

# OSNOVE MIKROBIOLOGIJE

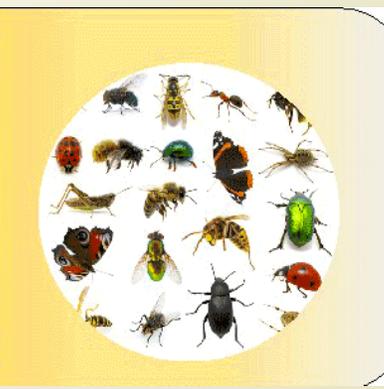
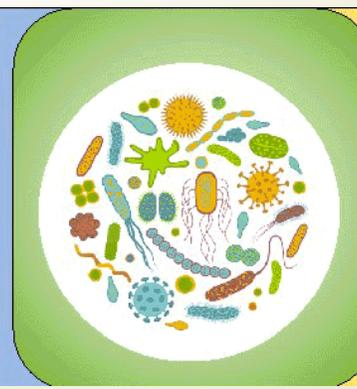
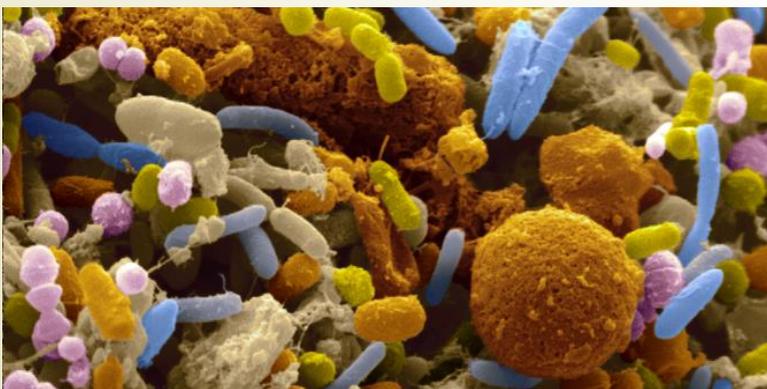
## 183958

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akad. god. 2025./2026.

studij biologije i kemije



## LITERATURA

Wiley J, Sandman K, and Wood D (2022) Prescott's Microbiology, 12th edition, McGraw-Hill, Boston

Wiley J, Sherwood L, Woolverton C (2019) Prescott's Microbiology, 11th edition, McGraw-Hill, Boston

Wiley J, Sherwood L, Woolverton C (2017) Prescott's Microbiology, 10th edition, McGraw-Hill, Boston

Wiley J, Sherwood L, Woolverton C (2014) Prescott's Microbiology, 9th edition, McGraw-Hill, Boston

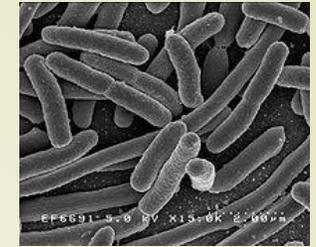
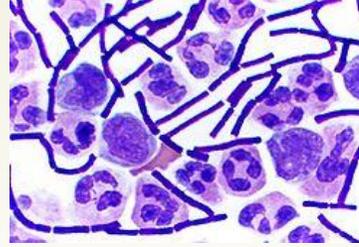
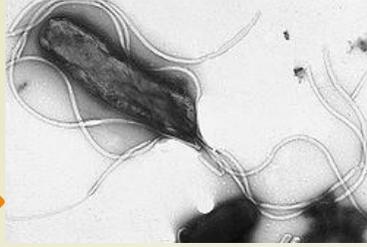
Priručnik za vježbe iz opće mikrobiologije (2016) (ur. Hajsig D, Delaš F), Zagreb, Hrvatsko mikrobiološko društvo.

**Postupak ocjenjivanja: Osnove mikrobiologije (183958) , integrirani preddiplomski i diplomski studij biologije i kemije**

- U prvom dijelu semestra studenti pohađaju nastavu iz bakteriologije, a u drugom dijelu iz virologije.
- Pohađanje predavanja i praktikuma je obavezno u obimu predviđenom Pravilnikom o studiranju (70% nastavnih sati).
- Dozvoljen je jedan neopravdani izostanak s praktikuma (tijekom trajanja kolegija), te još jedan uz valjanu službenu ispričnicu.
- Nakon obavljenog predavanja i praktikuma iz bakteriologije piše se kolokvij s ukupno 25 pitanja. Nakon obavljenog predavanja i praktikuma iz virologije piše se naredni kolokvij s ukupno 25 pitanja.
- Svaki točan odgovor donosi 1 bod. Ukupno je moguće ostvariti 50 bodova.
- Iz dijela nastave iz bakteriologije moguće je ostvariti do 2 dodatna boda putem dodatnih aktivnosti na nastavi
- Ukupna ocjena određuje se prema broju ostvarenih bodova kao što je prikazano u tablici.

Ocjena	Bodovi
Nedovoljan (1)	< 25
Dovoljan (2)	26-31
Dobar (3)	32-37
Vrlo dobar (4)	38-43
Izvrstan (5)	44-50

- Ako je student zadovoljan ocjenom koju je ostvario na kolokvijima kroz kontinuiranu provjeru znanja, ova se ocjena može odmah unijeti kao konačna u indeks i sustav ISVU. Ocjena se upisuje u PRVOM terminu ljetnog ispitnog roka, nakon što STUDENT ROK PROPISNO PRIJAVI.
- Ukoliko student nije zadovoljan ocjenom koju je postigao kroz kontinuiranu provjeru znanja ili uopće ne želi pristupiti kontinuiranim provjerama znanja, izlazi na ispit u ispitnom roku.
- Za one studente koji nisu zadovoljni ocjenom postignutom kroz kontinuiranu provjeru znanja (kolokviji), pristupanje pismenom ispitu podrazumijeva činjenicu da se student ODRICE ocjene dobivene prethodno na kolokvijima. To znači da se jednom odbijena ocjena iz kolokvija ne može upisivati u ISVU.
- Ispit je pismeni i obuhvaća cijelo gradivo uključujući i praktikum.

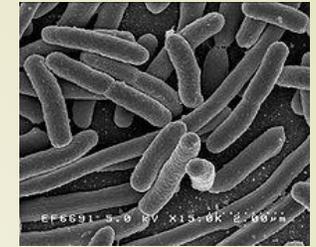
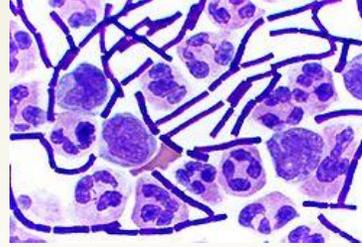
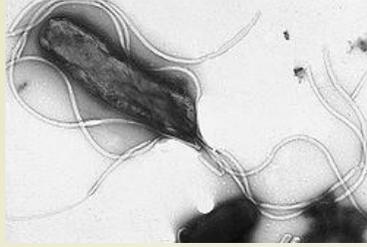


## I.UVOD U MIKROBIOLOGIJU

- Definicija, podjela i značaj mikrobiologije
- Podjela živog svijeta
- Povijesni razvoj mikrobiologije/bakteriologije

## II.BAKTERIJSKA STANICA

- Veličina, oblik i združeni oblici bakterijskih stanica
- Nomenklatura bakterija



# MIKROBIOLOGIJA

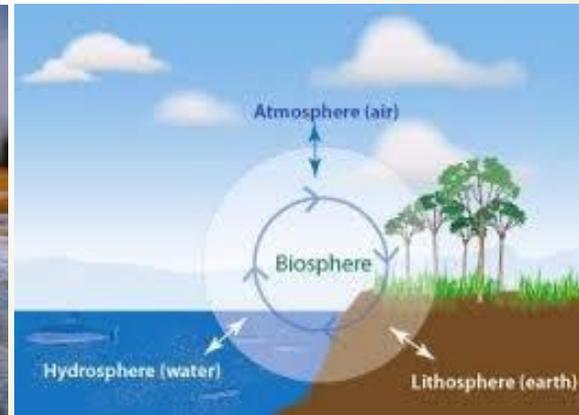
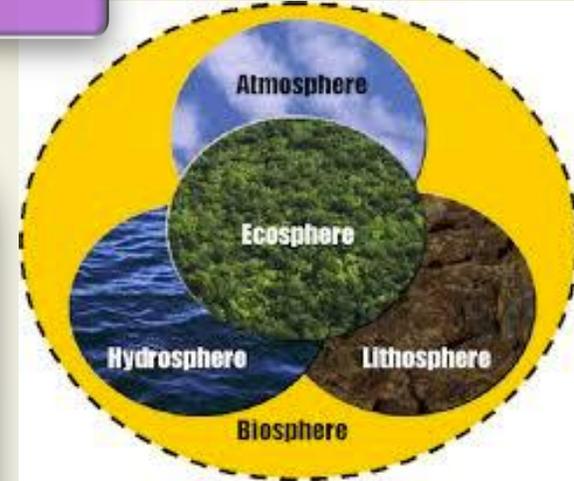
(grč. *micros* - malen, *bios* - život, *logos* - znanost)

“znanost o organizmima koje nije moguće vidjeti golim okom”

# ZNAČAJ MIKROBIOLOGIJE

Zbog čega istražujemo mikrobe?

Mikrobi su sveprisutni i utječu na čitavu biosferu

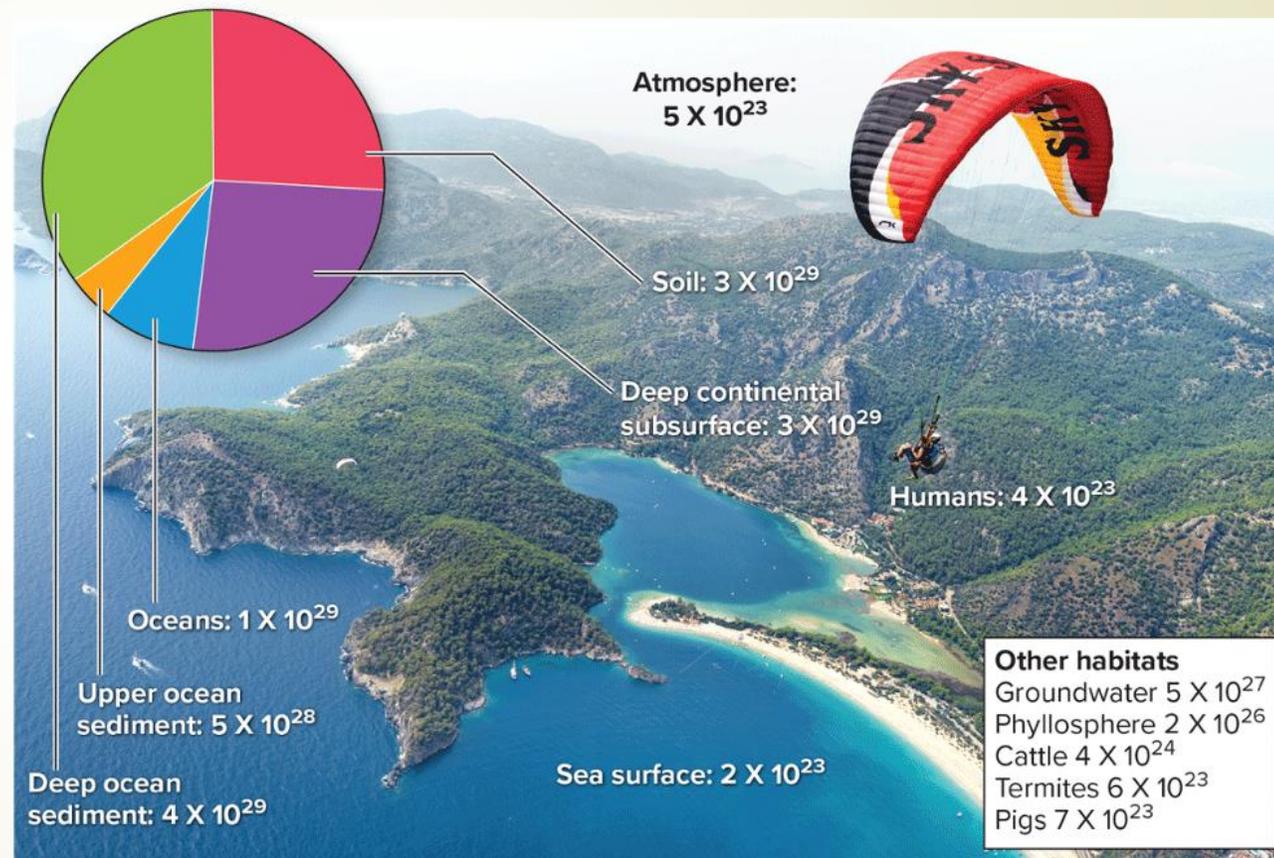


# ZNAČAJ MIKROBIOLOGIJE

## Zbog čega istražujemo mikrobe?

- omogućili su razvoj procesa staničnog disanja i života na Zemlji ovisnog o kisiku
- prisutni svuda – žive čak i u najekstremnijim uvjetima
- vjerojatno najbrojniji organizmi i entiteti –  $10^{30}$  stanica mikroba
- čine veliki postotak ukupne biomase na Zemlji

