



UNIVERSITÄT  
LEIPZIG

Endosymbiontentheorie

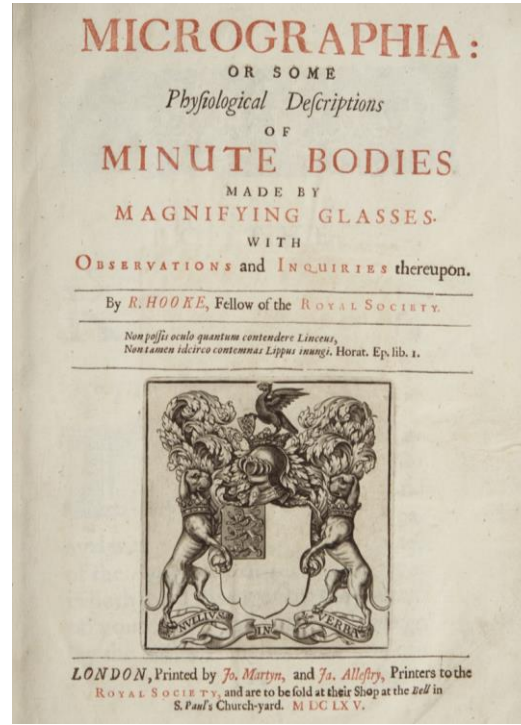
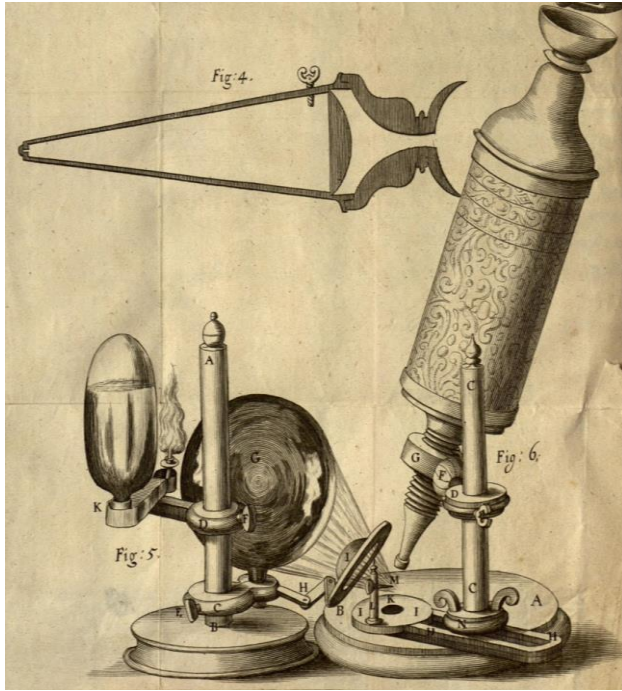
# Wie die Zelle ihr Kraftwerk bekam

Ludwig Lehmann

Leon Seidel

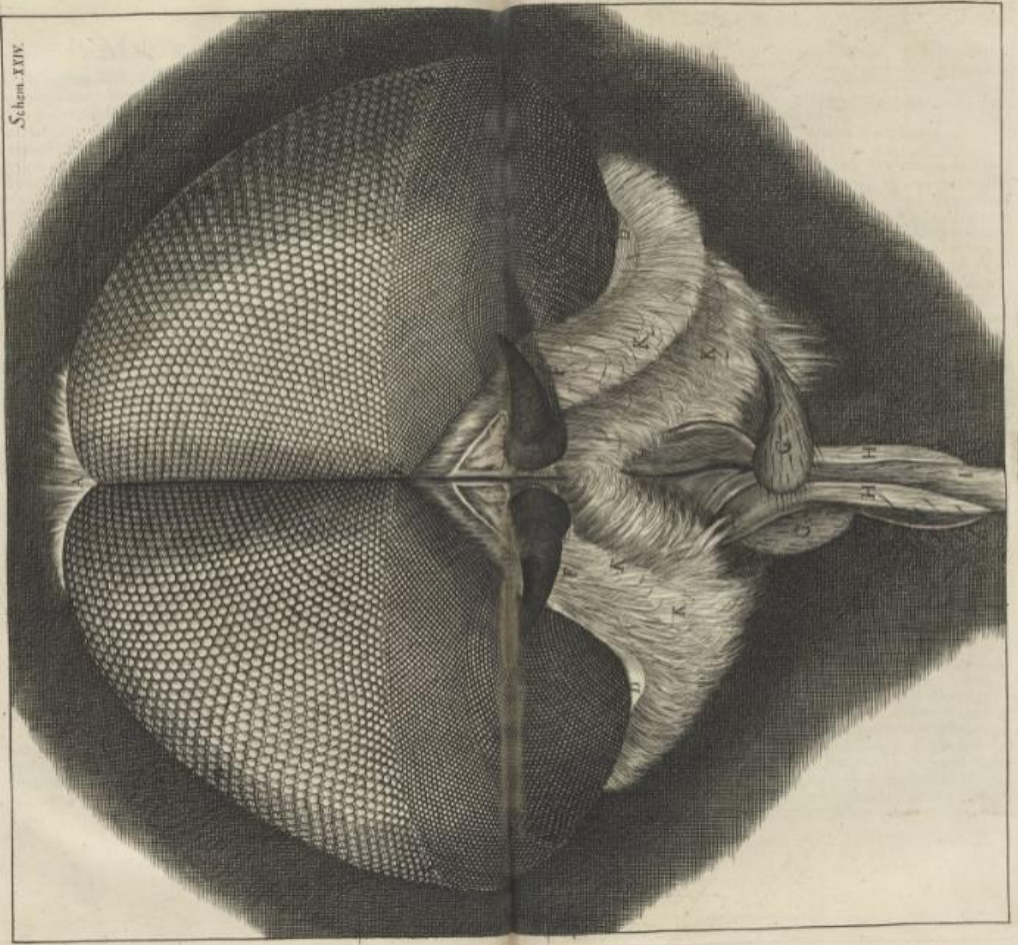
Leipzig, 22.06.2023

# AM ANFANG WAR DAS MIKROSKOP



Robert Hooke





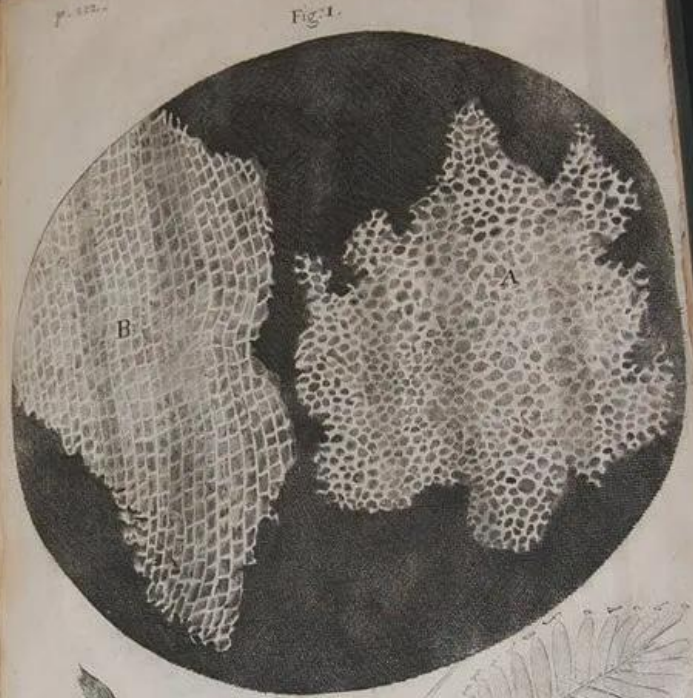
Schem. XIV.

MICROGRAPHIA.

