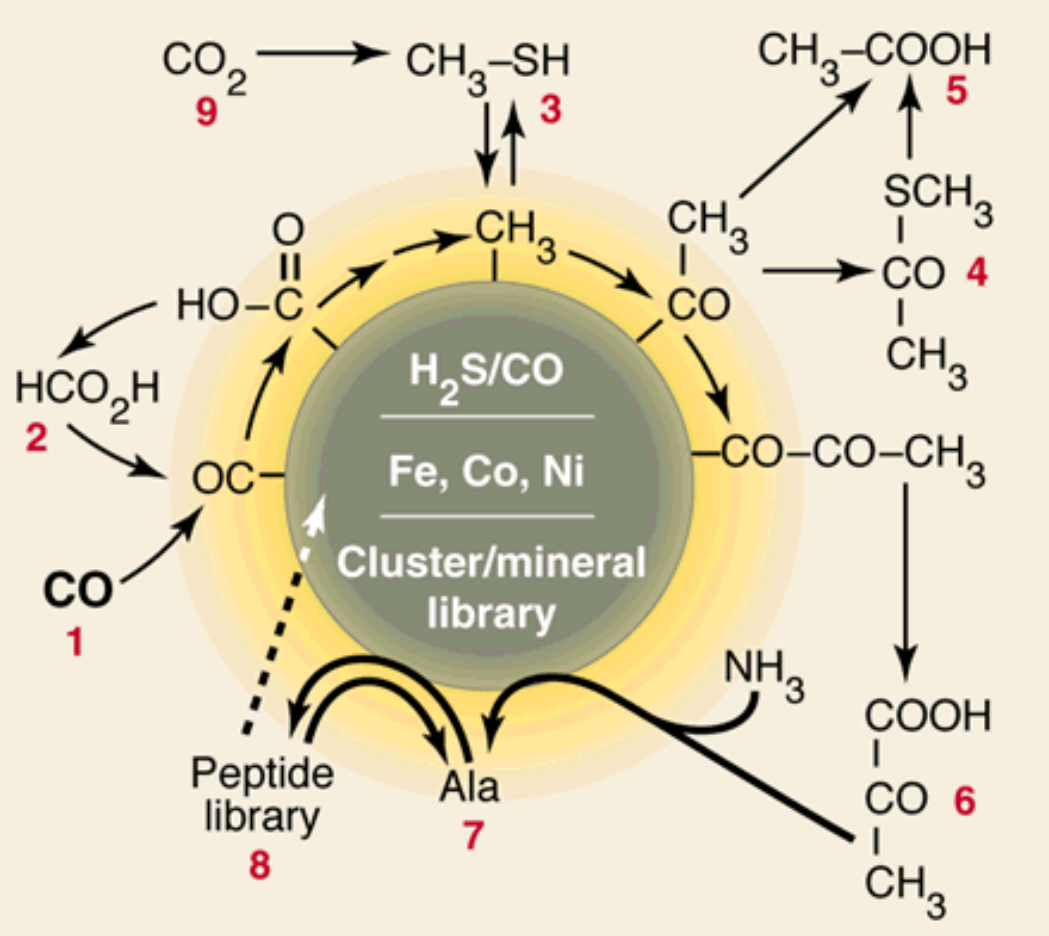
If the appropriate enzymes are included in the solution from which the lipids self-assemble, some can carry out metabolic pathways

RNA-World theory



The Iron/Sulfur-World theory

prebiotic reactions occurred not in solution but on a surface

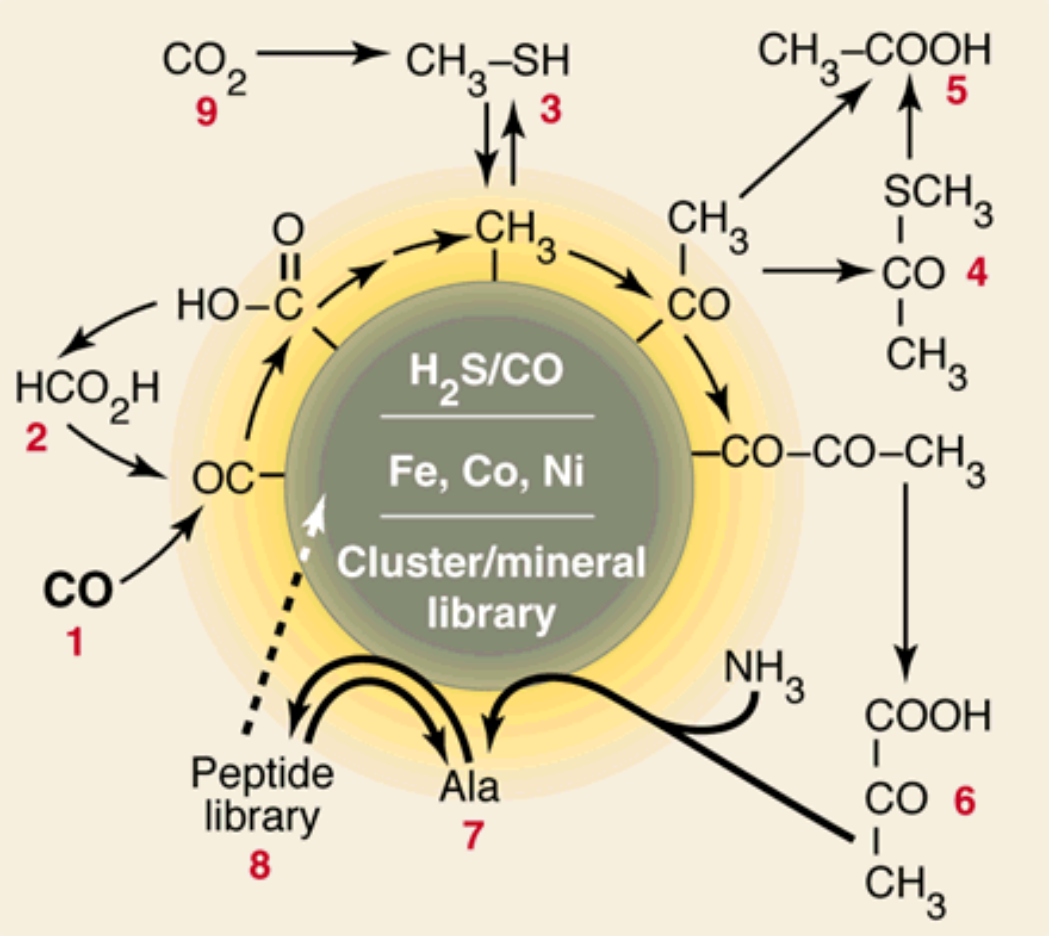


autocatalysis = reproduction.....evolution

Günter Wächtershäuser (2000) Life as We Don't Know It. *Science*, 289-1307 - 1308

The Iron/Sulfur-World theory

prebiotic reactions occurred not in solution but on a surface

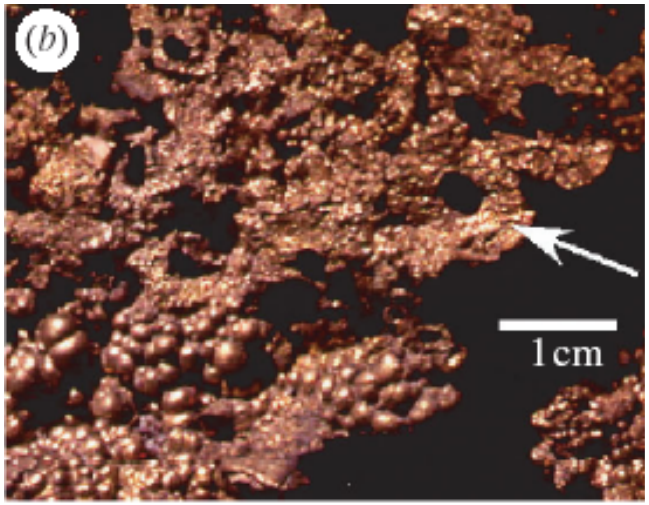


autocatalysis = reproduction.....evolution

"According to my theory, you can imagine life forms continuously, even today."