Major habitats



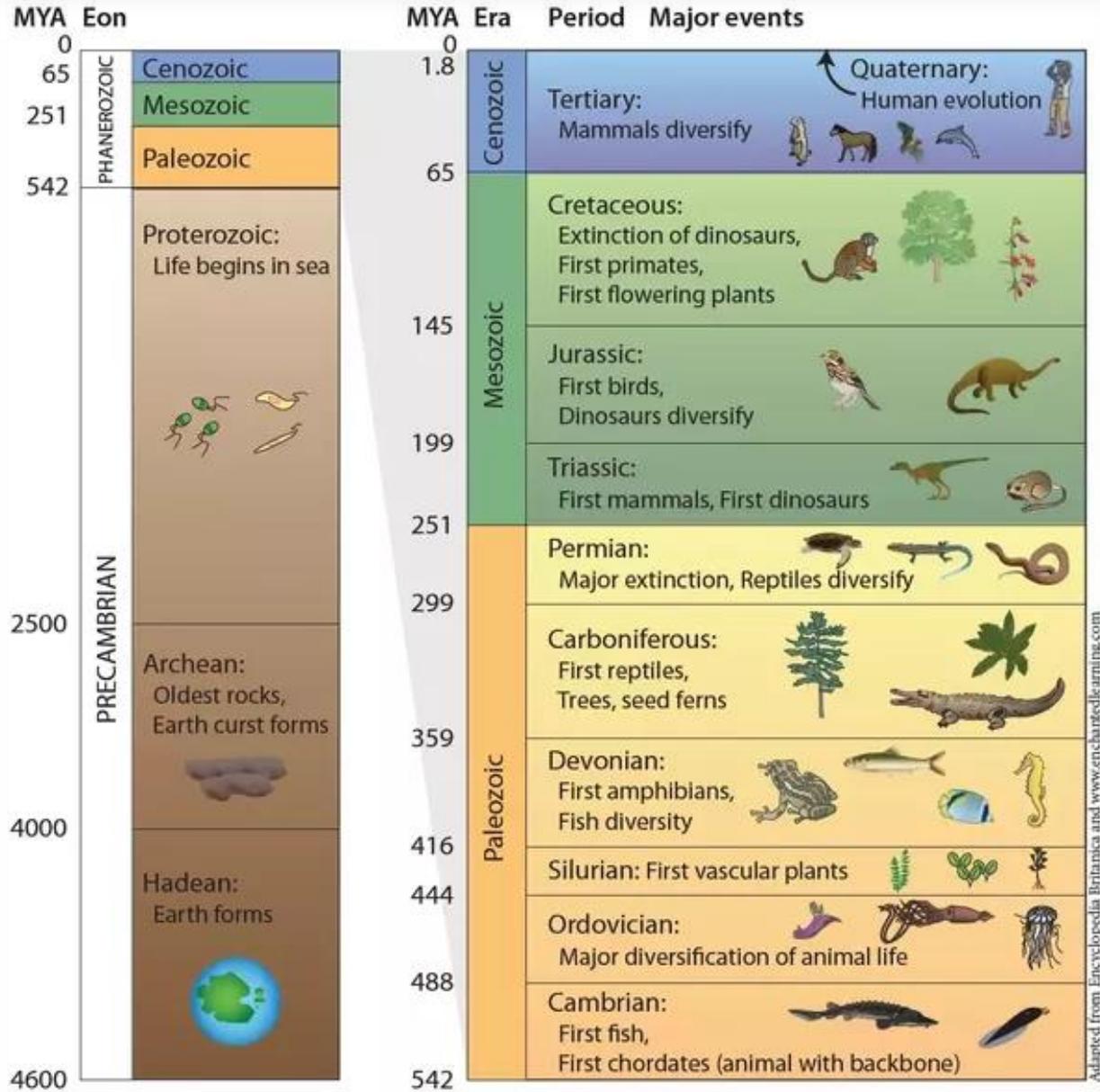
Staništa i brojnost bakterija i arheja.

# ZNAČAJ MIKROBIOLOGIJE

## Zbog čega istražujemo mikrobe?

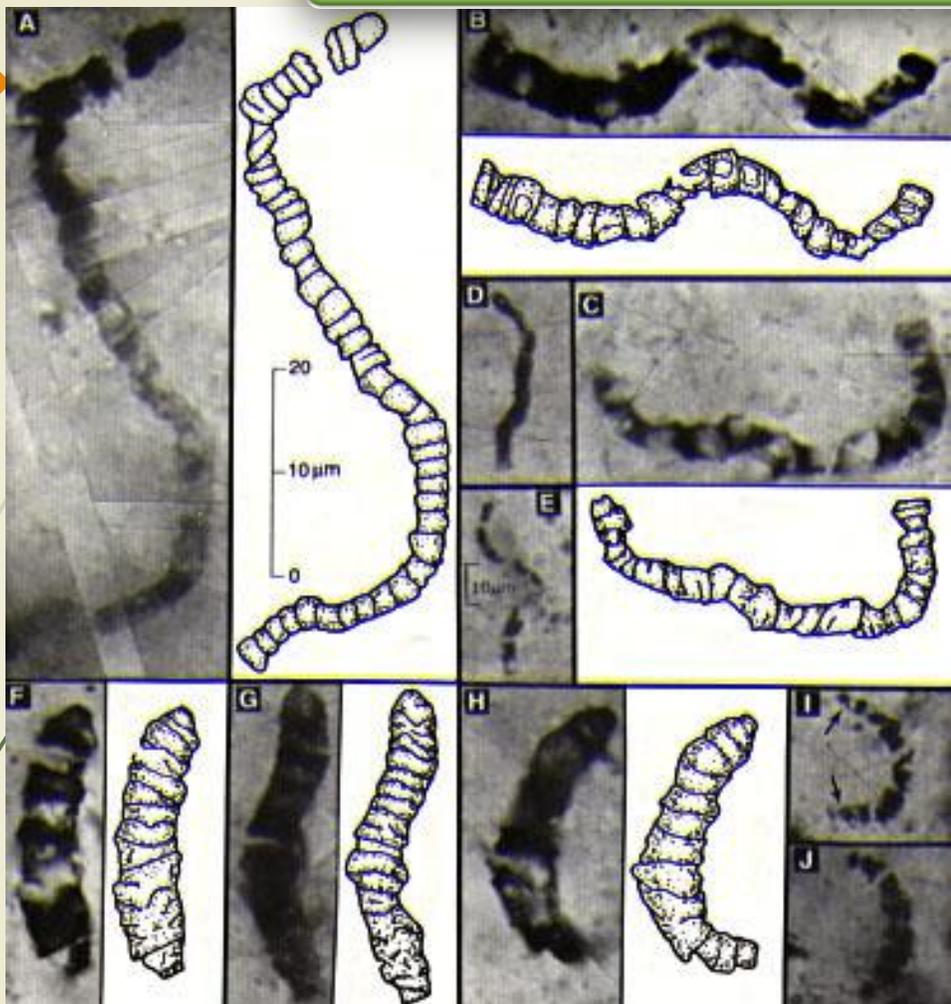
- **uzročnici bolesti**
- **dijelovi ekosustava** - kružni ciklusi kisika, ugljika, dušika, sumpora
- **značaj u industriji** - potrebni za proizvodnju brojnih prehrambenih proizvoda, antibiotika, vakcina, enzima, vitamina....
- **modeli u znanstvenim istraživanjima** – jednostavna stanična građa, brzi rast i jeftino kultiviranje
- **utjecaj na razvoj i povijest ljudske civilizacije** (epidemija kuge u 14. st., osvajanja Novoga svijeta)

# MIKROBI I PROŠLOST



Adapted from Encyclopedia Britannica and www.enchantlelearning.com

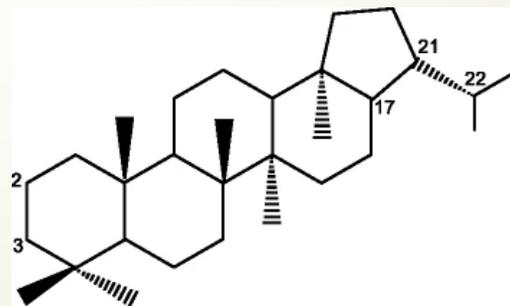
# MIKROBI I PROŠLOST



Mikrofosili nalik modernim cijanobakterijama – Archeon Apex Chert, Australija – 3,4 milijardi godina (Schopf, 1993, *Science*, 260, 640-646)



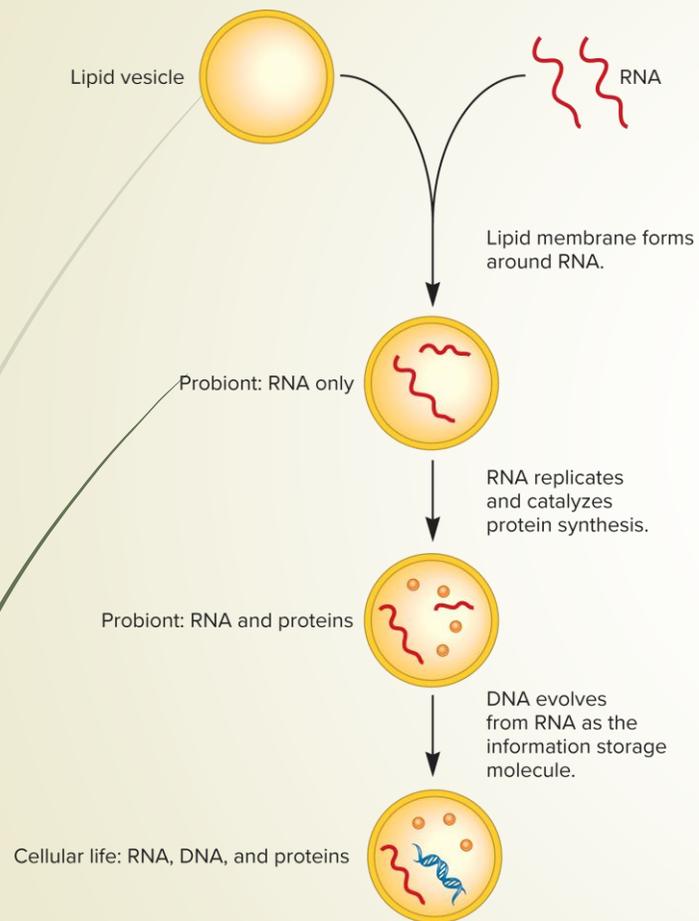
Nalaz stromatolita procijenjen na starost od 3,7 milijardi godina - Grenland (Nutman i sur., 2016, *Nature*, 537, 535-538)



Hopani - molekularni fosili – ostaci bakterijskih lipida (cijanobakterije)

# MIKROBI I PROŠLOST

## Porijeklo života na Zemlji



RNA svijet

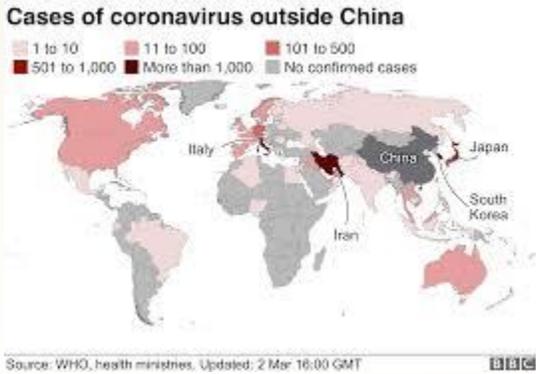
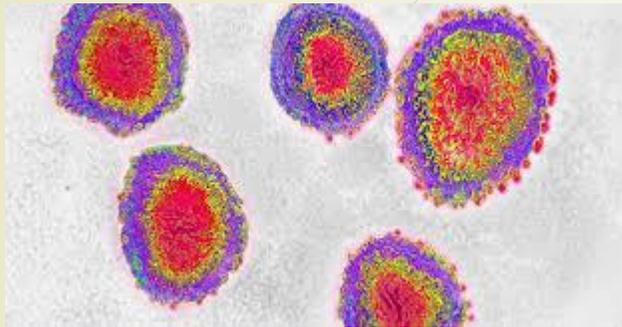
## Porijeklo metabolizma na Zemlji



Stromatoliti u Zapadnoj Australiji koji sadrže naslage cijanobakterija (procijenjena starost od 2,7 milijardi godina).

oksigena fotosinteza

# MIKROBI I SADAŠNJOST



**Vaccines for Children**  
Protecting America's children every day

The Vaccines for Children (VFC) program helps ensure that all children have a better chance of getting their recommended vaccines. VFC has helped prevent disease and save lives.