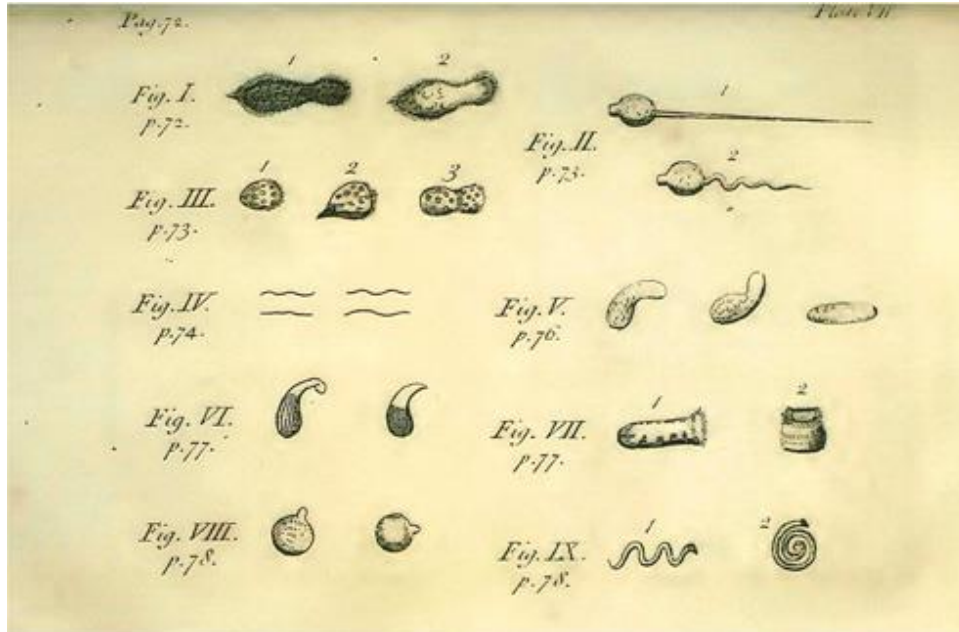
some other caverns in another, and others in a third, or a fourth, or a fifth place, for so many differing substances have I found in one of these porous Shells, and perhaps all these differing from the encompassing earth or Stone: the means how all these varieties may be caus'd, I think, will not be difficult to conceive, to any one that has taken notice of these Shells, which are commonly found on the Sea shore: And he that shall thoroughly examine several kinds of such curiously form'd Stones, will I am very apt to think) find reason to suppose their generation or formation to be ascribable to some such accidents as I have mention'd, and not to any *Plastic virtue*: For it seems to me quite contrary, and finite prudence of Nature, which is observable in all its works and productions, to design every thing to a determinate end, and for the attaining of that end, makes use of such ways as are (as far as the knowledge of man has yet been able to reach) altogether consonant, and most agreeable to humane Ratiocination; whereas it has a long time been or is contrary to man's reason, and of no way or means that does contradict a general observation and *maxime*, that *Nature does nothing in vain*. It seems, I say, contrary to that great Wisdom of Nature, that these prettily shap'd bodies should have all those curious Figures and contrivances (which many of them are adorn'd and contriv'd with) generated or wrought by a *Plastic virtue*, for no higher end then onely to exhibit such a form; which he that shall thoroughly consider all the circumstances of such kind of Figur'd bodies, will, I think, have great reason to believe, though I confess, one cannot presently be able to find out what Nature's designs are. It were therefore very desirable, that a good collection of such kind of figur'd Stones were collected; and as many particulars, circumstances, and informations collected with them as could be obtained, that from such a History of Observations well rang'd, examin'd and digested, the true original or production of all those kinds of Stones might be perfectly and surely known; such as are *Thunder-stones*, *Lapides stibares*, *Lapides Judaei*, and multitudes of other, whereof mention is made in *Alexandrus Wormius*, and other Writers of Minerals.

Observ. XVIII. Of the Schematisme or Texture of Cork, and of the Cells and Pores of some other such frothy Bodies.

I Took a good clear piece of Cork, and with a Pen-knife sharpen'd as keen as a Razor, I cut a piece of it off, and thereby left the surface of it exceeding smooth, then examining it very diligently with a *Micrascope*, me thought I could perceive it to appear a little porous; but I could not so plainly distinguish them, as to be sure that they were pores, much less what Figure they were of: But judging from the lightness and yielding quality of the Cork, that certainly the texture could not be so curious,