The Iron/Sulfur-World theory

“origin of biochemistry at an alkaline hydrothermal vent”



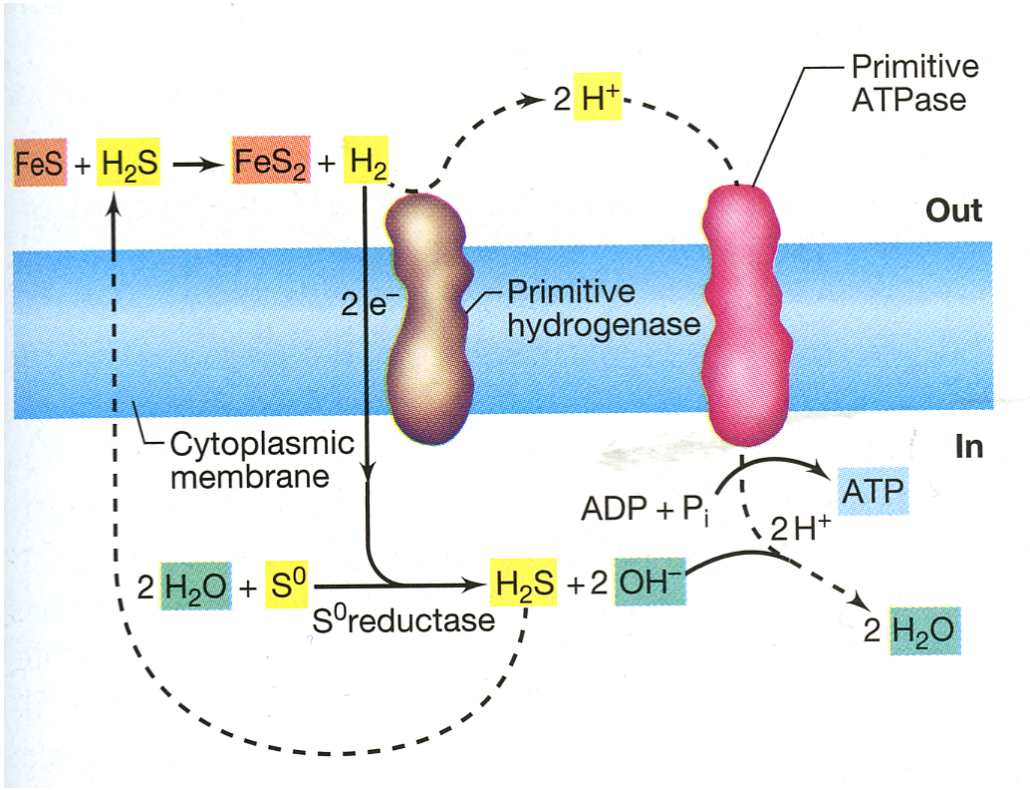
Lost City hydrothermal field (Mid-Atlantic ridge, 30 ° N)

Martin W and Russell MJ. (2007) On the origin of biochemistry at an alkaline hydrothermal vent. *Philos Trans R Soc Lond B Biol Sci.* 362:1887-1925.

The Iron/Sulfur-World theory

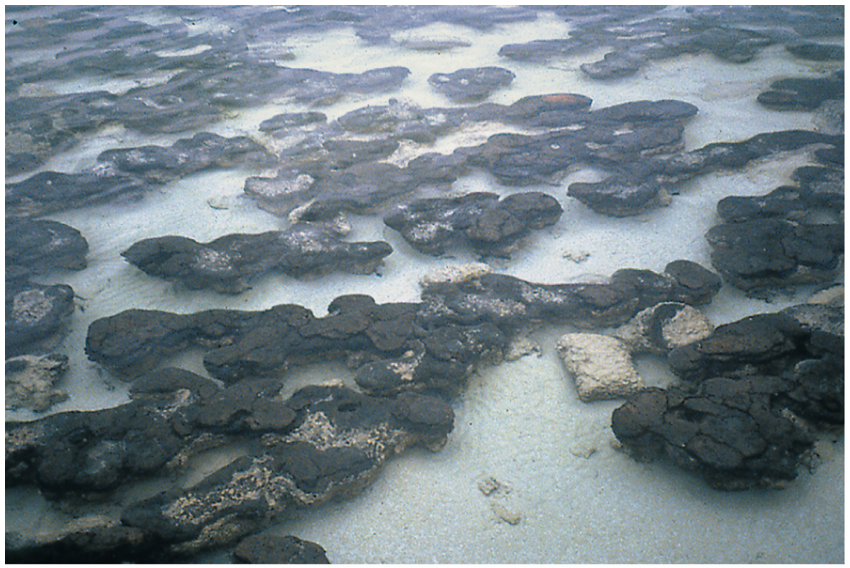
"origin of biochemistry at an alkaline hydrothermal vent"

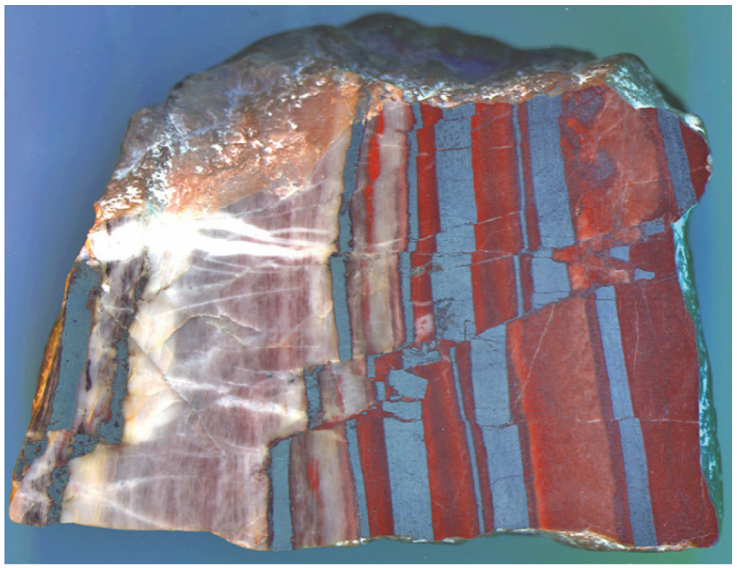
acetogen



methanogen

S/H_2 metabolism





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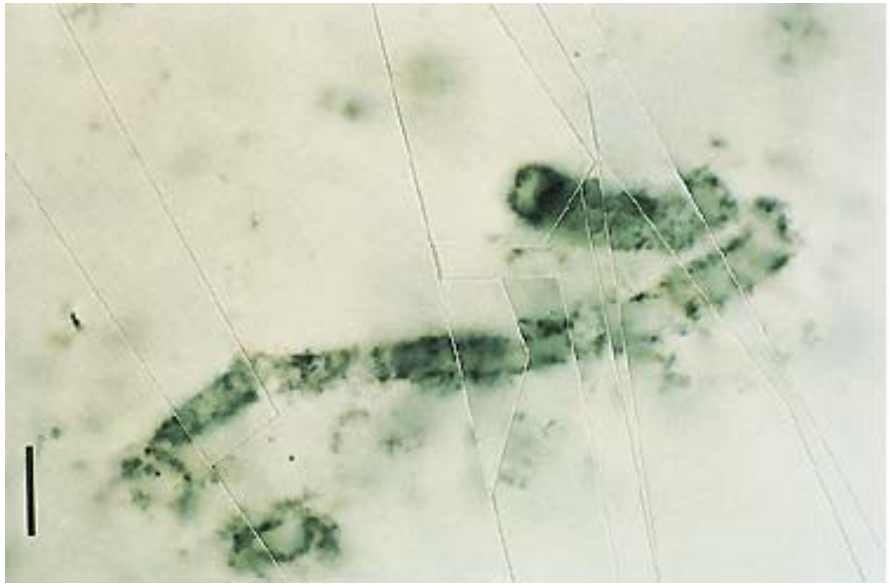
Fuchs et al.: Allgemeine Mikrobiologie, 8. Auflage · 2006