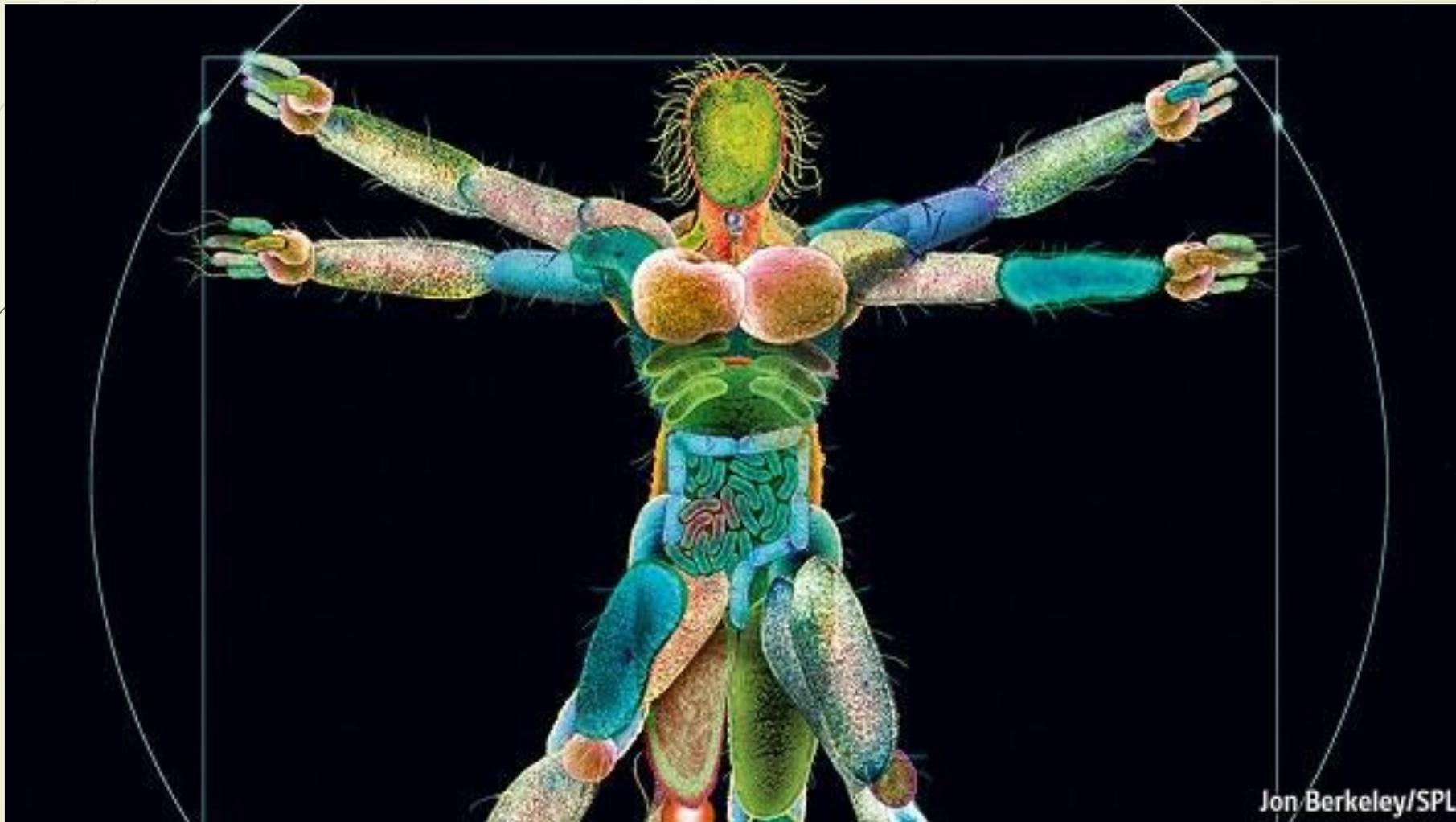
CDC estimates that vaccination of children born between 1994 and 2018 will:

- prevent **419 million** illnesses (that could be prevented)
- help avoid **936,000** deaths (that could be avoided)
- save nearly **\$1.9 trillion** in total societal costs (that include \$69 billion in productivity loss)

[www.cdc.gov/features/vfcprogram](http://www.cdc.gov/features/vfcprogram)

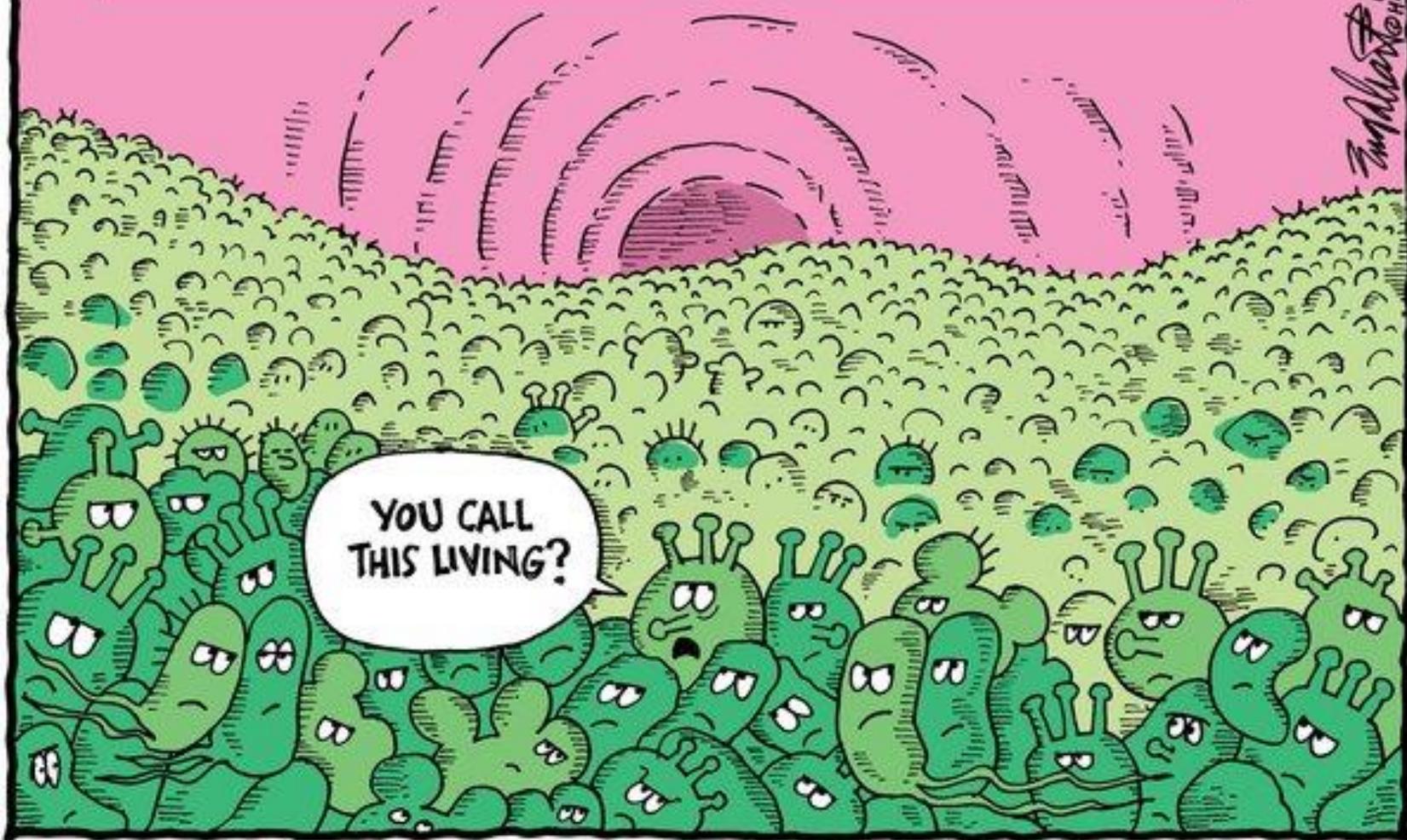


# MIKROBIOM ČOVJEKA



Jon Berkeley/SPL

THE HUMAN MICROBIOME PROJECT SAYS THE HUMAN BODY HAS 100 TRILLION MICROSCOPIC LIFE FORMS LIVING IN IT.



6/15/12  
© HARTFORD COURANT

# THE HUMAN MICROBIOME PROJECT

CONTAINS

**10** TIMES  
**MORE** MICROBIAL  
CELLS  
THAN HUMAN  
CELLS.

MICROORGANISMS,  
THEIR GENOMES  
& ENVIRONMENTAL  
INTERACTIONS

**250**

HEALTHY  
PEOPLE

SPOTS SAMPLED:



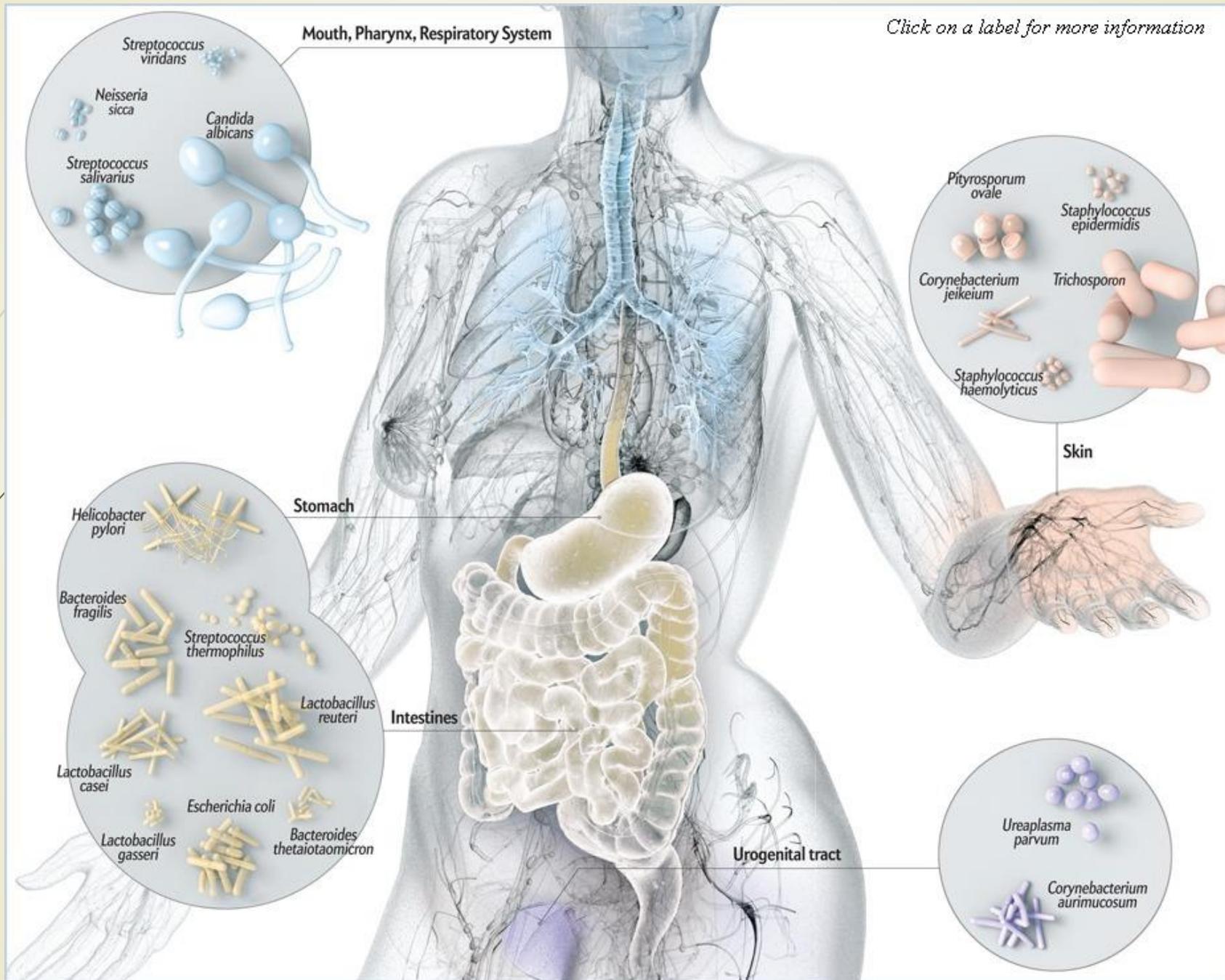
WE ALL CARRY  
2-5 LBS OF  
BACTERIA...