# AUF MEINEN ZÄHNEN LEBT ES



Antonie van Leeuwenhoek

## EINE LANGE PAUSE...



Marcello Malpighi



Nehemiah Grew



Robert Brown

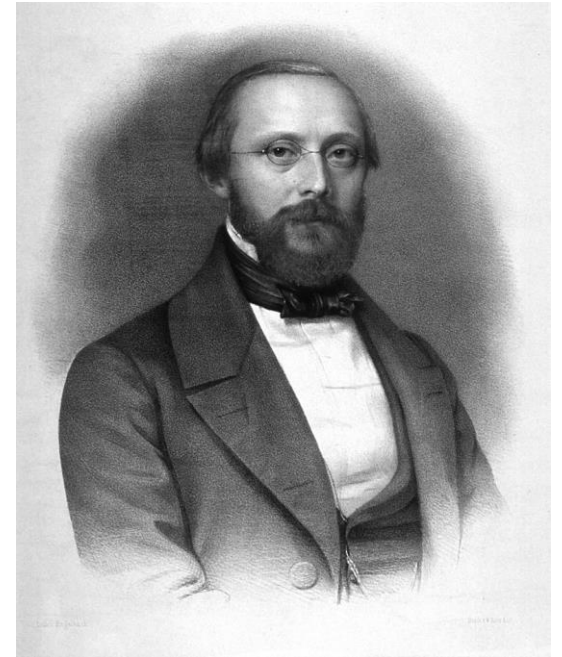
## ... UND DANN SCHLAG AUF SCHLAG



Theodor Schwann



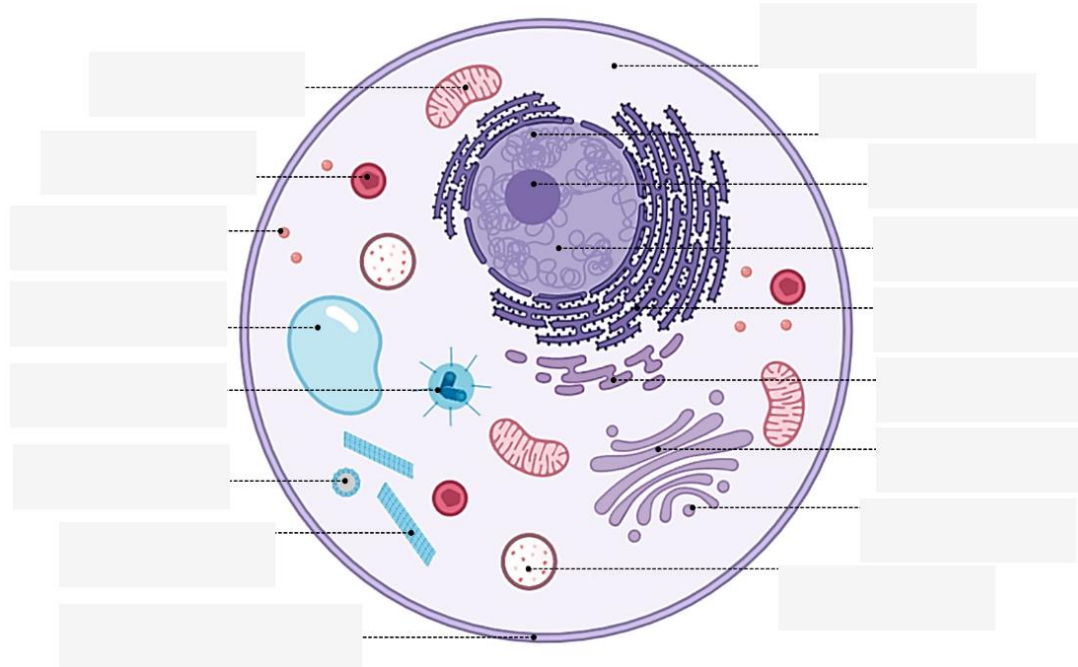
Matthias Schleiden



Rudolph Virchow

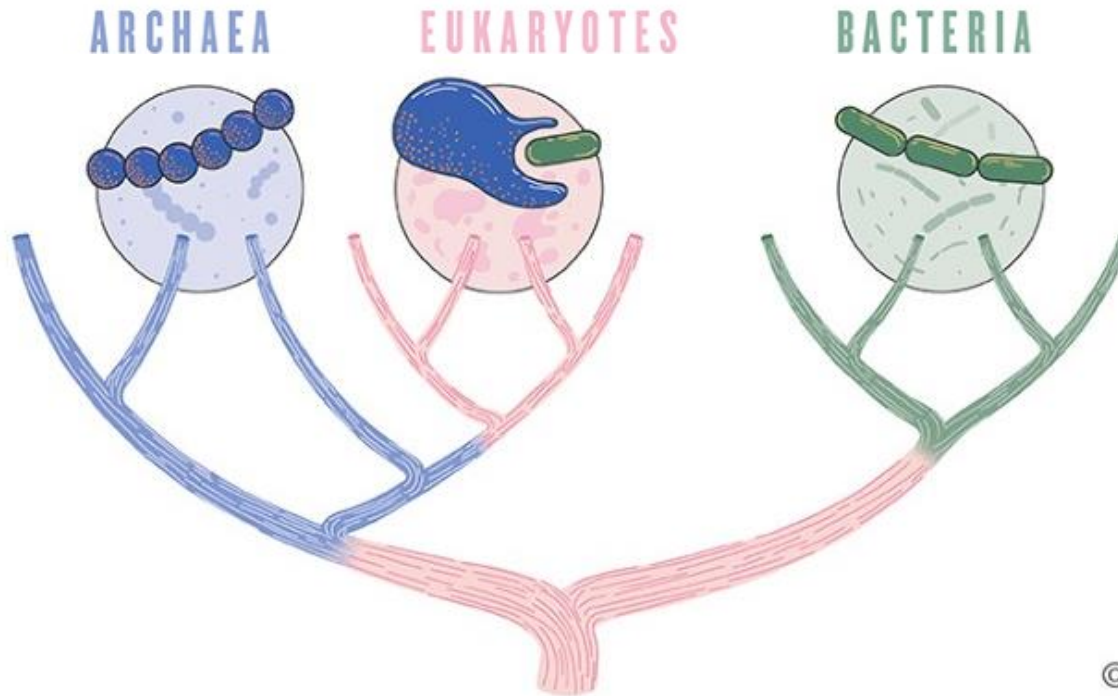


# WAS GEHÖRT IN EINE ZELLE



Lösung

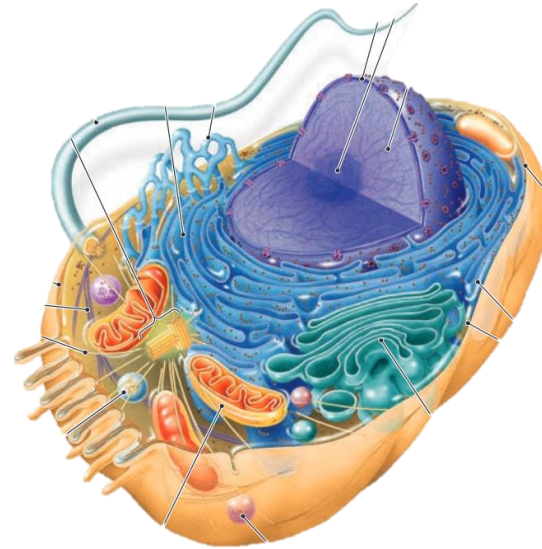
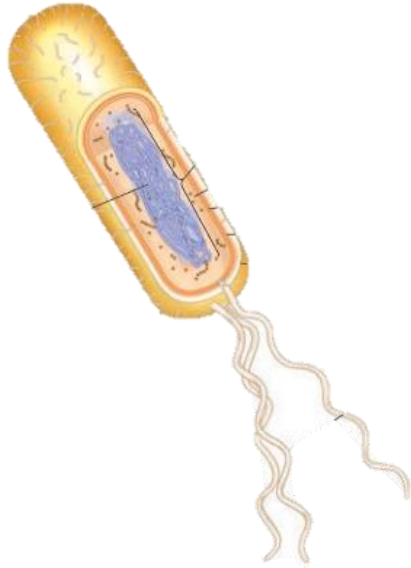




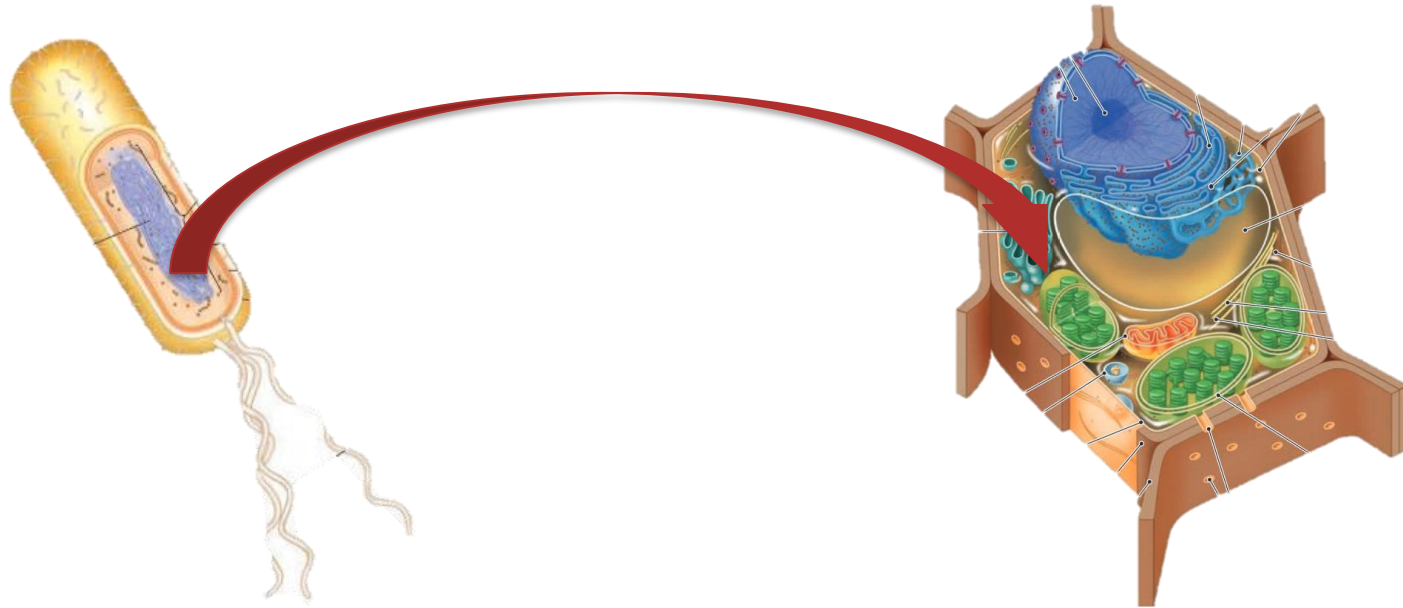
©nature

Verändert nach Watson, T. (2019)

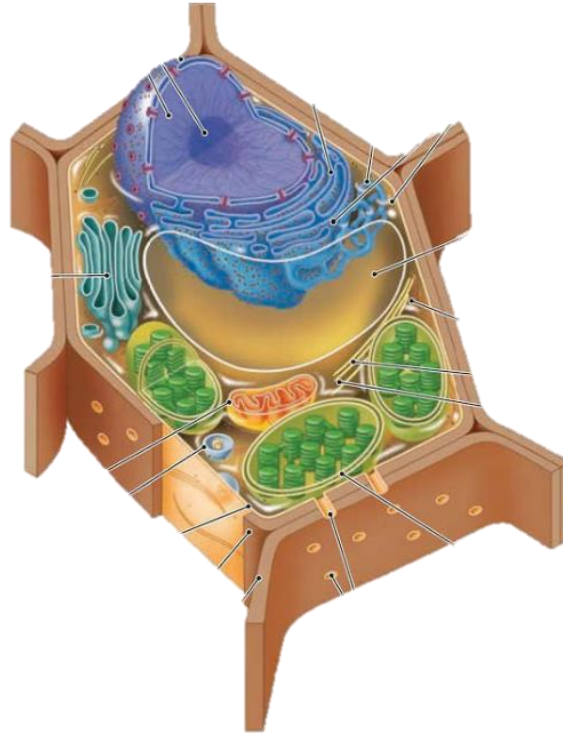
## VERGLEICH ZU EINER BAKTERIENZELLE



## VERGLEICH ZU EINER BAKTERIENZELLE



## LYNN MARGULIS UND IHRE THEORIE



### On the Origin of Mitosing Cells

LYNN SAGAN

*Department of Biology, Boston University  
Boston, Massachusetts, U.S.A.*

*(Received 8 June 1966)*

A theory of the origin of eukaryotic cells ("higher" cells which divide by classical mitosis) is presented. By hypothesis, three fundamental organelles: the mitochondria, the photosynthetic plastids and the  $(9+2)$  basal bodies of flagella were themselves once free-living (prokaryotic) cells. The evolution of photosynthesis under the anaerobic conditions of the early atmosphere to form anaerobic bacteria, photosynthetic bacteria and eventually blue-green algae (and protoplastids) is described. The subsequent evolution of aerobic metabolism in prokaryotes to form aerobic bacteria (proto-flagella and protomitochondria) presumably occurred during the transition to the oxidizing atmosphere. Classical mitosis evolved in protozoan-type cells millions of years after the evolution of photosynthesis. A plausible scheme for the origin of classical mitosis in primitive amoeboid flagellates is presented. During the course of the evolution of mitosis, photosynthetic plastids (themselves derived from prokaryotes) were symbiotically acquired by some of these protozoans to form the eukaryotic algae and the green plants.

The cytological, biochemical and paleontological evidence for this theory is presented, along with suggestions for further possible experimental verification. The implications of this scheme for the systematics of the lower organisms is discussed.

# DIE MEMBRAN

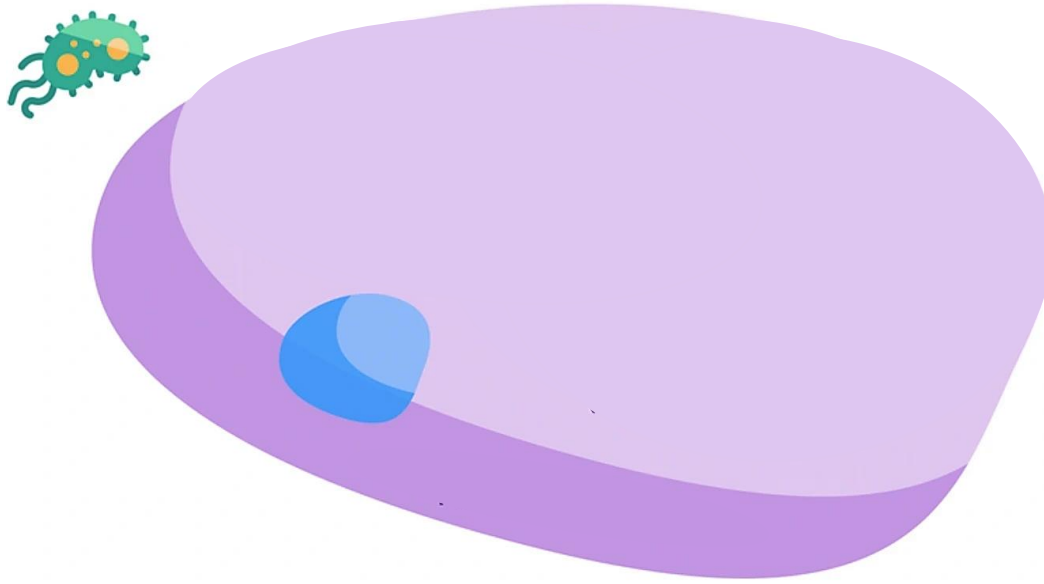
# WIE “ISST” EINE ZELLE ???