Prokaryoten-die ersten Organismen



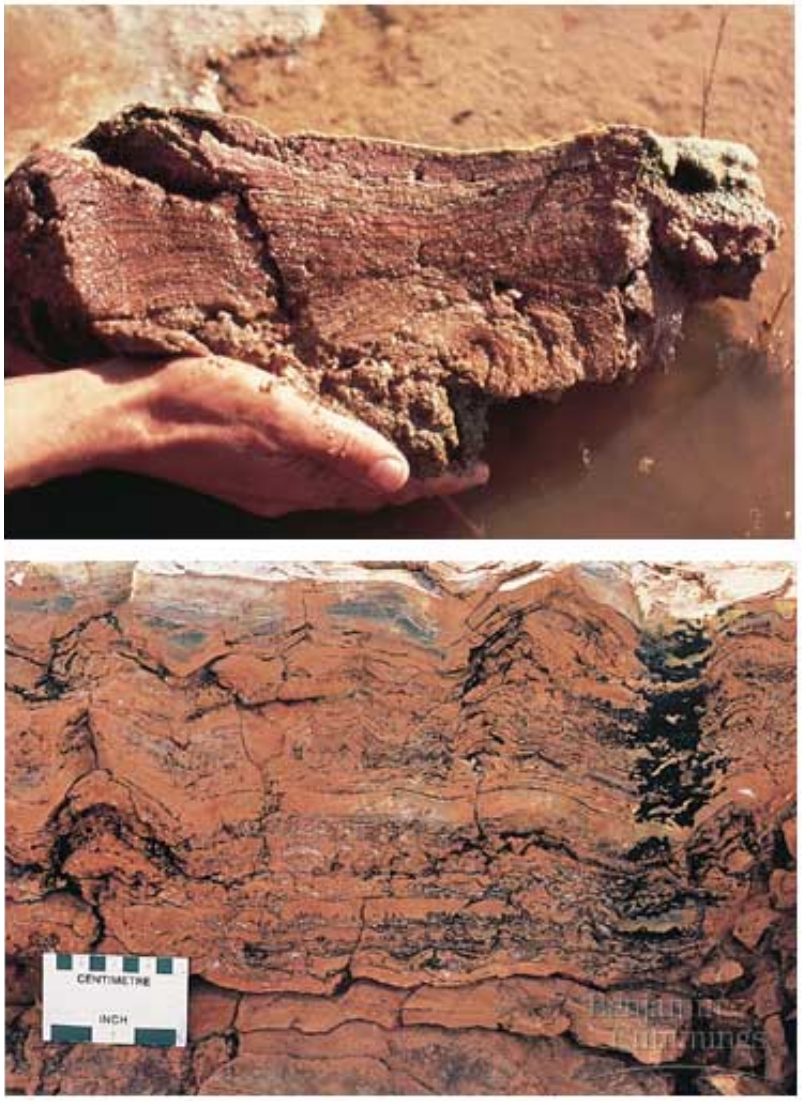
3.5 billion year-old bacteria?

Modern filamentous bacteria

Fossile Bakterien

Filamentöse Cyanobakterien (Bitter Springs chert, central Australia) datiert -850 Ma