HUMANS ARE LIKE  
CORAL: AN  
ASSEMBLAGE OF  
LIVING TOGETHER

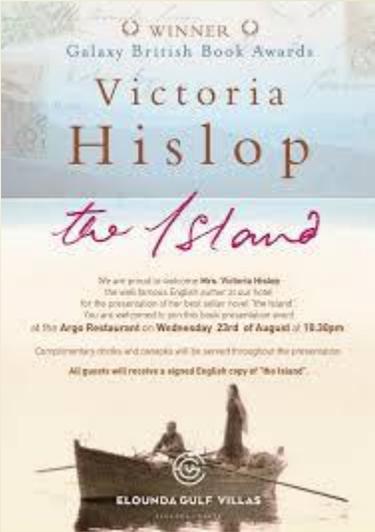
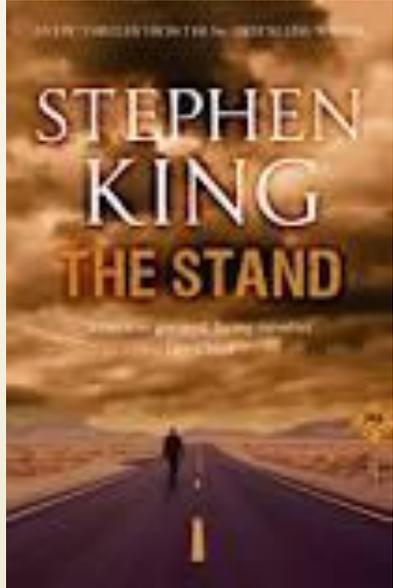
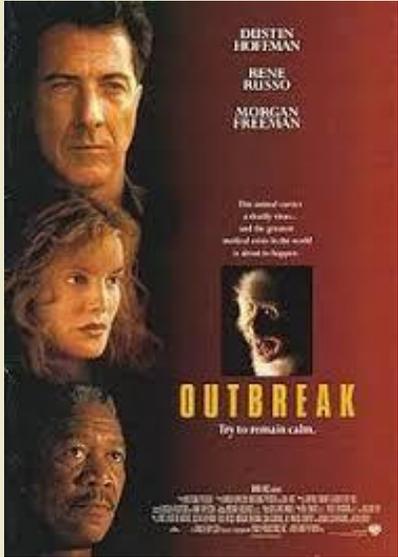
**LIFE FORMS**



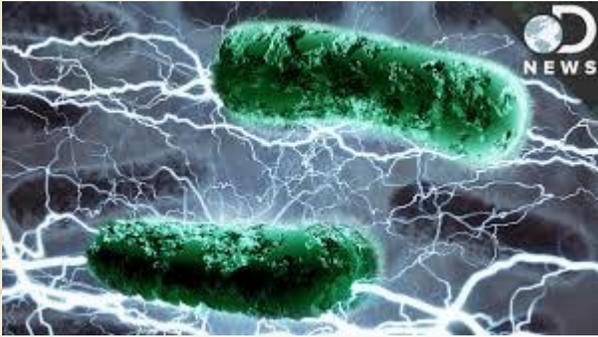
PRI



# MIKROBI I UMJETNOST



# MIKROBI I BUDUĆNOST



SHARE



856



2



Information was encoded in the DNA of a strain of salt-tolerant *Halobacterium salinarum*. JOE DAVIS

## Hardy microbe's DNA could be a time capsule for the ages

By Steve Nadis | Feb. 18, 2020, 4:30 PM

Joe Davis is looking for the ultimate time capsule. He wants to preserve a record of humanity that could survive for eons, to be read by successors to *Homo sapiens* on Earth or by sapient extraterrestrials. He has now found the right medium, he thinks: the DNA of an odd microbe that lives in deposits of rock salt. He believes this archive—protected by salt and renewed by the microbe—could possibly survive for hundreds of millions of years.

It's a visionary idea, owing as much to art as science. Davis, an artist affiliated with a Harvard University biology lab, bridges both worlds. His project took a step forward last week with a study

# Raznolikost mikroba

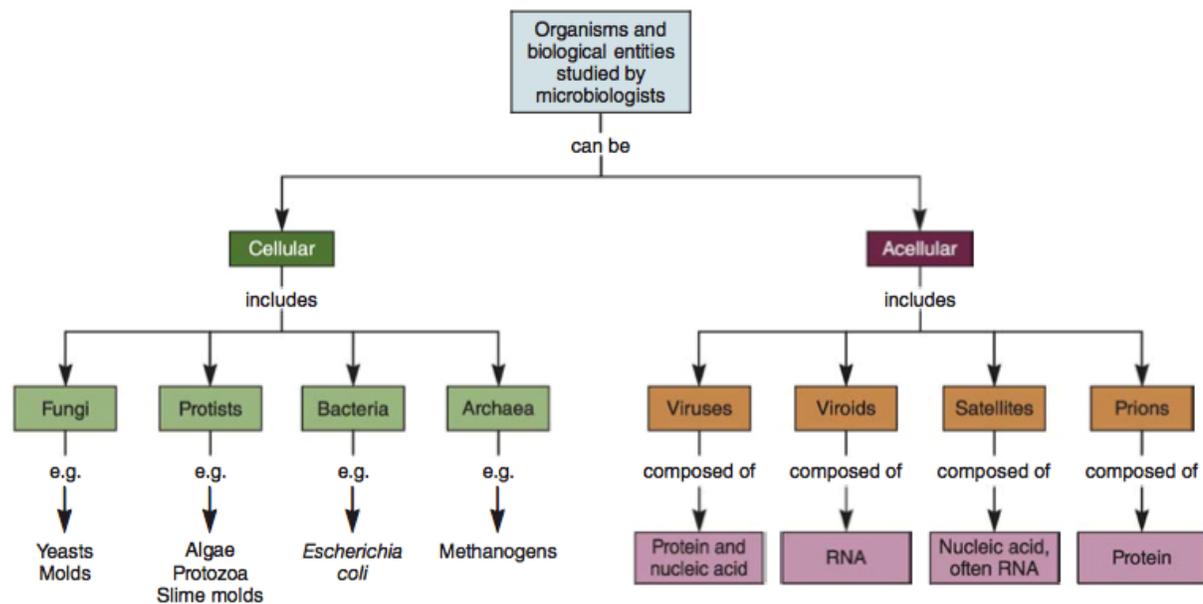


Figure 1.1 Concept Map Showing the Types of Biological Entities Studied by Microbiologists.

- stanični
- nestanični

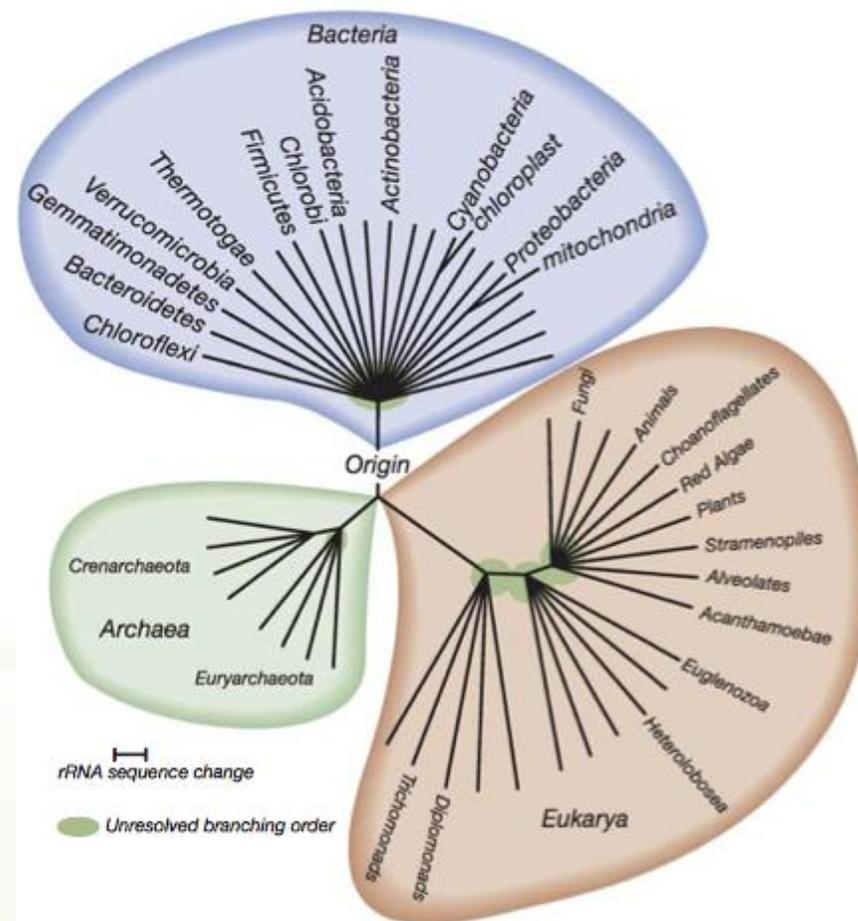


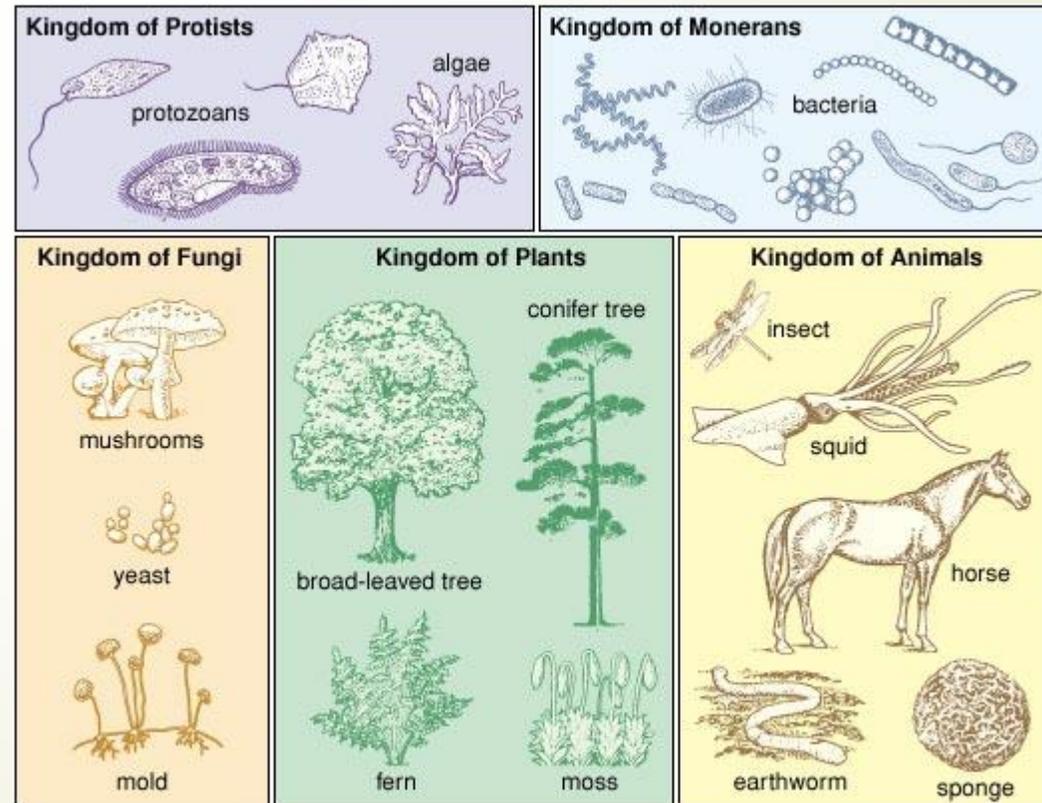
Figure 1.2 Universal Phylogenetic Tree. These evolutionary relationships are based on rRNA sequence comparisons. To save space, many lineages have not been identified.