## WIE "ISST" EINE ZELLE ???

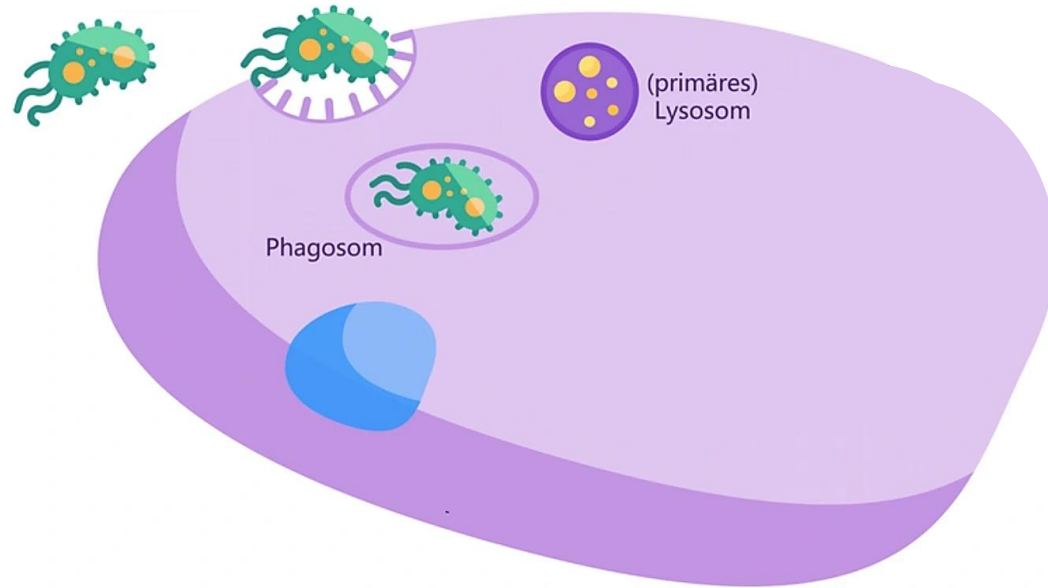




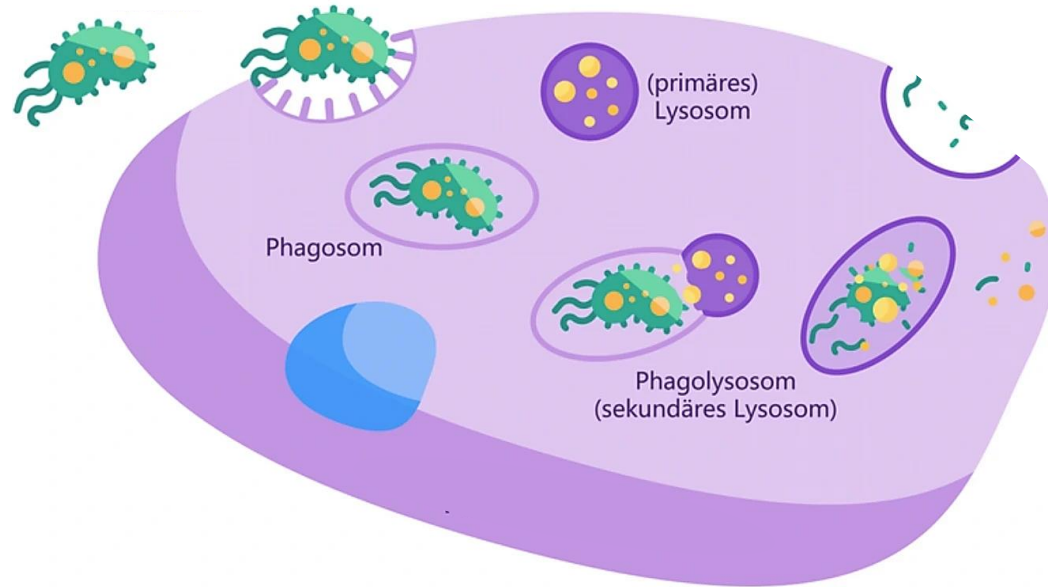
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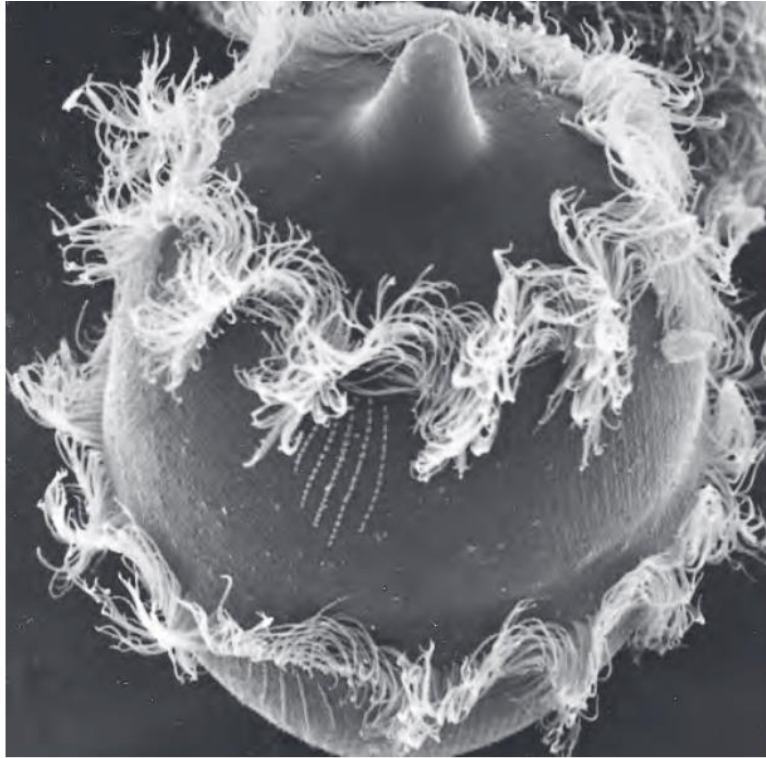