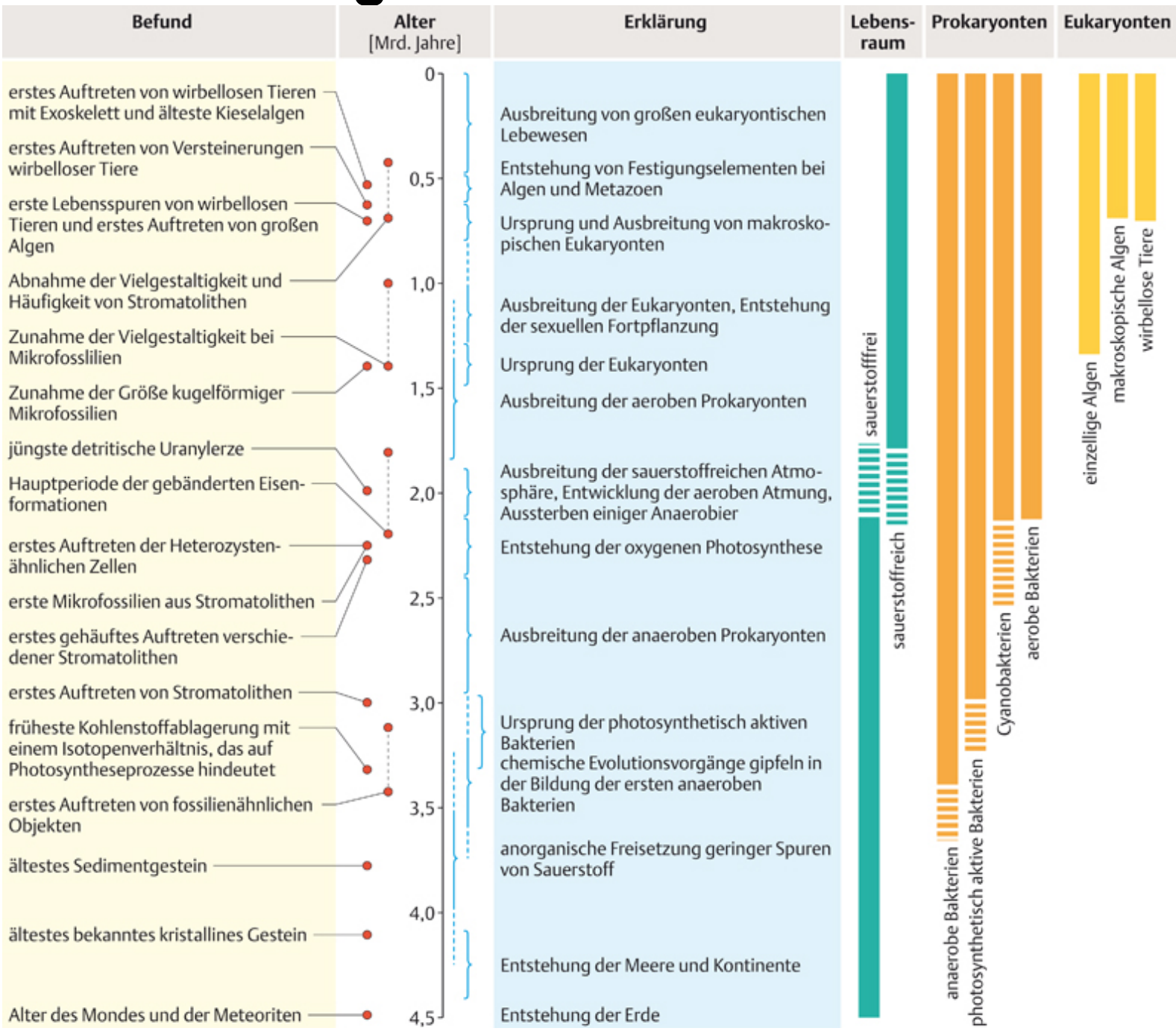
Cyanobakterien



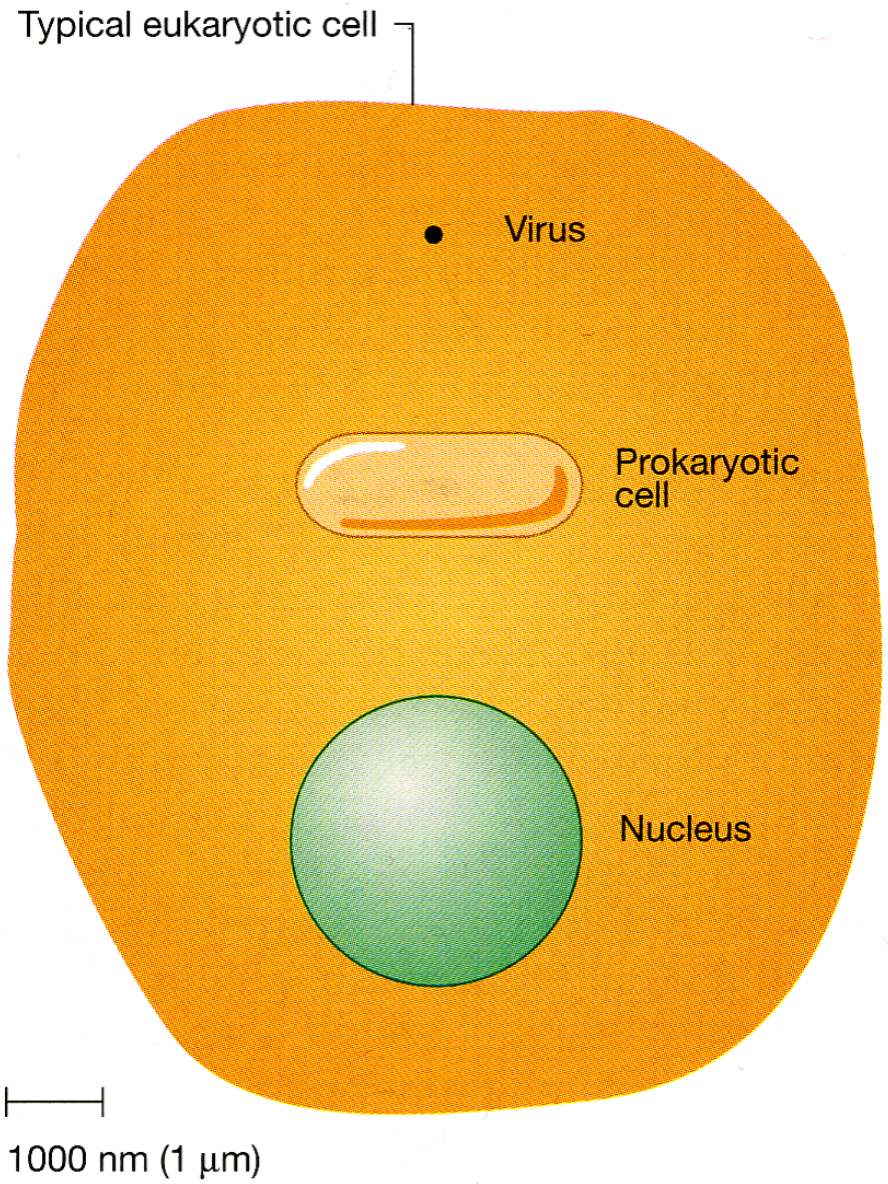
Fossilized (stromatolites)

Modern (living bacterial mats)

The origin of life: a brief review



Dimensionen von Zellen

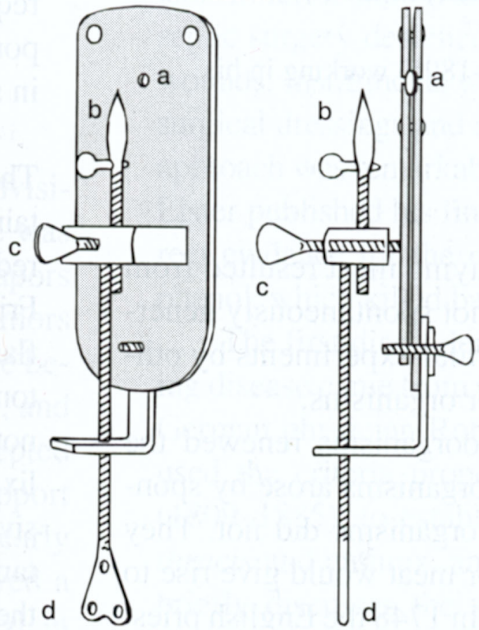


2.3c

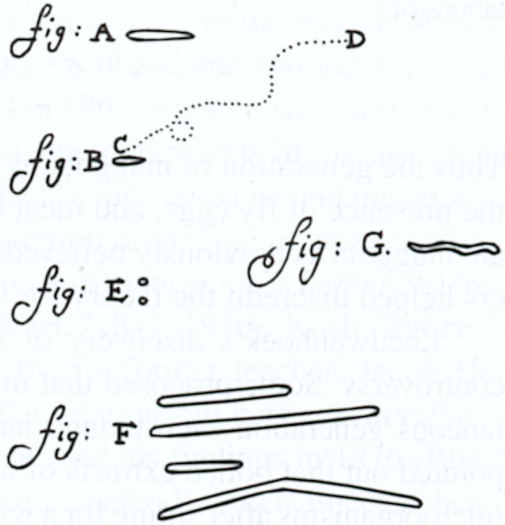
Historie

Mikroskopie: van Leeuwenhoek (1632-1723)

(a)

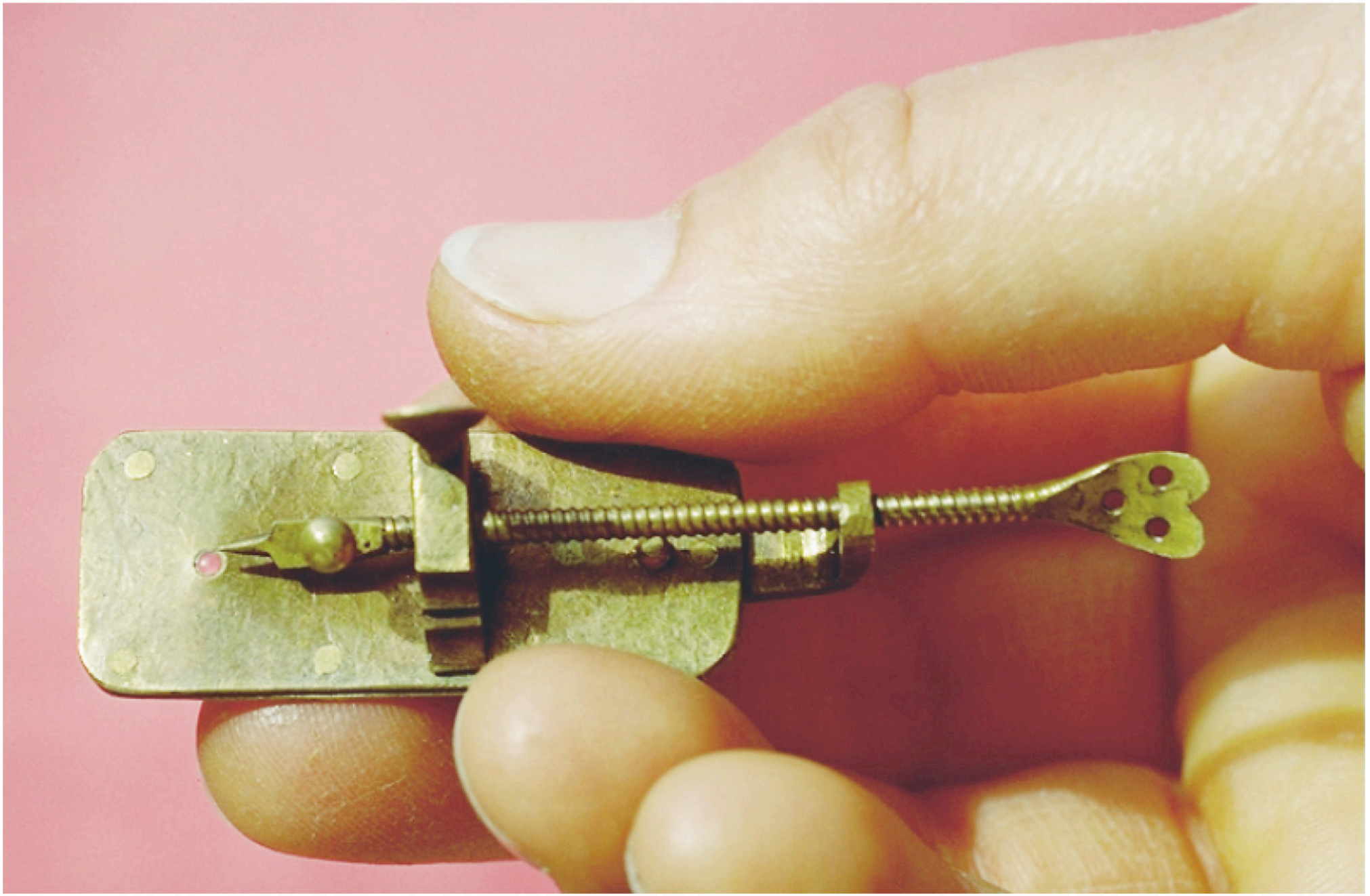


(b)