# PODJELA ŽIVOGEN SVIJETA NA CARSTVA (KRALJEVSTVA)

(Whittaker, 1969)

5 CARSTAVA (KRALJEVSTAVA)

- monere (**Monera**)
- protisti (**Protista**)
- gljive (**Fungi**)
- biljke (**Plantae**)
- životinje (**Animalia**)



# PODJELA ŽIVOOG SVIJETA NA CARSTVA (KRALJEVSTVA)

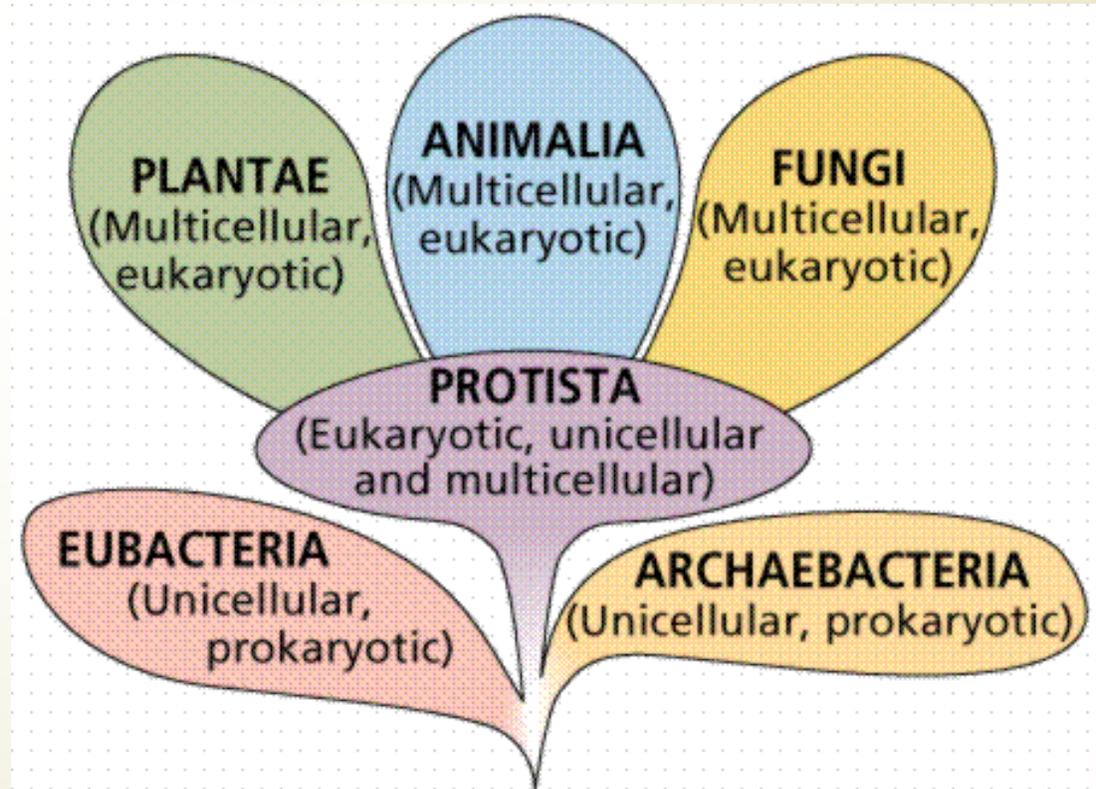
6 CARSTAVA (KRALJEVSTAVA)

- NADCARSTVO(KRALJEVSTVO) PROKARIOTI (**Prokaryota**)

**Monera**

➤ eubakterije  
(**Eubacteria**)

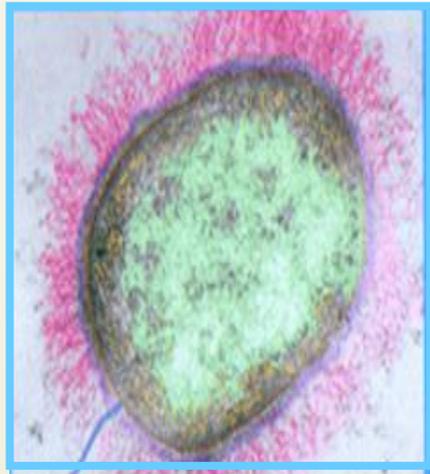
➤ arhebakterije  
(**Archaeobacteria**)



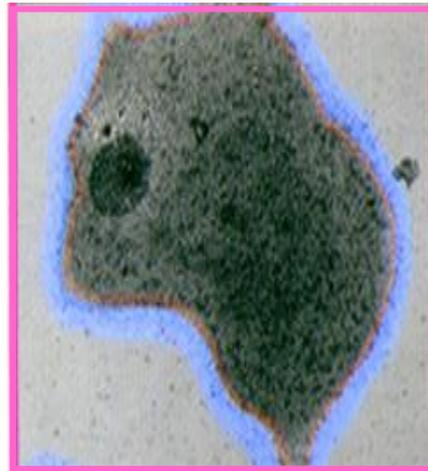
# PODJELA ŽIVOOG SVIJETA NA CARSTVA (KRALJEVSTVA)

(Woese, 1990)

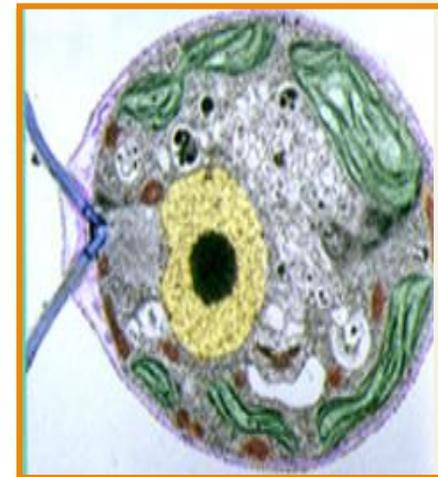
3 DOMENE



Bacteria

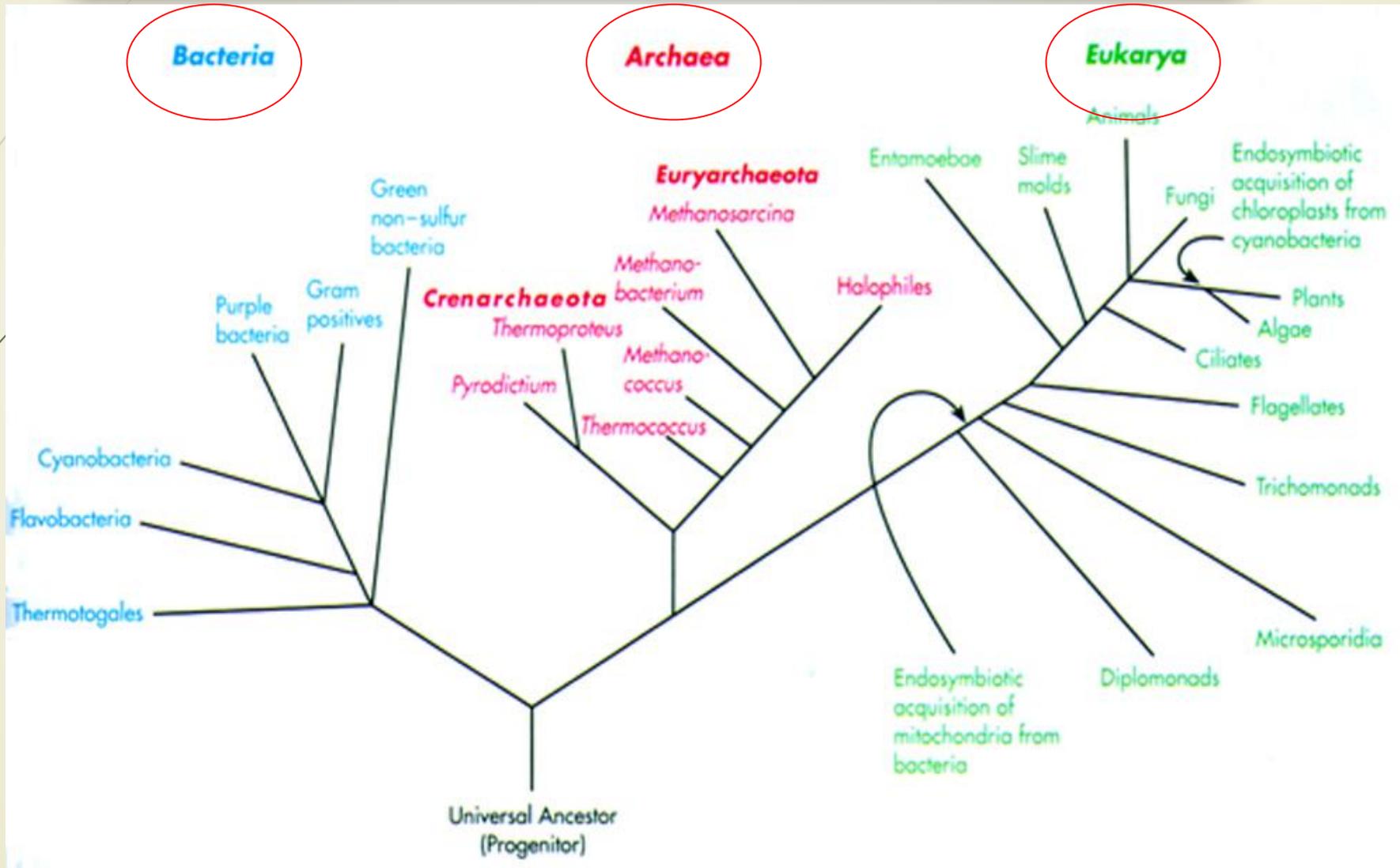


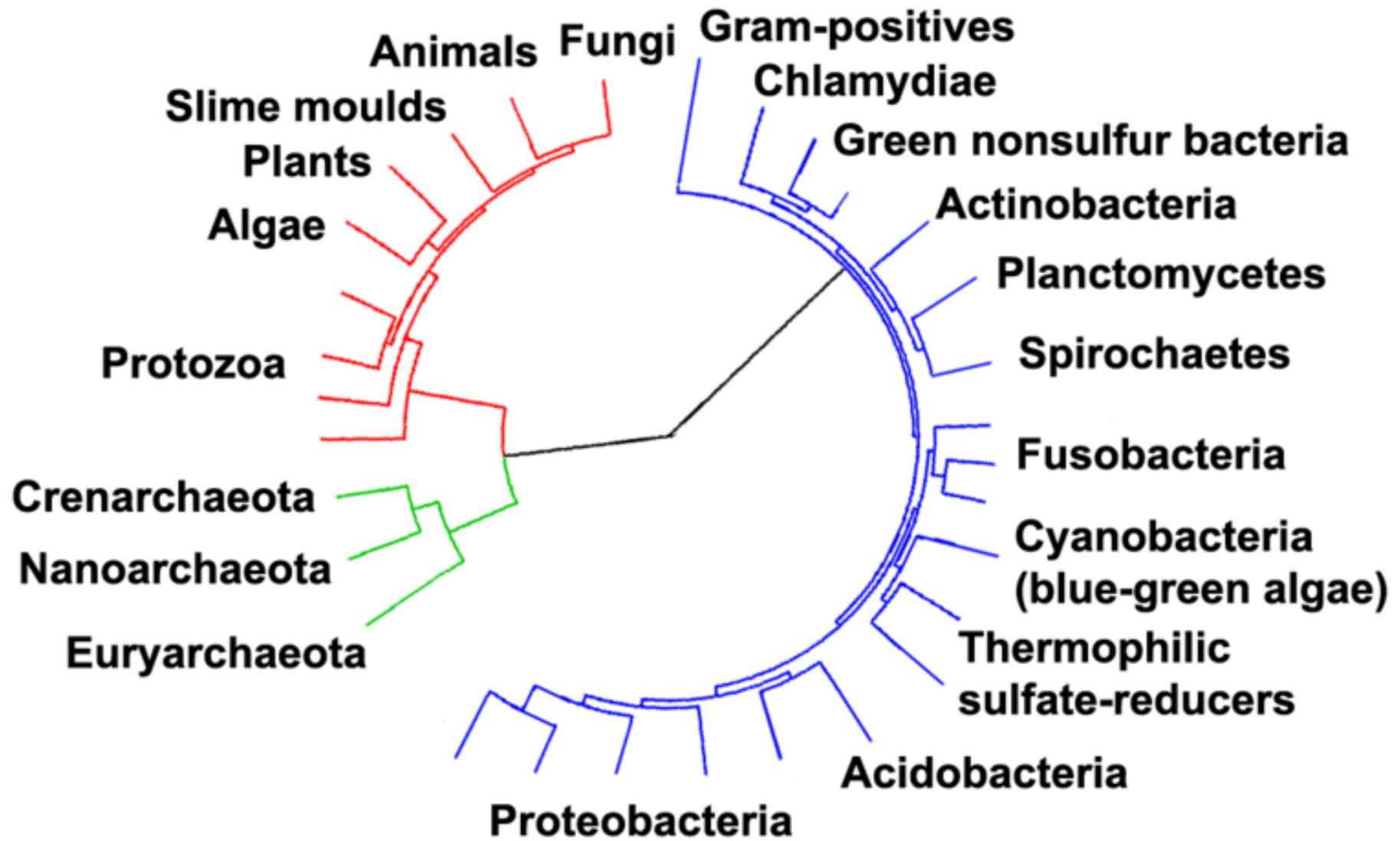
Archaea



Eucarya

# filogenetsko drvo života

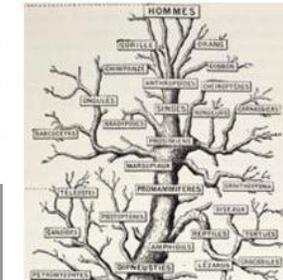




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## ONLY TWO DOMAINS, NOT THREE: CHANGING VIEWS ON THE TREE OF LIFE

Issue: What is life?