# PHAGOZYTOSE



# PHAGOZYTOSE



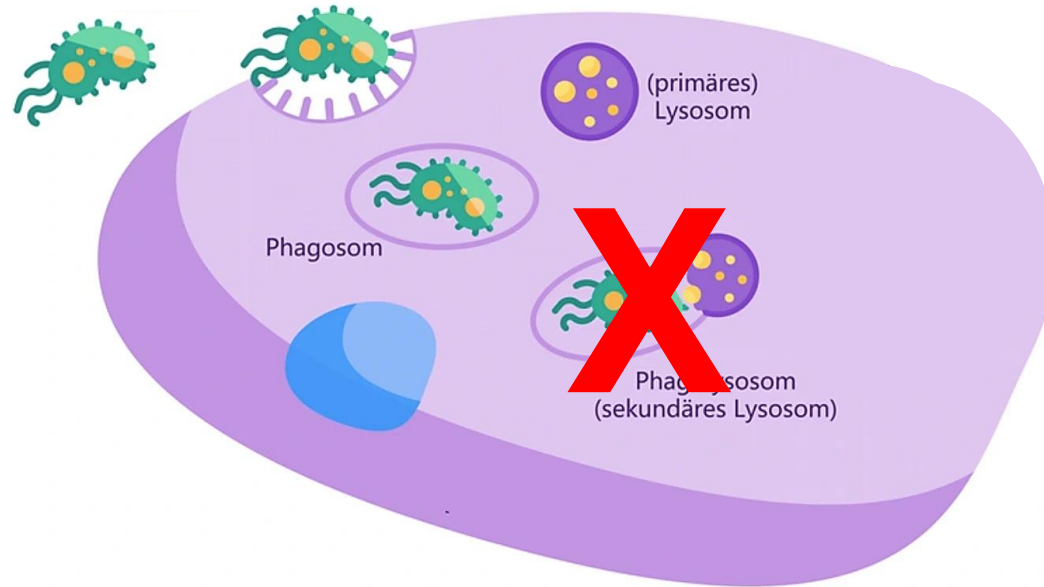


100 μm

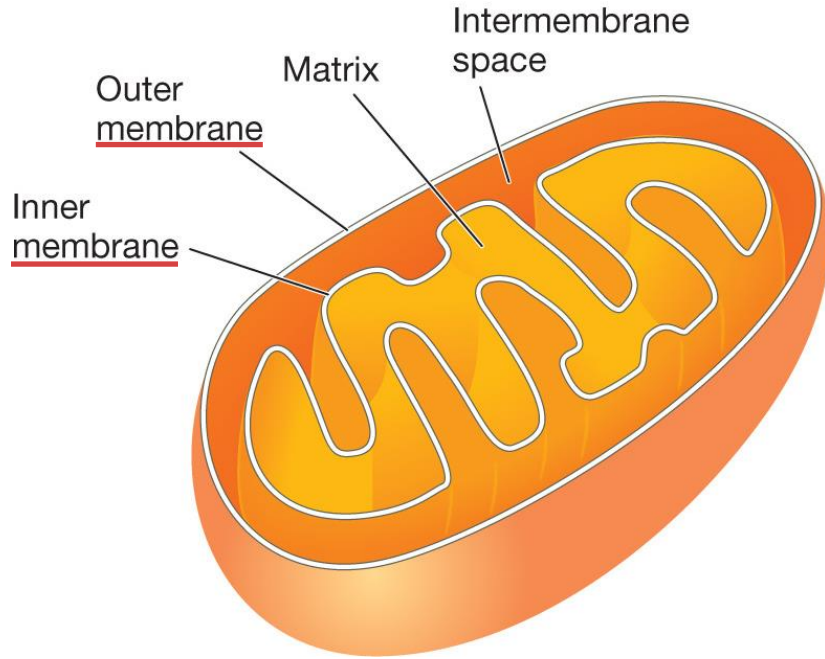
Alberts, B. (2017)



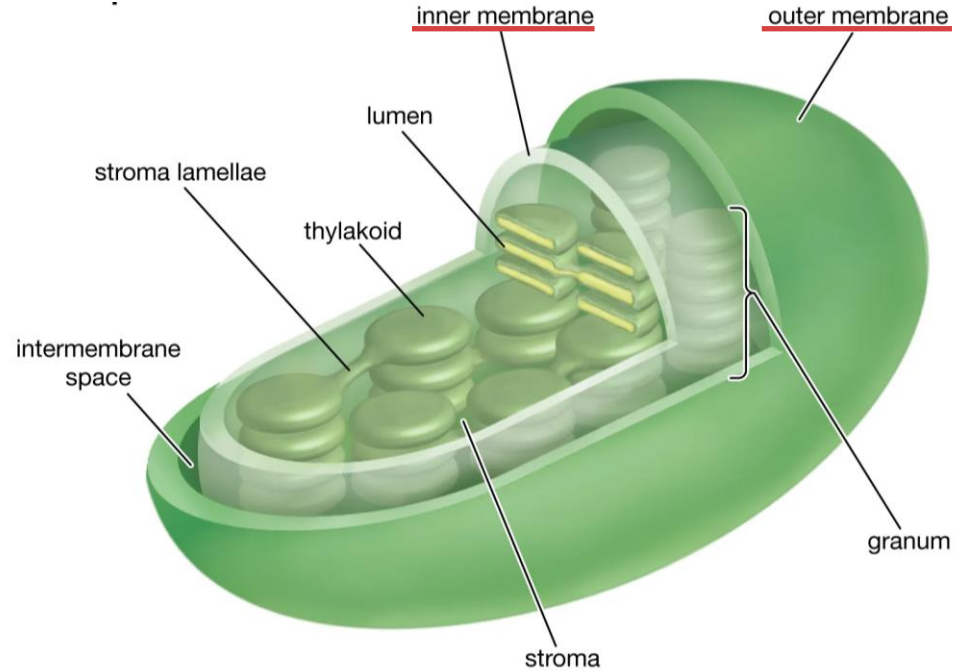
# ENTSTEHUNG DER ENDOSYMBIONTHEN



## Mitochondrium



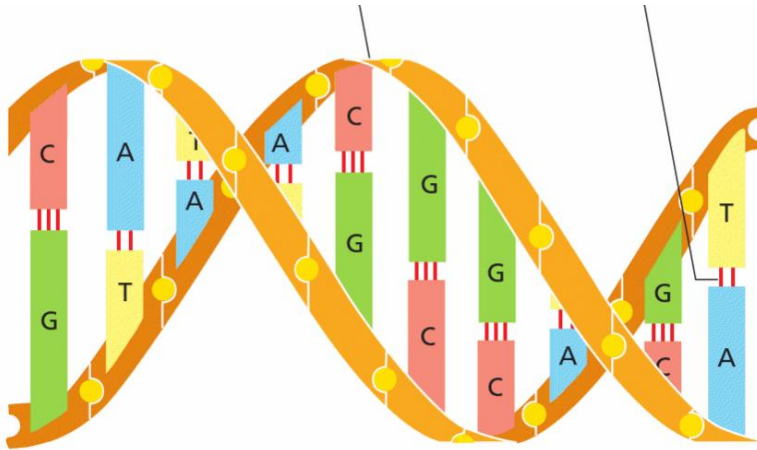
## Chloroplast



# DAS GENOM

## WAS BEDEUTET GENOM?

Das Genom ist die Gesamtheit der genetischen Information einer Zelle oder eines Organismus; besonders die DNA, welche diese Information trägt

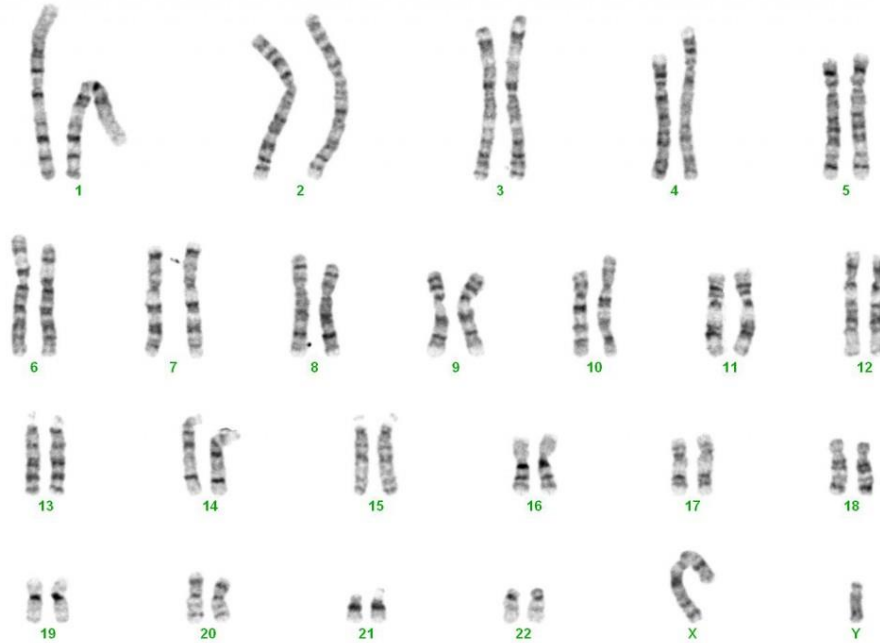


Organismus	Genomgröße [bp]
HIV	9.700
Backhefe	13.000.000
Gemüsekohl	$5,99-8,68 \times 10^8$
Mensch	$3,1 \times 10^9$

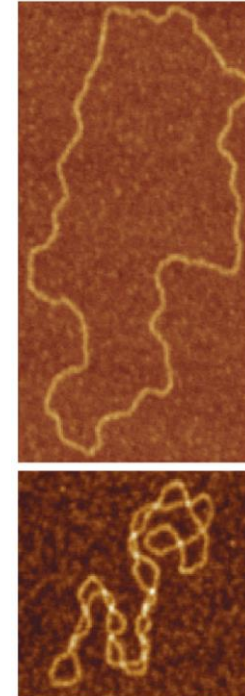
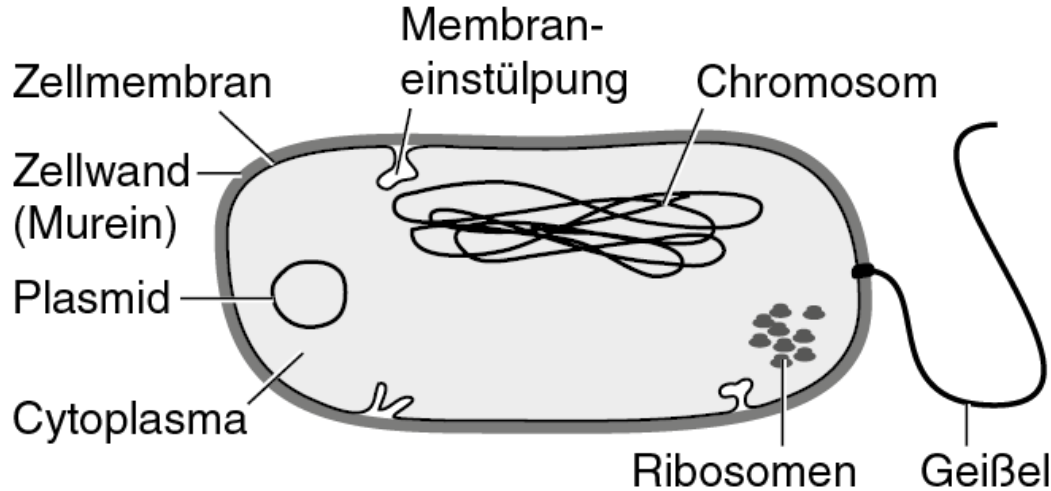
Verändert nach Wikipedia (Beispiele für Genomgrößen)