(c)

Figure 1.1 **Antony van Leeuwenhoek.** Leeuwenhoek (1632–1723) and his microscopes. (**a**) Leeuwenhoek holding a microscope. (**b**) A drawing of one of the microscopes showing the lens, *a;* mounting pin, *b;* and focusing screws, *c* and *d*. (**c**) Leeuwenhoek's drawings of bacteria from the human mouth. (*b*) *Source: C. E. Dobell,* Antony van Leeuwenhoek and His Little Animals *(1932), Russell and Russell, 1958.*



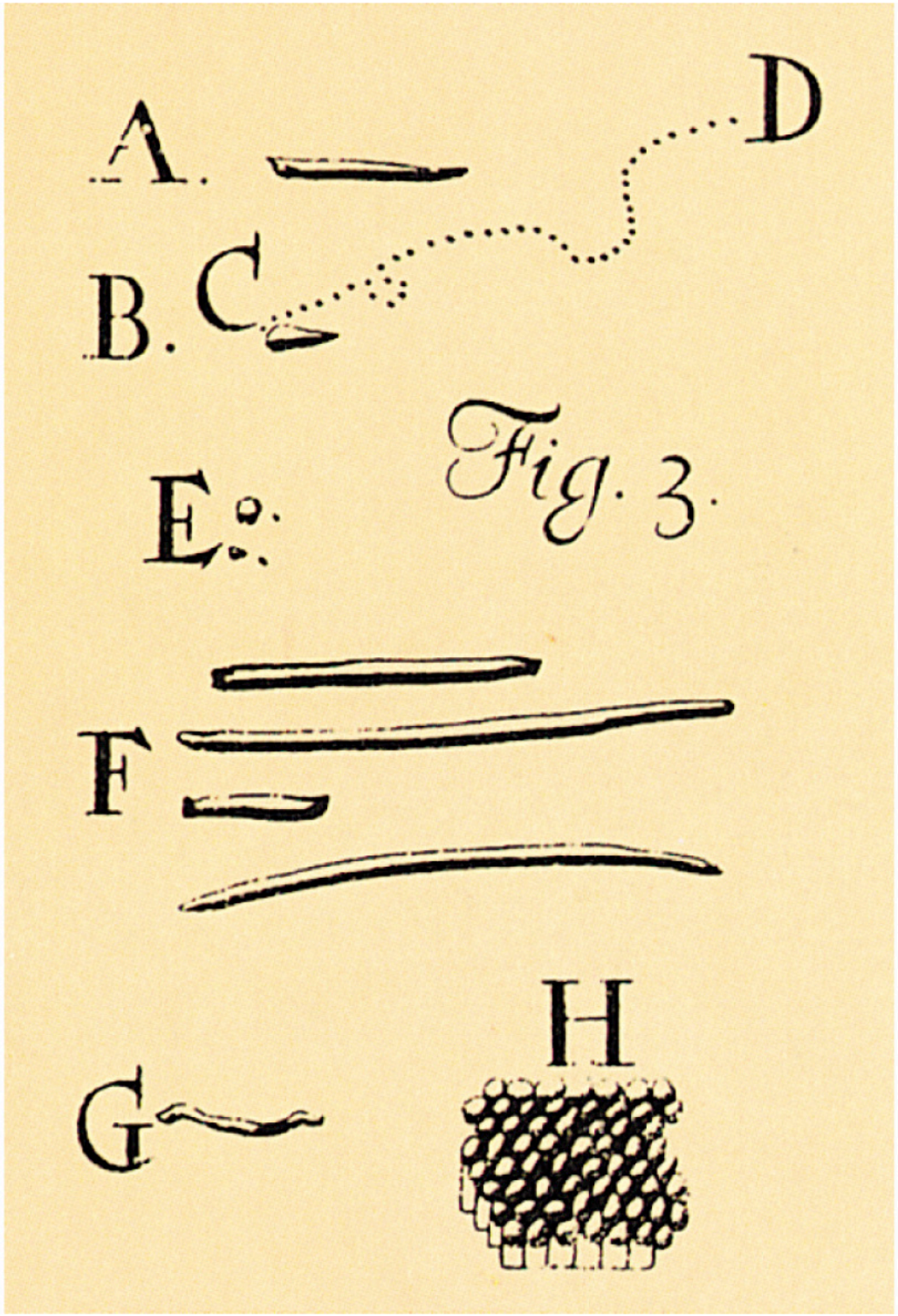


Fig. 3.

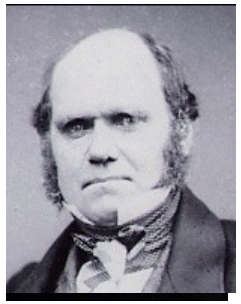
Geschichte der Systematik/Phylogenie

Aristoteles (ca. 350 v. Chr.): Scala Naturae. Einteilung nach dem Grad der Perfektion

Carl v. Linnné (1758) Systema Naturae. Binominale Nomenklatur (eindeutige Benennung der Arten unabhängig von ihrer Beschreibung)

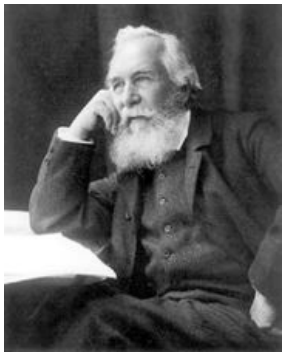
Evolutionstheorien

- **Wheewell** (1832, Katastrophismus)
- **Lamarck** (1809, Philosophie zoologique)
- **Darwin** (1859, On the Origin of Species)