 10 May 2016 **ARTICLE**


In 1857, Charles Darwin sent a letter to Thomas Huxley in which he wrote: "The time will come I believe, though I shall not live to see it, when we shall have very fairly true genealogical trees of each great kingdom of nature."

### A tree for all of life – the three-domains tree

Genealogical or evolutionary trees show the relationships between organisms based upon common ancestry, like the family trees that we use to investigate our own parentage. For many biologists, Darwin's dream was realised on the grandest scale when, in 1990, Carl Woese and colleagues proposed that all cellular life could be placed into one of three separate fundamental groups or 'domains' – the Bacteria, the

Archaea and the Eukarya, based upon sequence comparisons of small subunit (SSU) ribosomal (r) RNA sequences. According to the 'three-domains tree', the Eukarya and Archaea are more closely related to each other than they are to the Bacteria (Fig. 1). Hence, in this tree our closest cousins are the Archaea, a group of micro-organisms once thought to be restricted to anaerobic and other hostile habitats like hot springs and thermal vents in the deep ocean. However, although the three-domains tree of life has dominated debate about how to organise life's diversity at the highest level for the past 20 years or so, there is now increasing evidence that it is not the best-supported hypothesis for the evolutionary relationship between eukaryotes and Archaea.

## ARTICLES

<https://doi.org/10.1038/s41559-019-1040-x>

 nature  
ecology & evolution

# Phylogenomics provides robust support for a two-domains tree of life

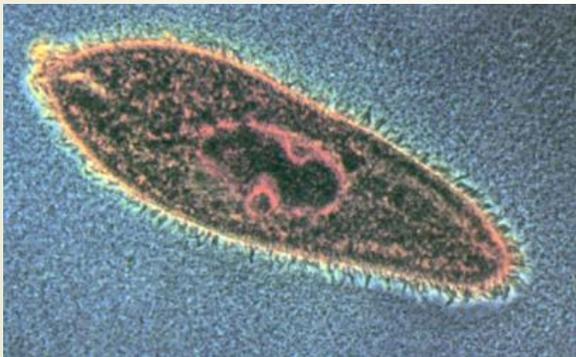
 Tom A. Williams<sup>1\*</sup>, Cymon J. Cox<sup>2</sup>, Peter G. Foster<sup>3</sup>, Gergely J. Szöllösi<sup>4,5,6</sup> and T. Martin Embley<sup>7\*</sup>

Hypotheses about the origin of eukaryotic cells are classically framed within the context of a universal 'tree of life' based on conserved core genes. Vigorous ongoing debate about eukaryote origins is based on assertions that the topology of the tree of life depends on the taxa included and the choice and quality of genomic data analysed. Here we have reanalysed the evidence underpinning those claims and apply more data to the question by using supertree and coalescent methods to interrogate >3,000 gene families in archaea and eukaryotes. We find that eukaryotes consistently originate from within the archaea in a two-domains tree when due consideration is given to the fit between model and data. Our analyses support a close relationship between eukaryotes and Asgard archaea and identify the Heimdallarchaeota as the current best candidate for the closest archaeal relatives of the eukaryotic nuclear lineage.

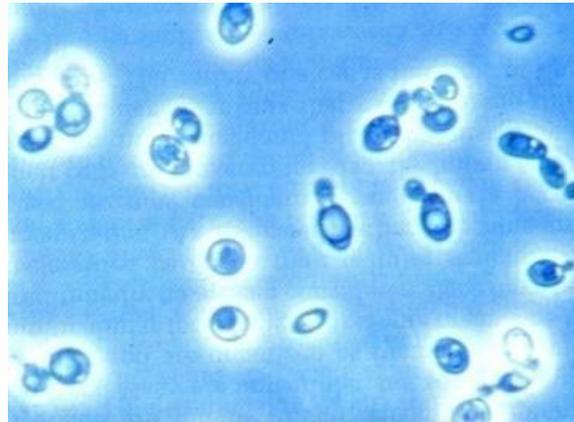
# PODJELA MIKROBIOLOGIJE



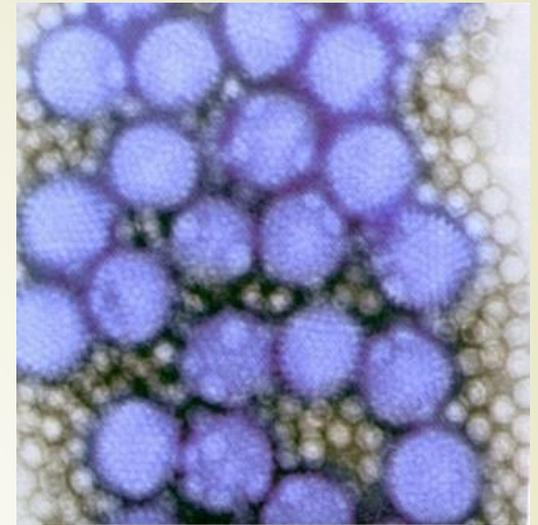
•bakteriologija



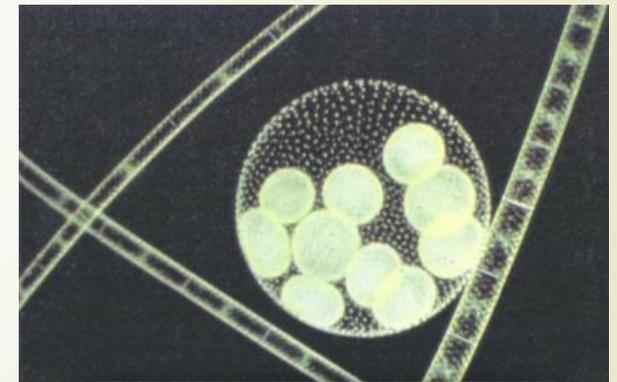
•protozoologija



•mikologija



•virologija



•fikologija  
(algologija)

## Svjetlosni mikroskop

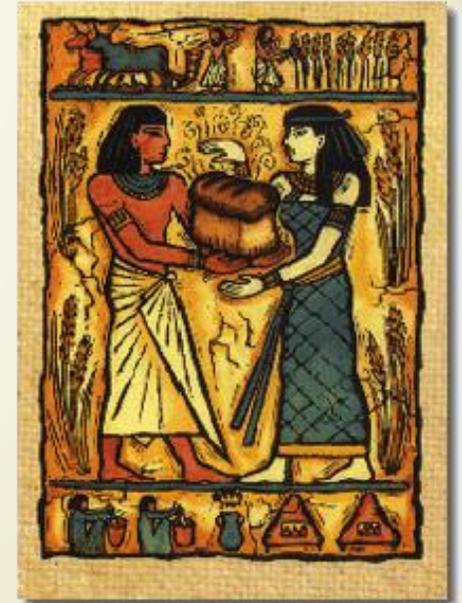


## Elektronski mikroskop



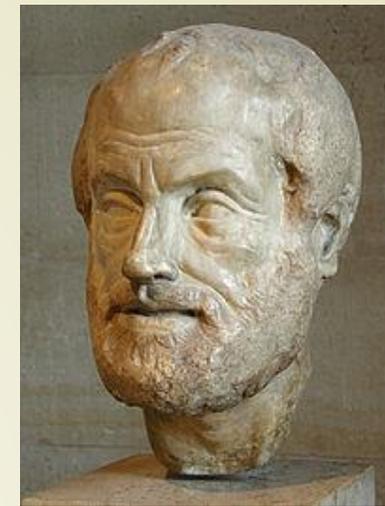
# POVIJESNI RAZVOJ MIKROBIOLOGIJE

- **Stari Egipćani** oko 4000 g.p.n.e. znali su da se neke bolesti prenose dodirrom s bolesnog čovjeka na zdravog
- proizvodnja kruha, piva, vina, sira – korištenje mikroba u svrhu fermentacije
- **Asirci i Babilonci** su prije 3500 g znali da je lepra (guba) prenosiva bolest
- poznavali su proces fermentacije
- U Mojsijevoj knjizi pisanoj 400 g.p.n.e. nalaze se podaci iz kojih se vidi da su stari Židovi znali da su kuga, antraks, trahom, šuga i tuberkuloza bolesti koje se dodirrom, odjećom i prašinom prenose sa bolesnih ljudi na zdrave te da su prakticirali dezinfekciju i izolaciju bolesnika



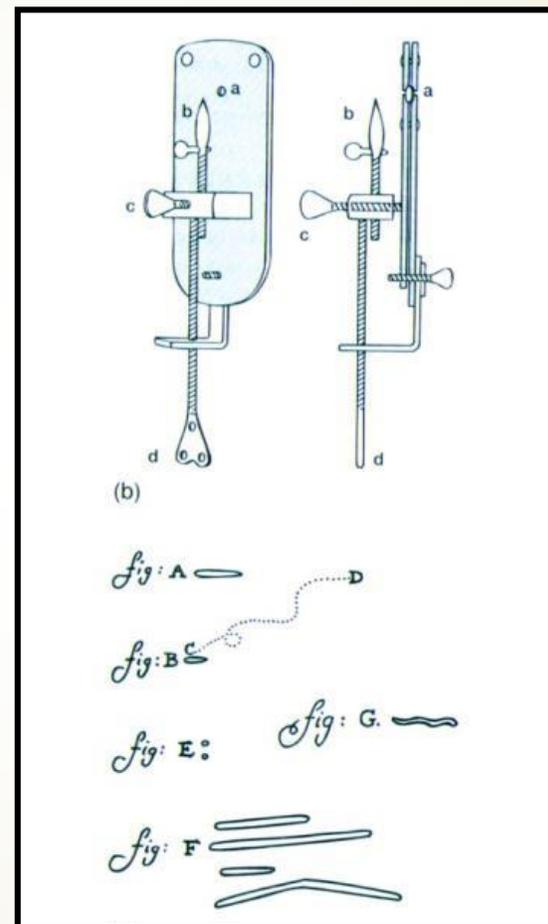
# POVIJESNI RAZVOJ MIKROBIOLOGIJE

- **Aristotel** (4. st. p.n.e.) - vjerovanje o samoniklom ili spontanom postanku života (“spontana generacija”)
- **Lukrecije** (1. st. p.n.e.) - bolesti uzrokuju nevidljiva živa stvorenja
- **Srednji vijek** (5-15 st.) je bio razdoblje velikih epidemija raznih zaraznih bolesti
- od **kuge** (“crna smrt”) je u 14 st. U Europi umrlo oko 50.000000 ljudi (trećina tadašnjeg stanovništva).
- **Fracastoro** (16. st.) – objavio je djelo «*De contagionibus et contagiosis eorum curatione*» - uzročnici zaraznih bolesti su živi organizmi i nazvao ih je «*seminaria morbi*»
- Sifilis – ime pastira iz njegova djela