# LINEARE CHROMOSOMEN



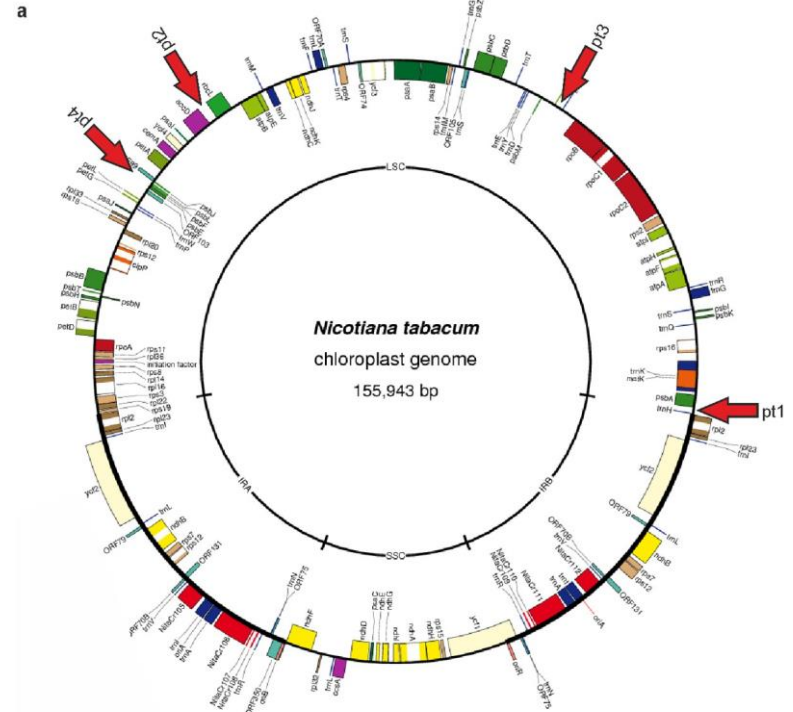
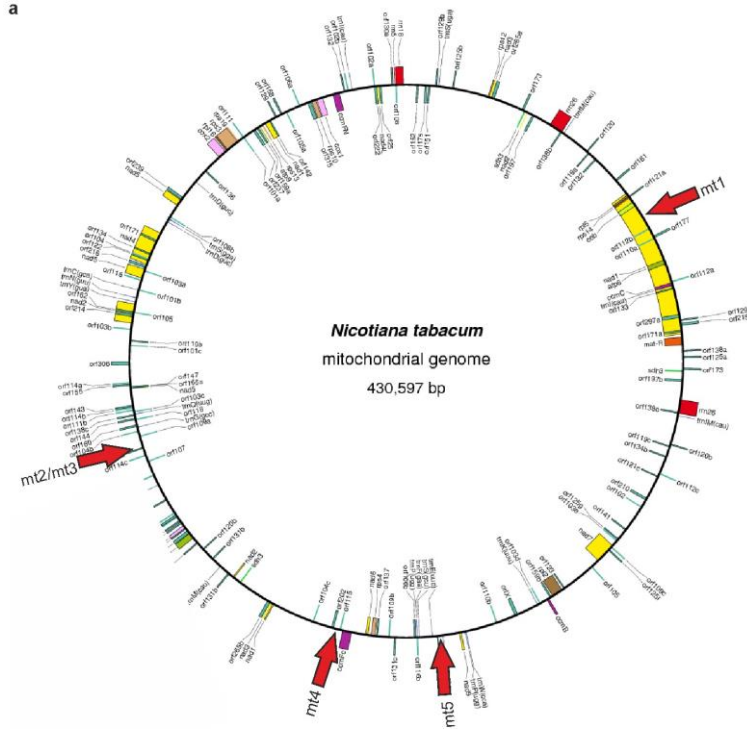
# ZIRKULÄRES CHROMOSOM



Andrzej Stasiak. Modified from G. Witz and A. Stasiak. 2010. Nucleic Acids Research 38:2119-2133.

Verändert nach Brock et al. (2020)

# GENOM VON DEN ENDOSYMBIONTEN



Verändert nach I. Fuentes et al. (2014)

# WAS IST EINE SEQUENZ?

Die Sequenz ist die Abfolge der einzelnen „Bausteine“ (hier Nukleotide)

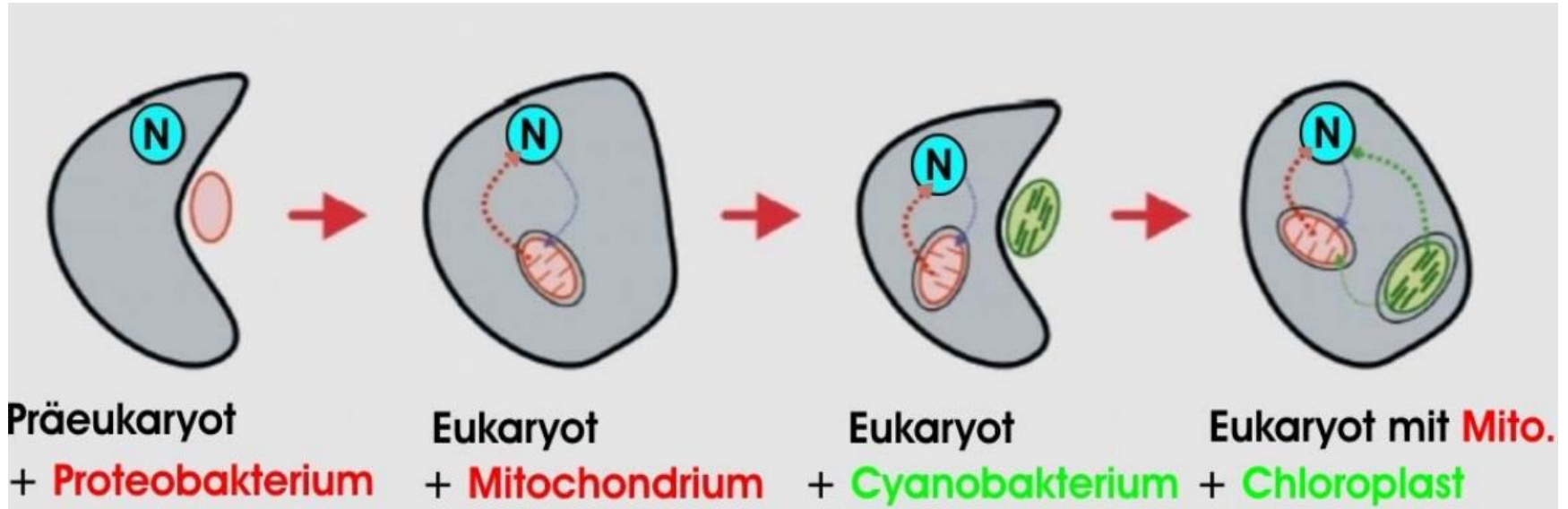
C	A	T	G	C	G	A	G	T	A	-	G	T	A	G
C	A	T	G	-	-	-	G	T	A	-	G	T	A	G
C	C	T	G	-	G	A	G	T	A	C	G	T	A	G
C	A	T	G	-	-	A	G	-	-	C	G	T	A	G

Layeb, A. (2013)

The image shows a screenshot of the National Library of Medicine (NIH) BLAST search interface. The header includes the NIH logo and the text "National Library of Medicine National Center for Biotechnology Information". Below the header, it says "BLAST® » blastn suite". There is a button that says "Take the BLAST survey today". The main section is titled "Standard Nucleotide BLAST". It features a search form with the following elements:

- Enter Query Sequence:** A text input field for "Enter accession number(s), gi(s), or FASTA sequence(s)", a "Clear" button, and a "Query subrange" section with "From" and "To" input fields.
- Or, upload file:** A "Datei auswählen" button and a "Keine ausgewählt" button.
- Job Title:** A text input field for "Enter a descriptive title for your BLAST search".
- Align two or more sequences:** A checkbox.
- Choose Search Set:** A section with radio buttons for "Standard databases (nr etc.)", "rRNA/ITS databases", "Genomic + transcript databases", and "Betacoronavirus". There is also a "New" button for "Experimental databases" and a "Download" button for "Try experimental taxonomic nt databases".
- Database:** A dropdown menu currently set to "Nucleotide collection (nr/nt)".
- Organism:** A text input field for "Enter organism name or id - completions will be suggested", an "exclude" checkbox, and an "Add organism" button.
- Exclude:** A checkbox for "Models (XM/XP)" and a checkbox for "Uncultured/environmental sample sequences".
- Limit to:** A checkbox for "Sequences from type material".
- Entrez Query:** A text input field for "Enter an Entrez query to limit search" and a "Create custom database" button.