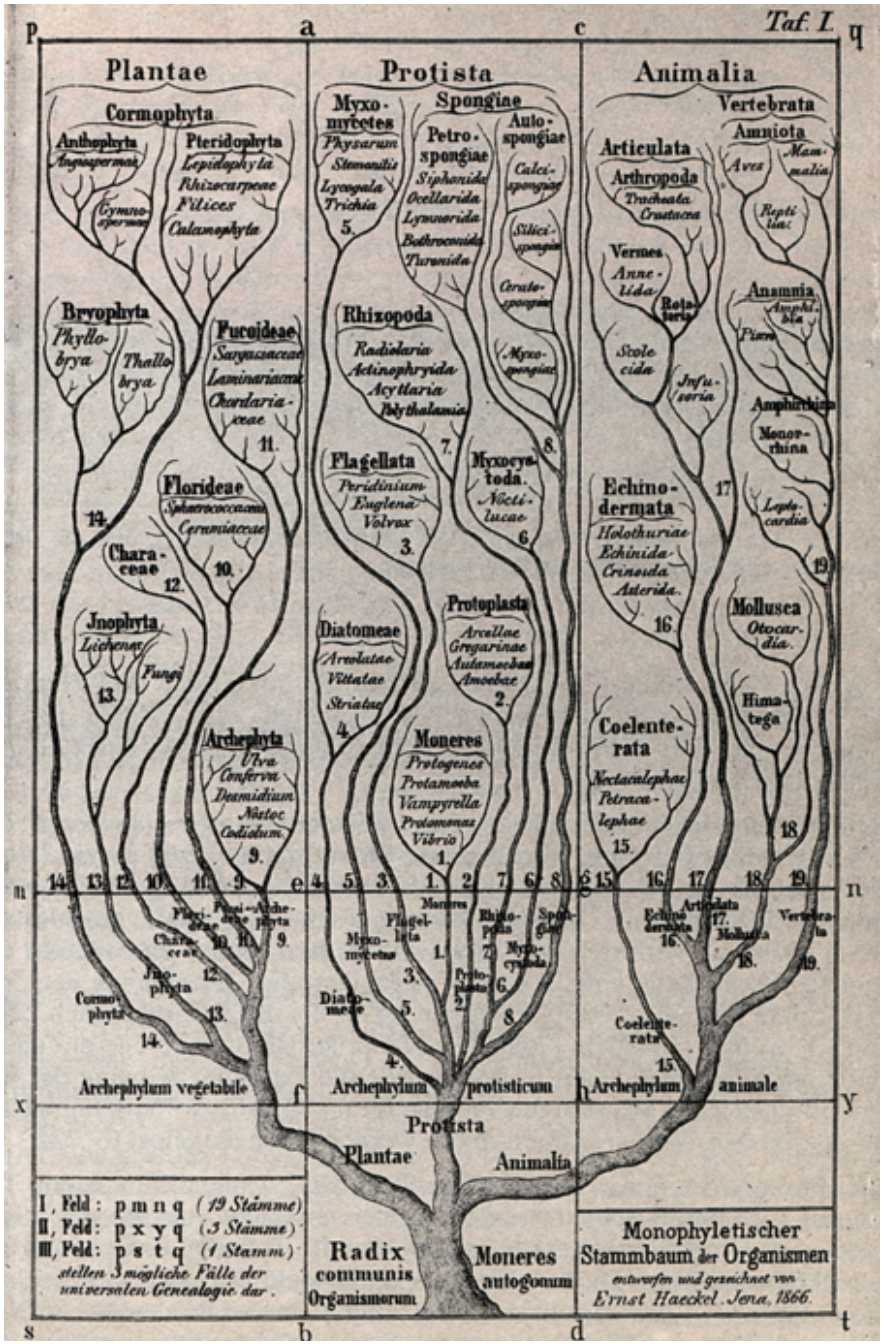


Ernst Heinrich Haeckel (1866, Generelle Morhologie)

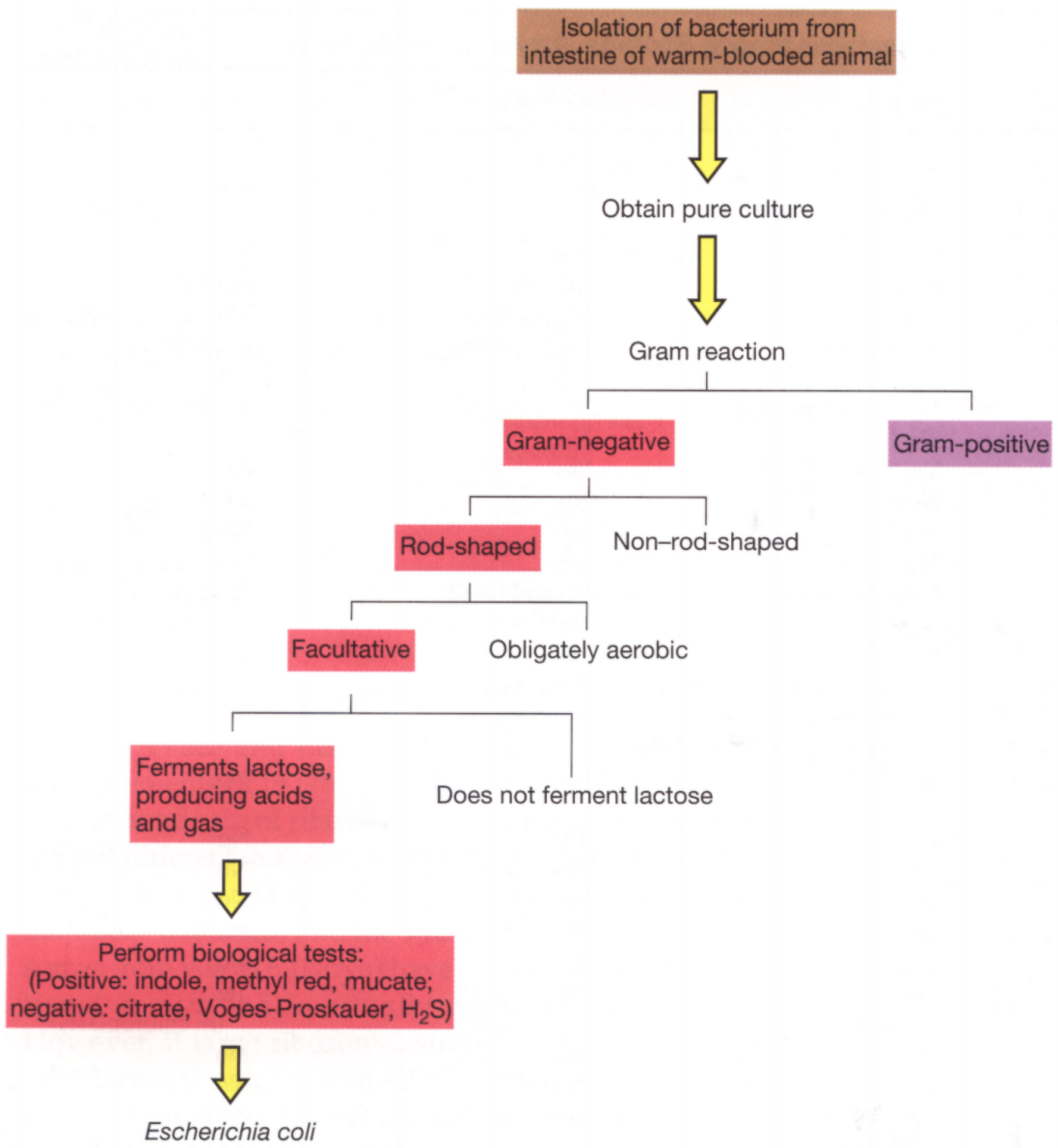
3 Reiche: Plantae, Animalia, Protista



Haeckels Stammbaum (1866)



Taxonomie: Identifizierung



Isolierung

↓

Reinkultur

↓

Bestimmungsschlüssel

↓

Identifizierung

Systematik/Phylogenie

Auswertung von strukturellen (morphologischen/anatomischen) Merkmalen von Fossilien.

Vergleich der strukturellen Merkmale rezenter Lebewesen (Analyse von Homologien).

Vergleich der Ontogenese (Individualentwicklung) vorwiegend rezenter Lebewesen

Vergleich der physiologischen Merkmale rezenter Lebewesen (Analyse von Homologien).

Molekulargenetische Analyse (z. B. DNA-Sequenzanalyse).

schwierig

schwierig

schwierig

Die molekulare Uhr

1. universell verbreitet
2. funktionell homolog = gleiche Funktion
3. konservierte / variable Regionen
4. "Langsame" Evolutionsrate
5. ausreichende Länge (Statistik)

Zuckerkandl und Pauling

16S rRNA als Molekulare Uhr

Carl Woese: 1928-

"Comparison of the DNA sequences of a specific gene can offer evolutionary and taxonomical insights in the microbial world."