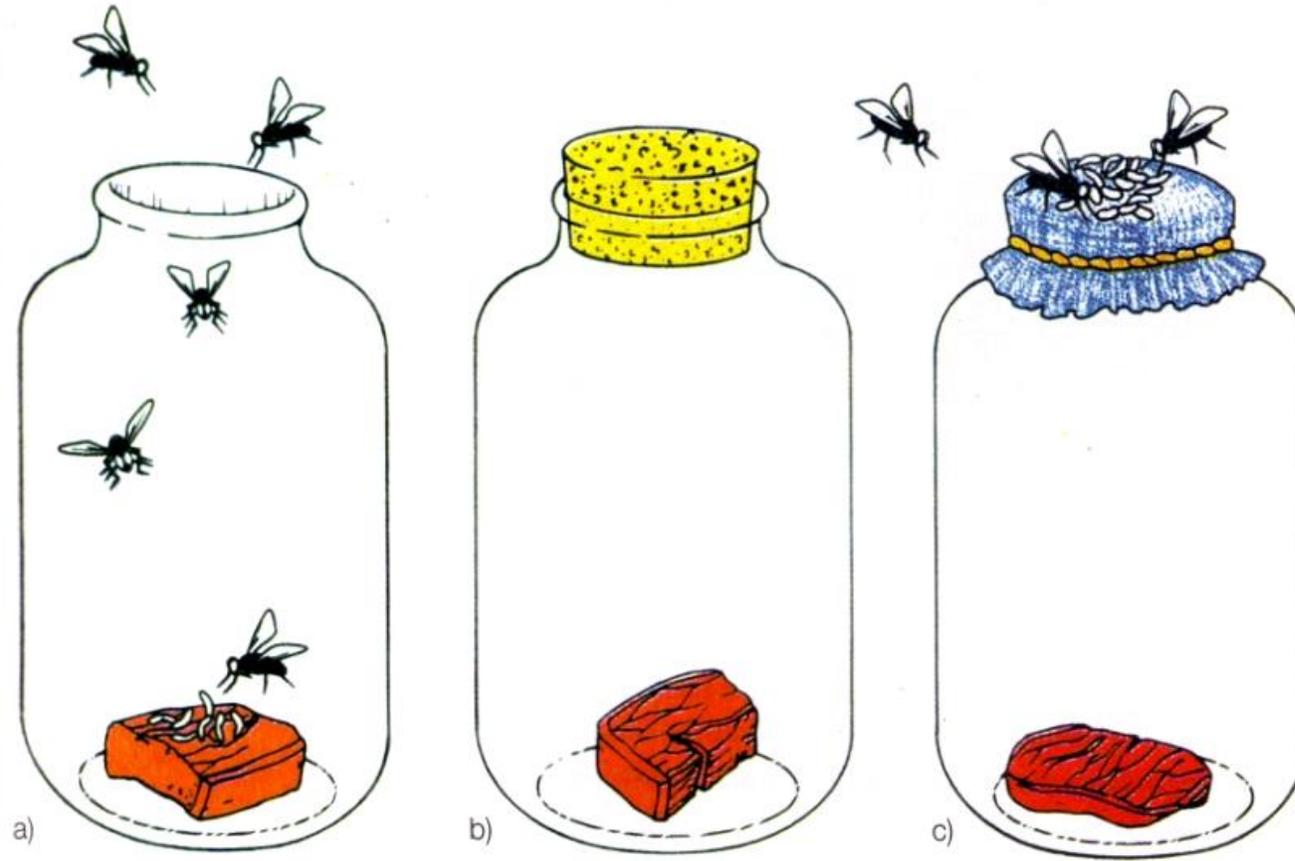
# POVIJESNI RAZVOJ MIKROBIOLOGIJE

**Antony van Leeuwenhoek (17. st.)** - promatranje mikroba jednostavnim mikroskopom



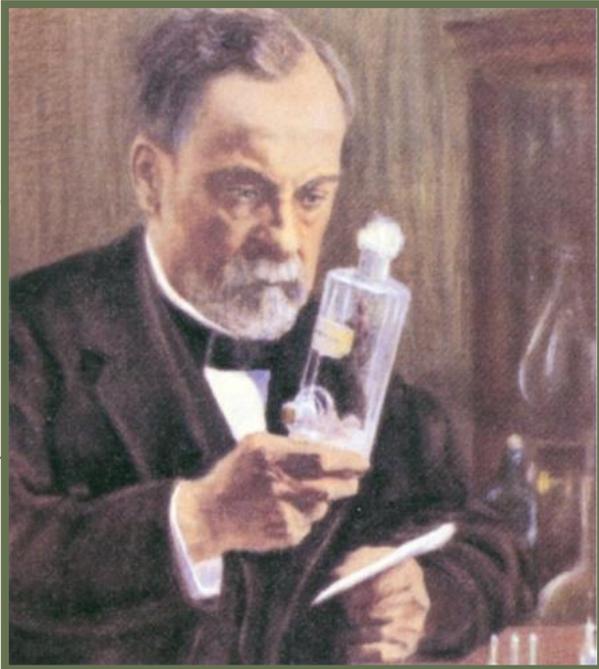
povećanje  
50-300X

- **Francesco Redi (17. st.)** - rušenje teorije o “spontanoj generaciji”
- eksperimentalno dokazao da se ličinke i crvići u mesu i zemlji razvijaju iz jajašaca koja tu izlegu muhe.

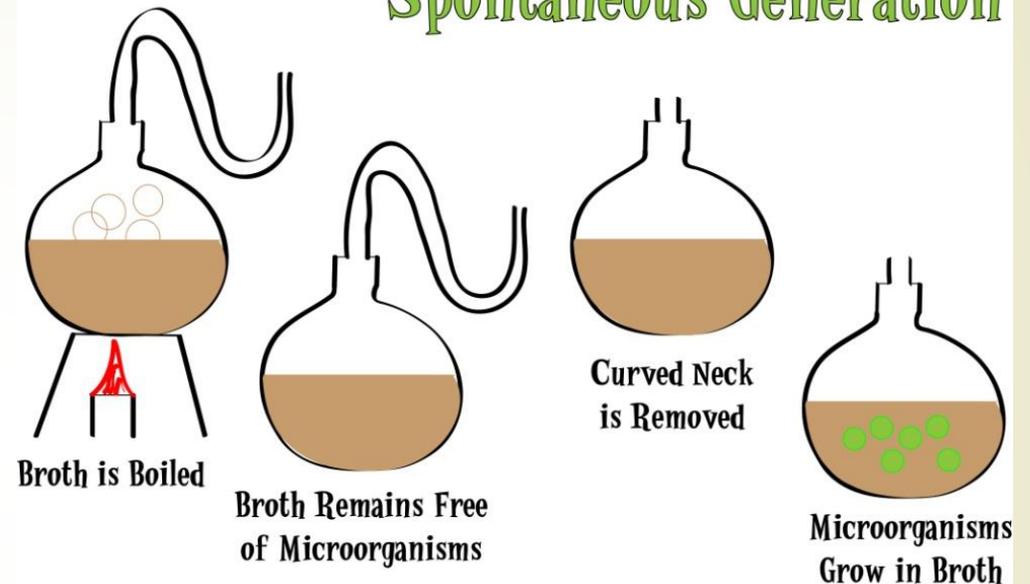


17. stoljeće Pokus F. Redija pokazuje da muhe nisu spontano stvorene u mesu. U uporabljenom sustavu su posude: a) u izravnom kontaktu s okolinom, b) posuda u kojoj meso nije izloženo izravnom kontaktu s okolinom i c) posuda prekrivena gazom.

**Louis Pasteur (1822-1895)** - definitivna potvrda neutemeljenosti  
“spontane generacije”



## Pasteur's Test of Spontaneous Generation



-mikrobi- uzročnici vrenja

-mikrobi - uzročnici zaraznih bolesti ljudi i životinja

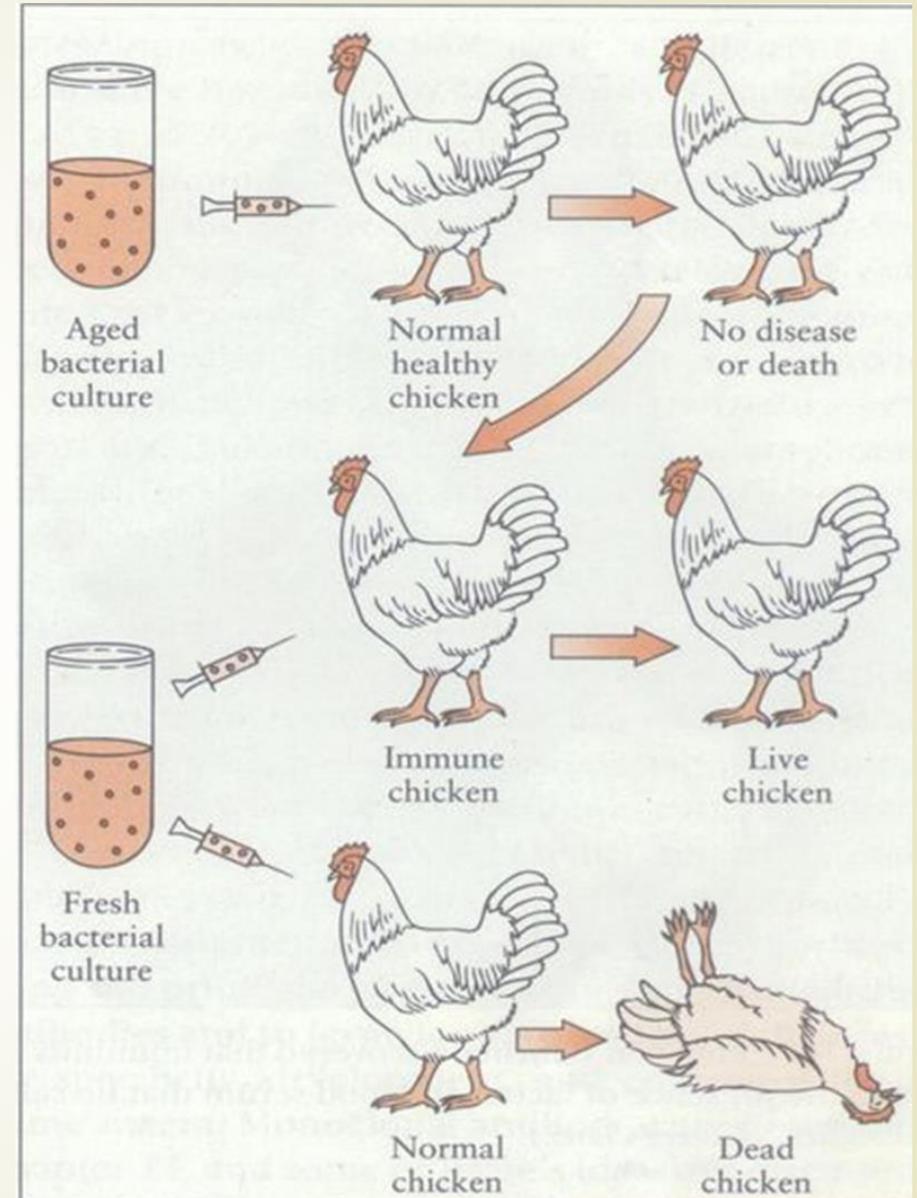
-utemeljenje zaštitnog cijepljenja (bjesnoća) – oslabljivanje uzročnika u laboratoriju

-*pasterizacija*; anaerobioza

<https://www.youtube.com/watch?v=0OmWbRKW4K8>

## Louis Pasteur (1822-1895)

- kokošja kolera – uzročnik *Pasteurella multocida* – uspješno kultiviranje
- slučajno otkriće da “zaboravljene” kulture stajanjem postepeno gube virulentnost
- inokulacija kokoši sa starim kulturama *P. multocida* pokazala je da su kokoši razvile blage simptome i oporavile su se, a nakon toga stekle imunost na zarazu svježim kulturama uzročnika kokošje kolere
- oslabljene (atenuirane) vakcine



## Robert Koch (1843-1910)

- otkriće uzročnika nekih zaraznih bolesti (tuberkuloza, antraks, kolera)
- primjena čistih kultura
- upotreba čvrstih hranjivih podloga (želatina, agar)
- bojanje bakterijskih stanica