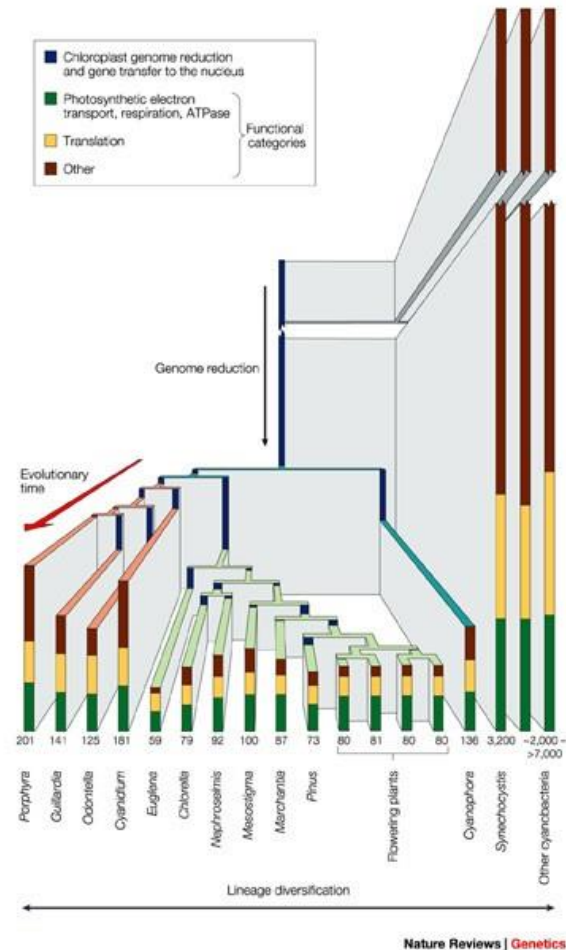
## GEN-TRANSFER



Bock, R.

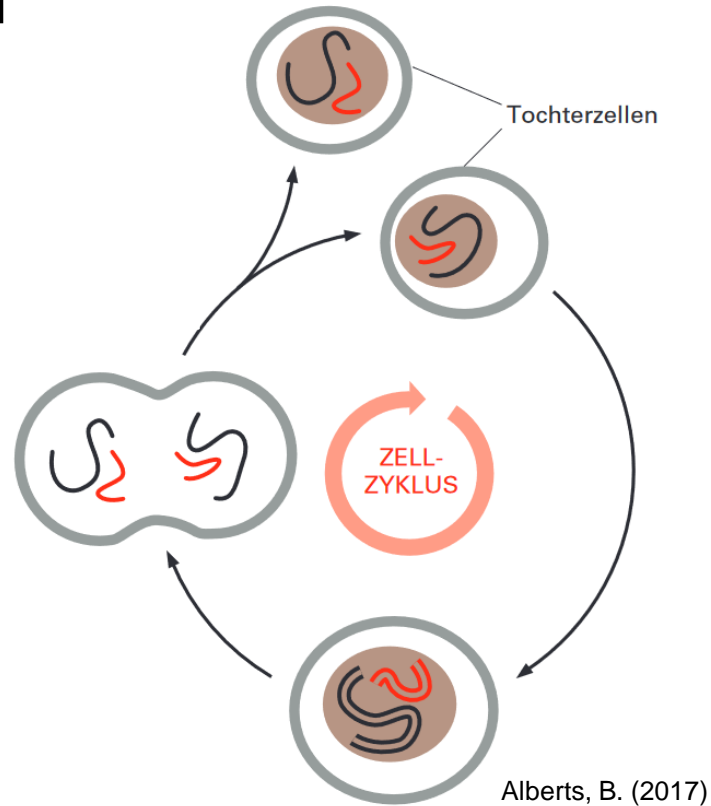
# VERKLEINERUNG DES GENOMS DURCH GEN- TRANSFER

- funktionaler Gentransfer in den Zellkern
- Endosymbionten transferierten bis zu 90 Prozent ihres Genoms in den Kern der Wirtszelle
- dieser Prozess scheint bis heute nicht abgeschlossen zu sein



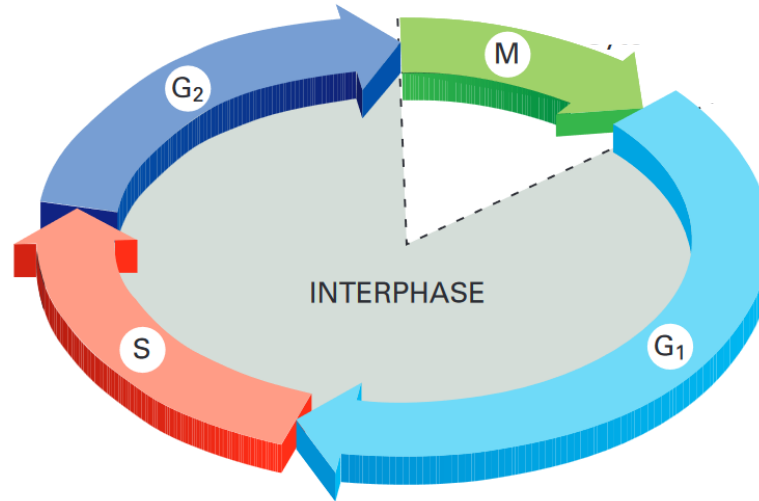
# DER ZELLYKLUS

# WAS VERSTEHEN WIR DARUNTER?



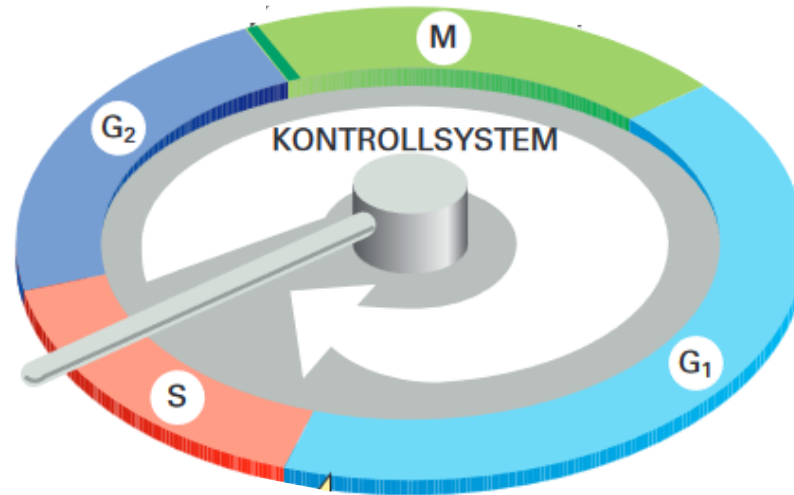


## DER ZELLZYKLUS IST IN PHASEN UNTERTEILT...



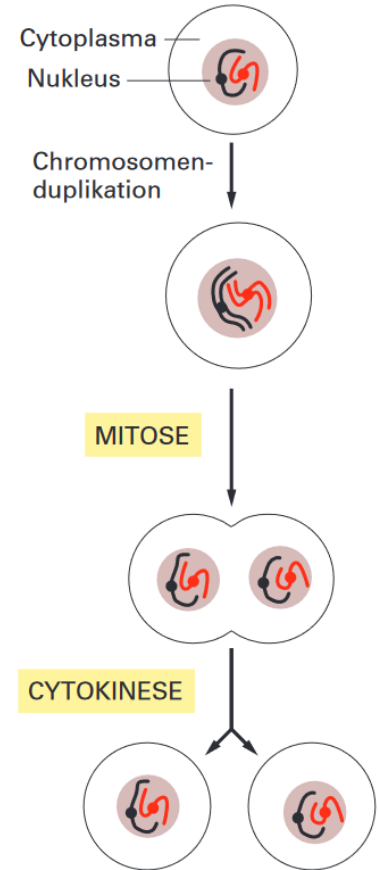
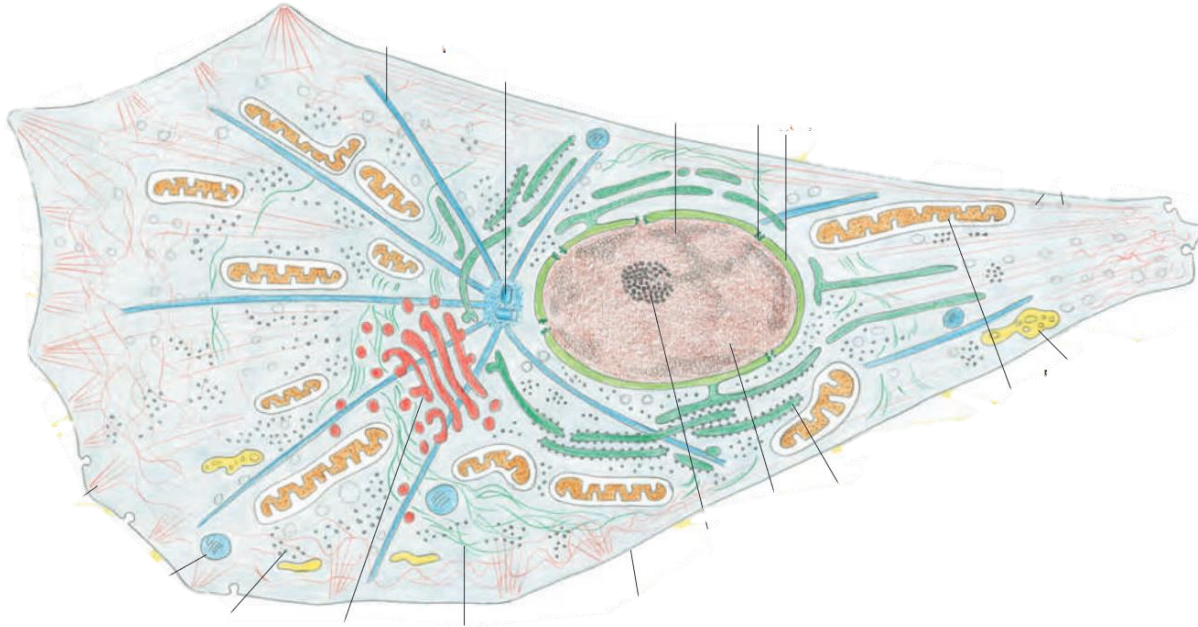
Alberts, B. (2017)