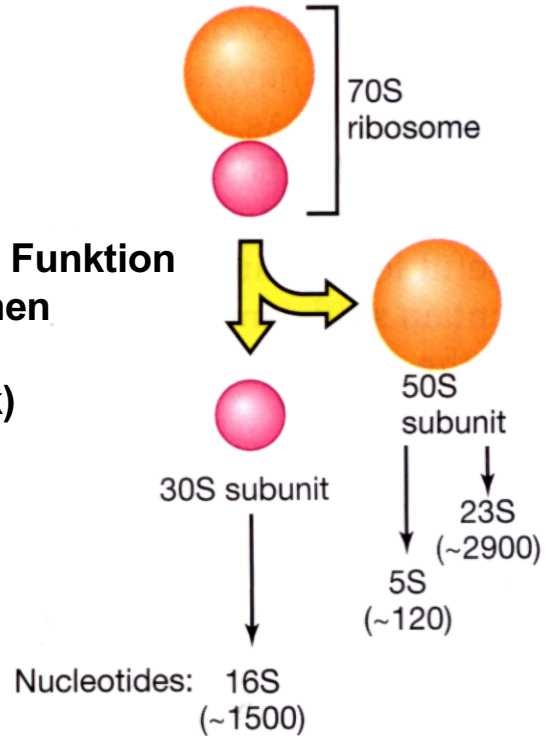
Carl Woese an Thanksgiving vor seinem Wagen. Man beachte das Nummernschild.

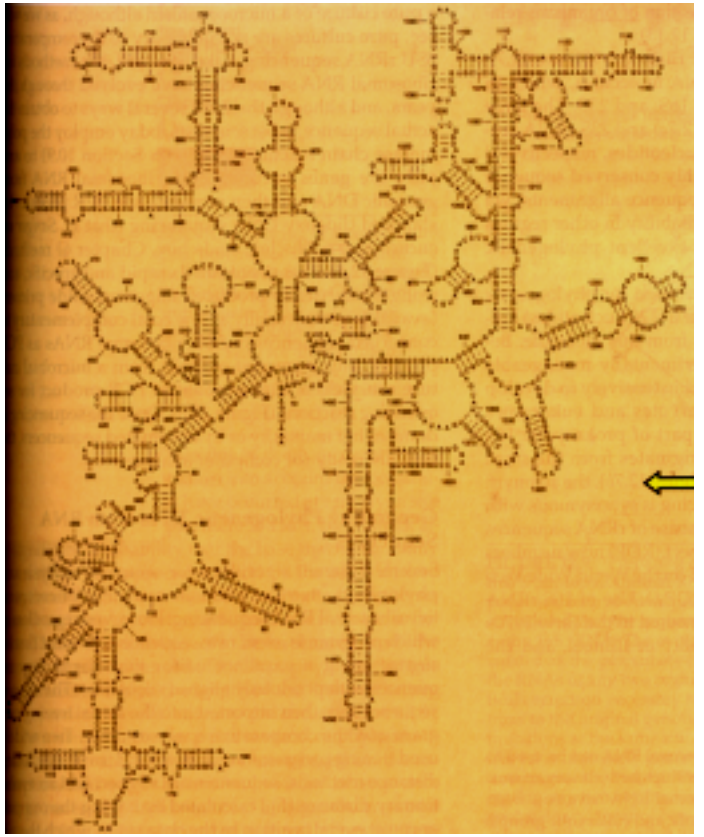
16S rRNA als Molekulare Uhr

Sequenzierung von 16S rRNA Genen (DNA) verschiedenster Mikroorganismen ergab:

1. **Universell konservierte Regionen.**
2. **Regionen, die innerhalb von Phyla, Klassen, Genera konserviert sind.**
3. **Hypervariable Regionen.**

1. universell verbreitet
2. funktionell homolog = gleiche Funktion
3. konservierte / variable Regionen
4. "Langsame" Evolutionsrate
5. ausreichende Länge (Statistik)





"A stool with one leg will not stand"

"Ether lipids"
(T. Langworthy)

"No murein"
(O. Kandler)

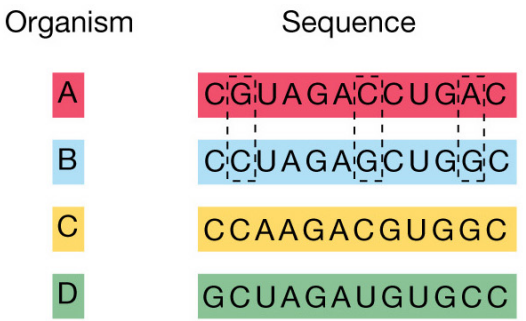
"multi SU RNAP"
(W. Zillig)

"16S rRNA"
(C. Woese)

Evolutionäre Distanz/Stammbäume

Sequenz

Stammbaum

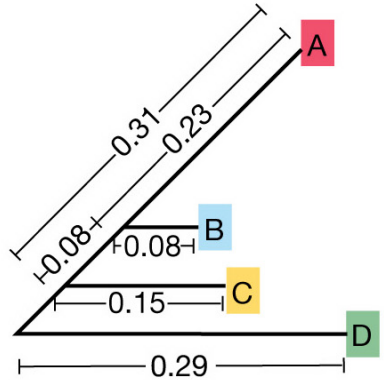


(a) **Sequence alignment and analysis**

Analysis

For A → B, three differences occur out of a total of twelve; thus $\frac{3}{12} = 0.25$

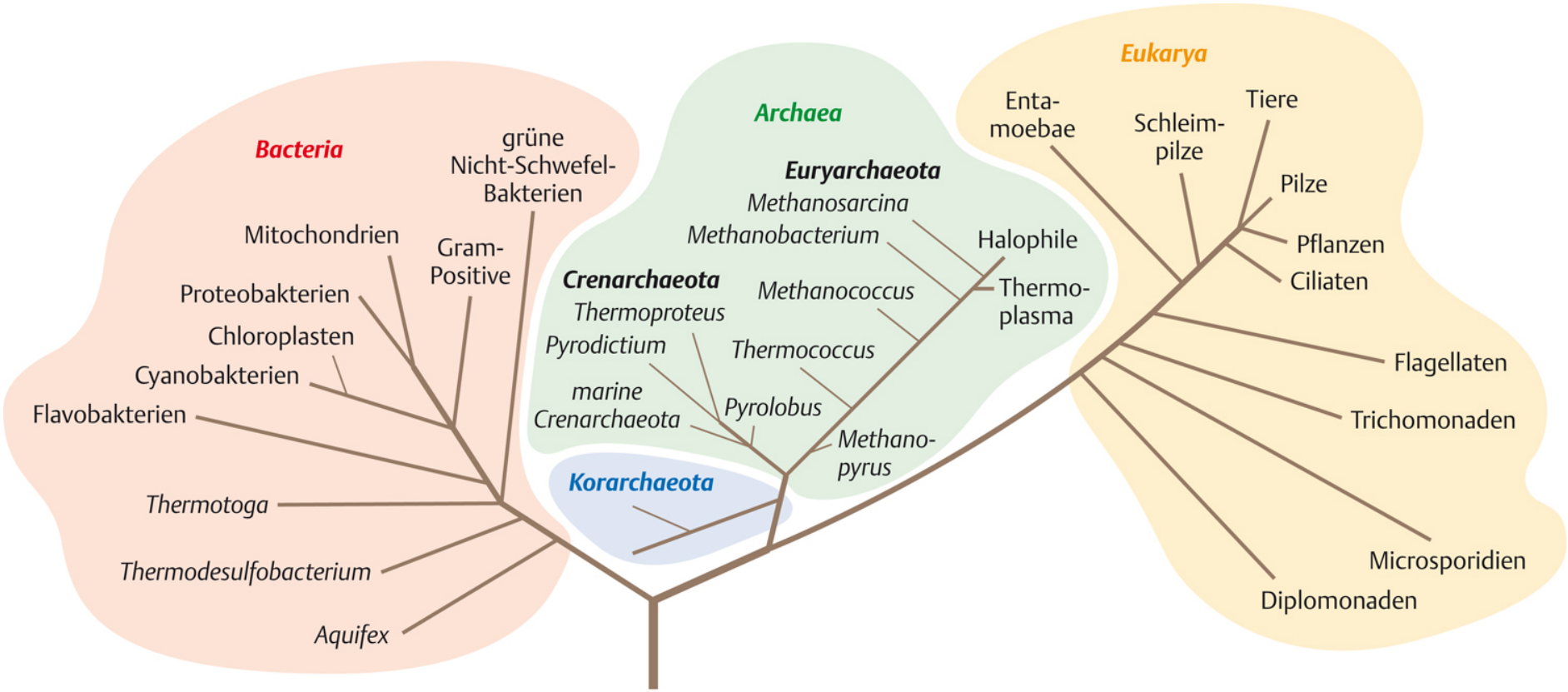
evolutionäre Distanz



(c) **Phylogenetic tree**

		Evolutionary distance	Corrected evolutionary distance
E_D	A → B	0.25	0.30
E_D	A → C	0.33	0.44
E_D	A → D	0.42	0.61
E_D	B → C	0.25	0.30
E_D	B → D	0.33	0.44
E_D	C → D	0.33	0.44