## ... UND STARK REGULIERT

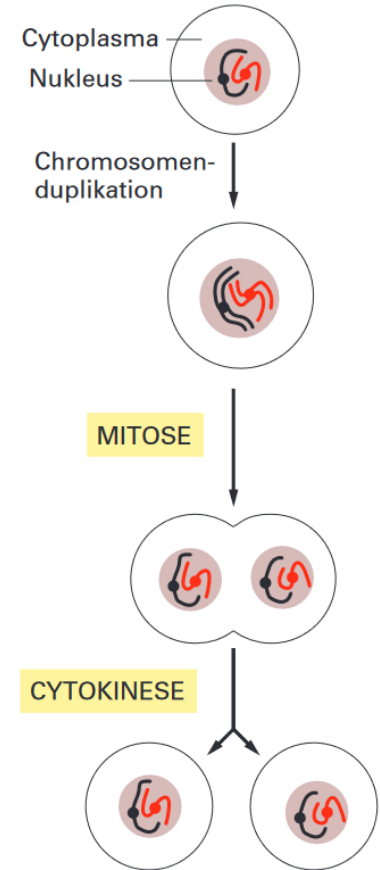
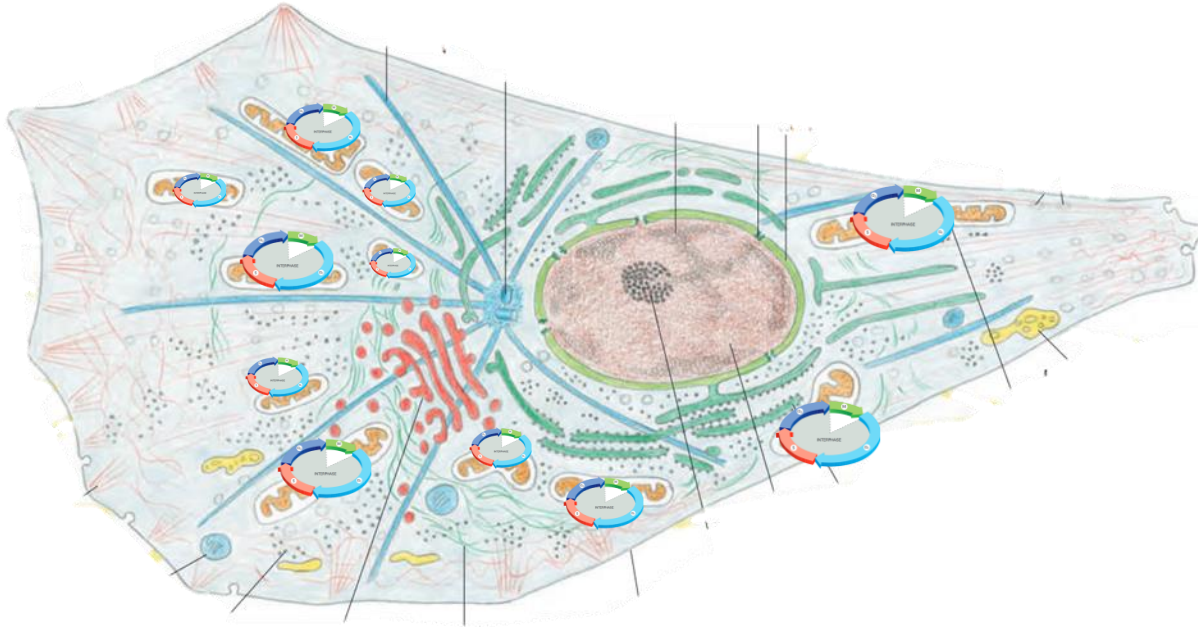


Alberts, B. (2017)

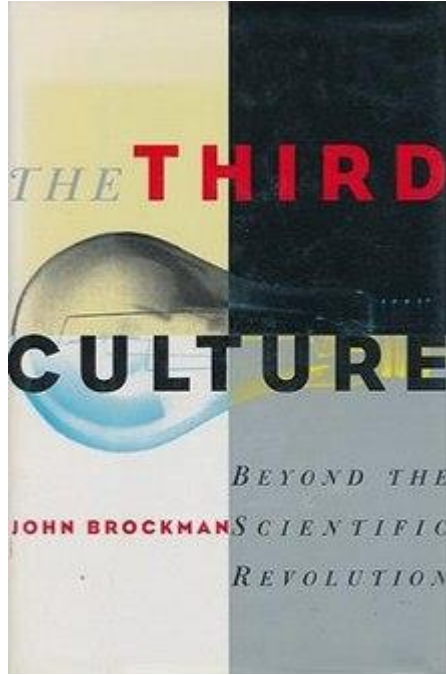
# ALLES DURCH ZWEI



# ALLES DURCH ZWEI



## REAKTIONEN



In 1966, I wrote a paper on symbiogenesis called "The Origin of Mitosing [Eukaryotic] Cells," dealing with the origin of all cells except bacteria. (The origin of bacterial cells is the origin of life itself.) The paper was rejected by about fifteen scientific journals, because it was flawed; also, it was too new and nobody could evaluate it. Finally, James F. Danielli, the editor of *The Journal of Theoretical Biology*, accepted it and encouraged me. At the time, I was an absolute nobody, and, what was unheard of, this paper received eight hundred reprint requests. Later, at Boston University, it won an award for the year's best faculty publication. I was only an instructor at the time, so my Biology Department colleagues reacted to the commotion and threw a party. But it was more of "Isn't this cute," or "It's so abstruse that I don't understand it, but others think it worthy of attention." Even today most scientists still don't take symbiosis seriously as an evolutionary mechanism. If they were to take symbiogenesis seriously, they'd have to change their behavior. The only way behavior changes in science is that certain people die and differently behaving people take their places.

## REAKTIONEN

**Daniel C. Dennett:** One of the most beautiful ideas I've ever encountered is Lynn Margulis's idea about the birth of the eukaryotic cell through a transformation of what started out as a parasitic infestation of one cell by another. When she first proposed it, she was scoffed at, laughed at, and it's delicious that this is now pretty well accepted as a major, major theoretical development. I think of her as **one of the heroes of twentieth-century biology.**

Some of her recent popular writing disturbs me, because I think she's trying to take that wonderful idea and harness it as a political idea, **stressing cooperation over competition.** But that seems to me to be a mistake. Yes, the eukaryotic revolution was an instance in which what began as competition evolved into what is fundamentally a cooperative arrangement. That's its beauty, but precisely what it doesn't show is that cooperation is the norm or that cooperation is always good or that it's always possible. It's the rare and wonderful thing that enabled multicellular life to take off. **But you can't read into it any message such as that nature is fundamentally cooperation; it isn't.**

## REAKTIONEN

**George C. Williams:** I'm probably being unfair, but I would say that Lynn Margulis is very much afflicted with a kind of "God-is-good" syndrome, in that she wants to look out there at nature and see something benign and benevolent and ultimately wholesome and worth having. Whereas I look out there with Tennyson and see things red in tooth and claw. In other words, it's a bloody mess out there.

She likes to look out there and see cooperation and things being nice to each other. This culminates in this Gaia idea. There's this entity — we will not make it a god or a goddess, let's say that the implication is just a metaphor. But that's what she wants to see, and therefore, come what may, that's what she's going to see. She could say the same about me — that I think "God is evil," and I look out there at His creations and see nothing but evil. Time will tell, and will show that my approach is more fruitful in generating predictions about discoveries we're going to make.

## REAKTIONEN

**Richard Dawkins:** I greatly admire Lynn Margulis's sheer courage and stamina in sticking by the endosymbiosis theory, and carrying it through from being an unorthodoxy to an orthodoxy. I'm referring to the theory that the eukaryotic cell is a symbiotic union of primitive prokaryotic cells. This is one of the great achievements of twentieth-century evolutionary biology, and I greatly admire her for it.



## DISKUSSION

- Was können wir daraus lernen???
- Würdet ihr eine Theorie veröffentlichen die nicht in euer Weltbild past???
- Können wir Theorien glauben die wir “nicht” Beweisen können???



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**VIELEN DANK!**

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13-SQM-04 Naturwissenschaft für Querdenker

Sommersemester 2023