(b) **Calculation of evolutionary distance**



Georg Thieme Verlag, Stuttgart
Fuchs et al.: Allgemeine Mikrobiologie, 8. Auflage · 2006

Domänen des Lebens: Unterscheidung

1. Proteinsynthese

Bacteria: 70S-Ribosomen
Streptomycin, Chloramphenicol, Erythromycin
Diphtherietoxin-resistent

Archaea: 70S-Ribosomen
Antibiotika: Anisomycin
Diphtherietoxin-sensitiv

Eukarya: 80S-Ribosomen
Antibiotika: Anisomycin, Cycloheximid
Diphtherietoxin-sensitiv

Domänen des Lebens: Unterscheidung

2. Zellwände

Bacteria:	**Murein**
Archaea:	**Pseudomurein, S-Layer**
Eukarya:	**Cellulose, Chitin**

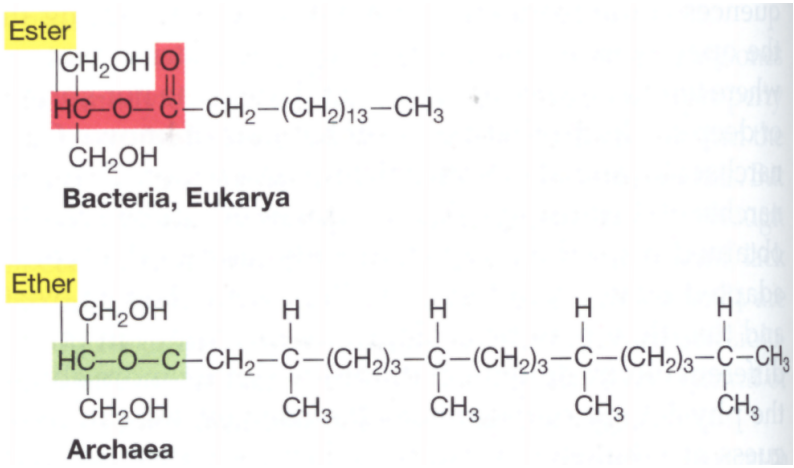
Domänen des Lebens: Unterscheidung

3. Lipide

Bacteria: **Esterlipide linear**

Archaea: **Etherlipide verzweigt**

Eukarya: **Esterlipide linear**



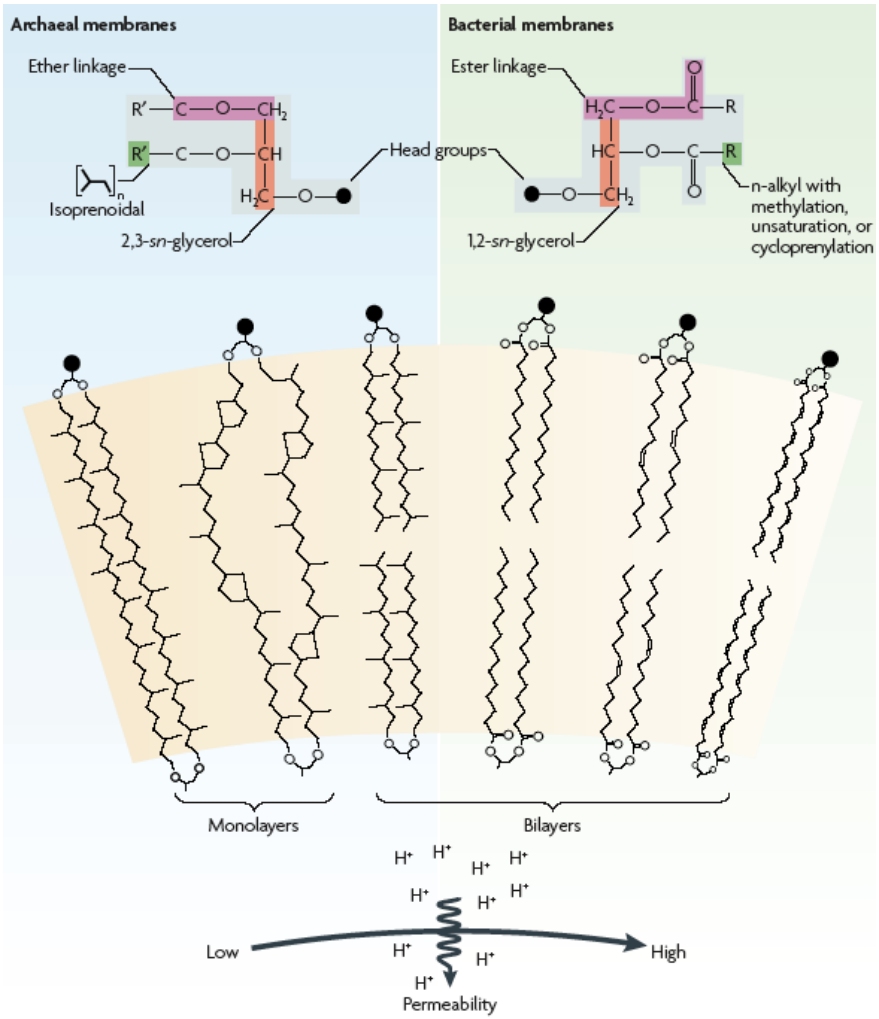
Domänen des Lebens: Unterscheidung

3. Lipide

Bacteria: **Esterlipide linear**

Archaea: **Etherlipide verzweigt**

Eukarya: **Esterlipide linear**



Domänen des Lebens: Unterscheidung

4. RNA-Polymerase

Bacteria:	**4 Untereinheiten** **Rifamycin-sensitiv**
Archaea:	**8-10 Untereinheiten** **Rifamycin-resistent**
Eukarya:	**10-12 Untereinheiten** **3 RNA-Polymerasen** **Rifamycin-resistent**

Prokaryontische/Eukaryontische Zellen

Gruppen:	**Bacteria/Archaea**	**Eukarya (Algen, Pilze, Protozoen, Pflanzen, Tiere**
Größe:	**< 2 μM**	**2 μM bis > 100 μM**
Zellkern:	**nein**	**ja**
DNA:	**meist ein Chromosom**	**mehrere Chromosomen**
	Plasmide	**keine Plasmide**
Ribosomen:	**70 S**	**80 S**
Membran:	**meist keine Steroide**	**meist Steroide, keine Hopanoide**
	Hopanoide	
Organelle:	**nein**	**ja: Chloroplasten, Mitochondrien**
Einschl.:	**Endosporen (selten)**	**nie**
	Magnetosomen (selten)	**selten**
	Gasvesikel (selten)	**nie**
Zellwand:	**Murein, S-Layer**	**Polysaccharide in Pflanzen,Pilzen**
Motilität:	**Flagellen, Rotation**	**Flagellen, Cilien, keine Rotation**
	Gleiten	