## Kochovi postulati za priznavanje uzročnika neke bolesti:

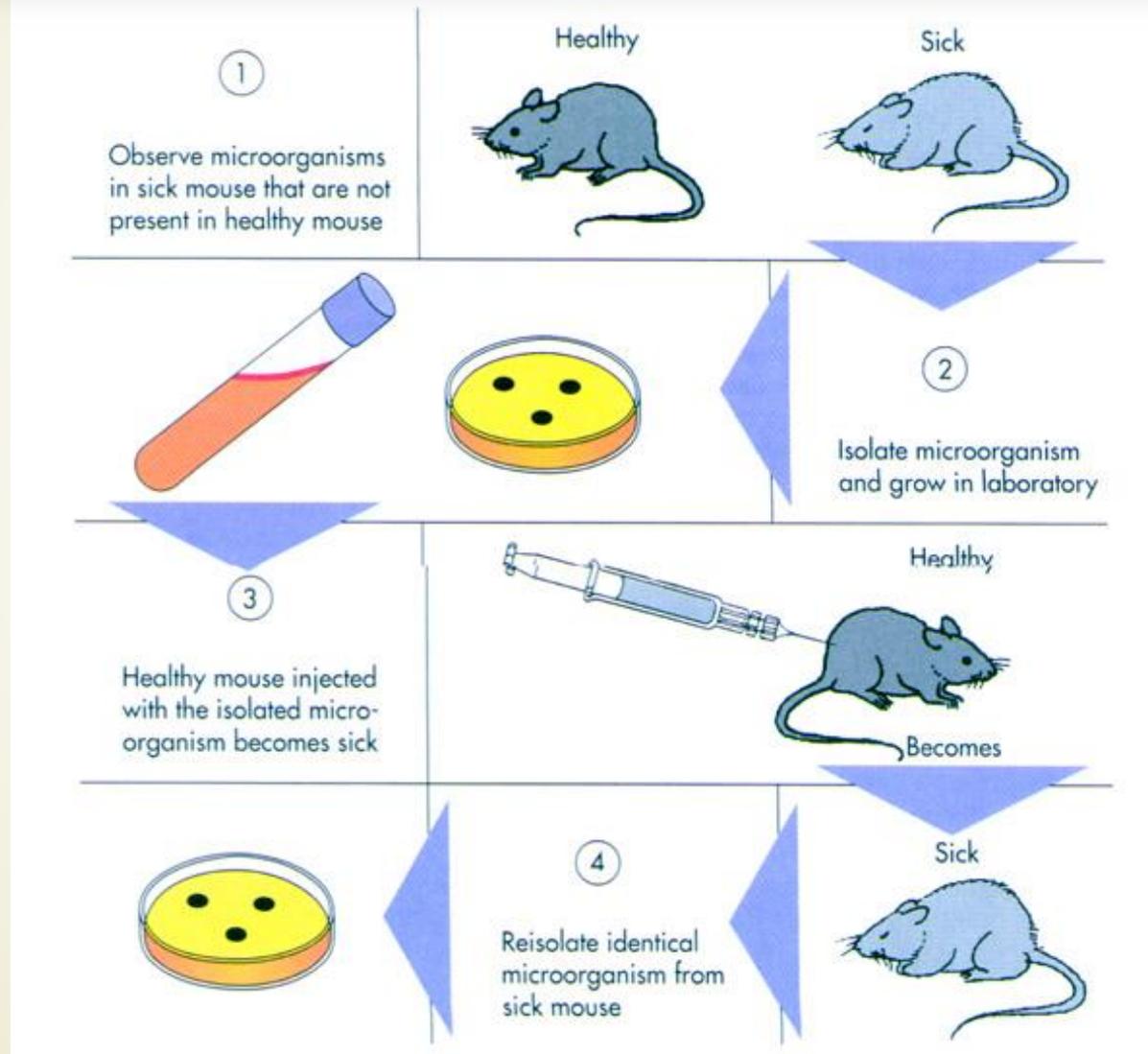
-u bolesnom organizmu mora biti prisutan neki mikrob-uzročnik

-on se mora izolirati iz organizma u čistoj kulturi

-izolirana čista kultura mora uzrokovati istu bolest nakon unošenja u zdravi organizam

-iz pokusno zaraženog organizma treba ponovno izdvojiti uzročnika u čistoj kulturi

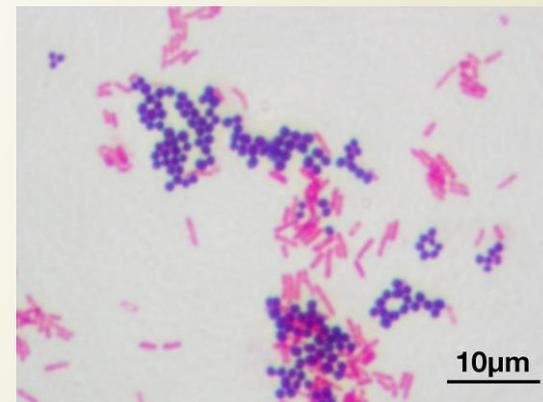
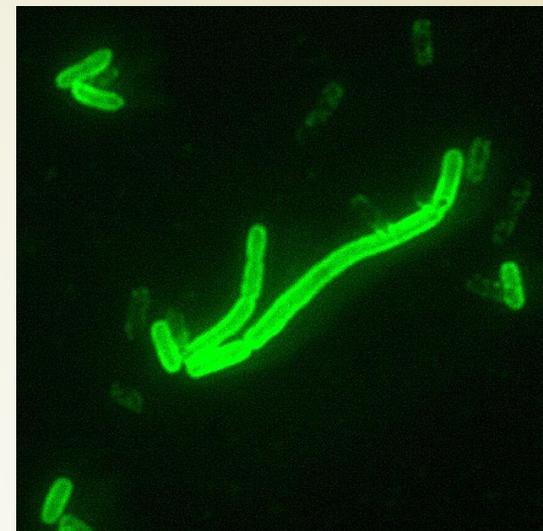
# Kochovi postulati za priznavanje uzročnika neke bolesi



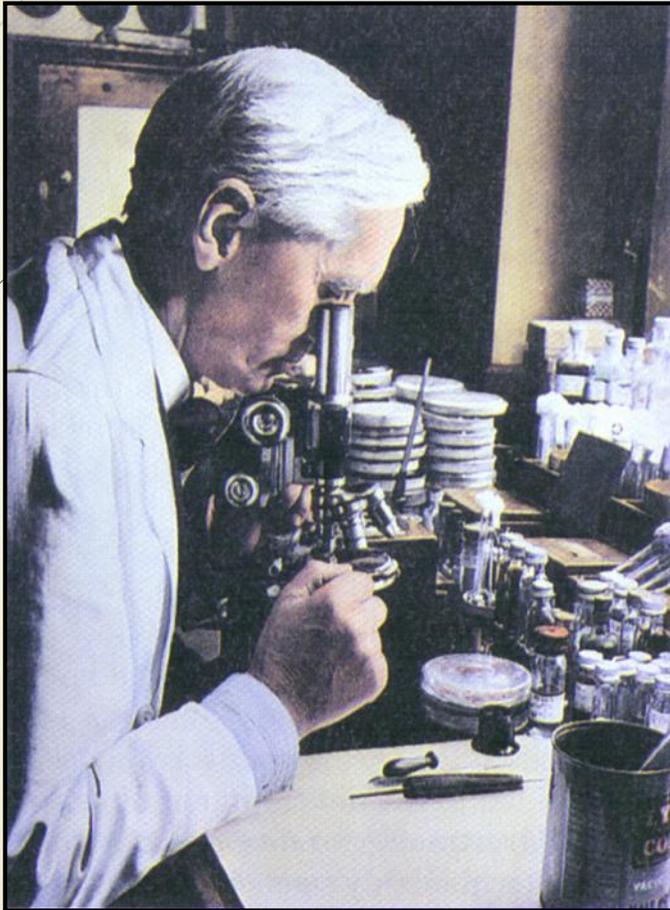
Period 1876-1900 naziva se **zlatni vijek bakteriologije**

Neka najvažnija otkrića:

- 1879. uzročnik kapavca (gonoreje), Neisser
- 1880. trbušni tifus, Eberth
- **1882. tuberkuloza, Koch (tzv. Kochov bacil)**
- 1883 azijska kolera, Koch
- **1884 bojenje po Gramu (Hans Christian Gram)**
- 1884 difterija, Klebs i Löffler; tetanus, Nicolaier
- 1887 epidemični meningitis, Weichselbaum
- 1894 kuga, Kitasato i Yersin
- 1897 bacilarna dizenterija, Shiga
- 1888 toksin uzročnika difterije, Roux i Yersin
- 1889 toksin uzročnika tetanusa, Kitasato

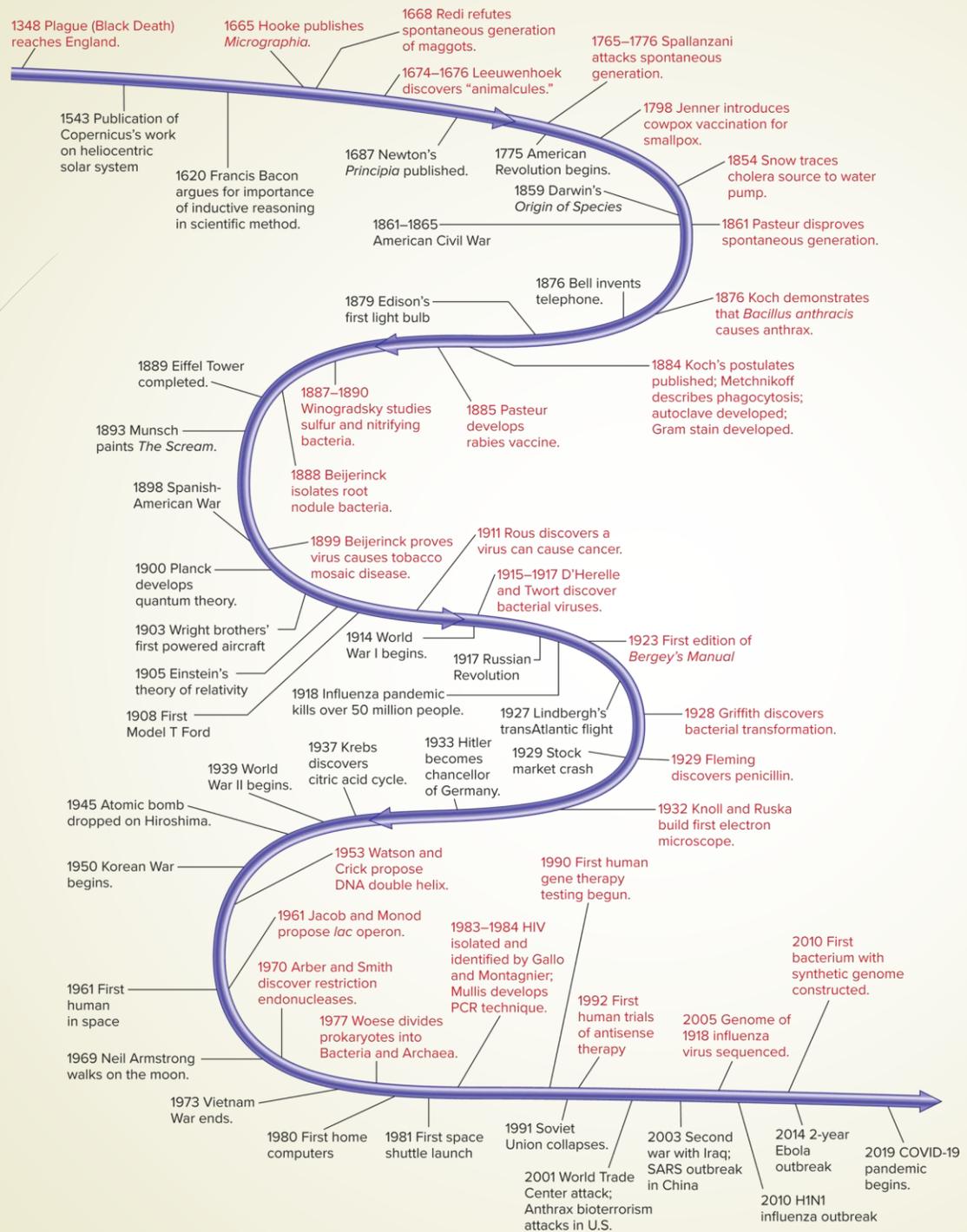


**Sir Alexander Fleming (1881-1955)** - otkriće penicilina, početak primjene antibiotika



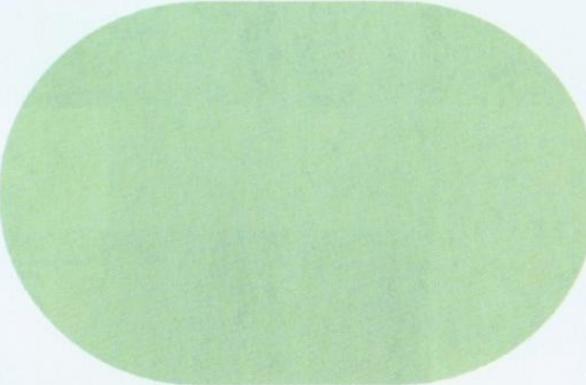
- filtrat kulture *Penicillium notatum* ubija *Staphylococcus aureus* - penicilin
- Chain i Florey su pročistili supstancu i prvi put su je upotrijebili 1941. za liječenje piogenih (gnojnih) infekcija ljudi





## Povijesni kontekst nekih od značajnih otkrića i događaja u razvoju mikrobiologije

# VELIČINA BAKTERIJSKIH STANICA

Specimen	Approximate diameter or width × length in nm	
<i>Oscillatoria</i> Red blood cell	7,000	
<i>E. coli</i>	1,300 × 4,000	
Rickettsia	475	
Poxvirus	230 × 320	
Influenza virus	85	
T2 <i>E. coli</i> bacteriophage	65 × 95	
Tobacco mosaic virus	15 × 300	
Poliomyelitis virus	27	

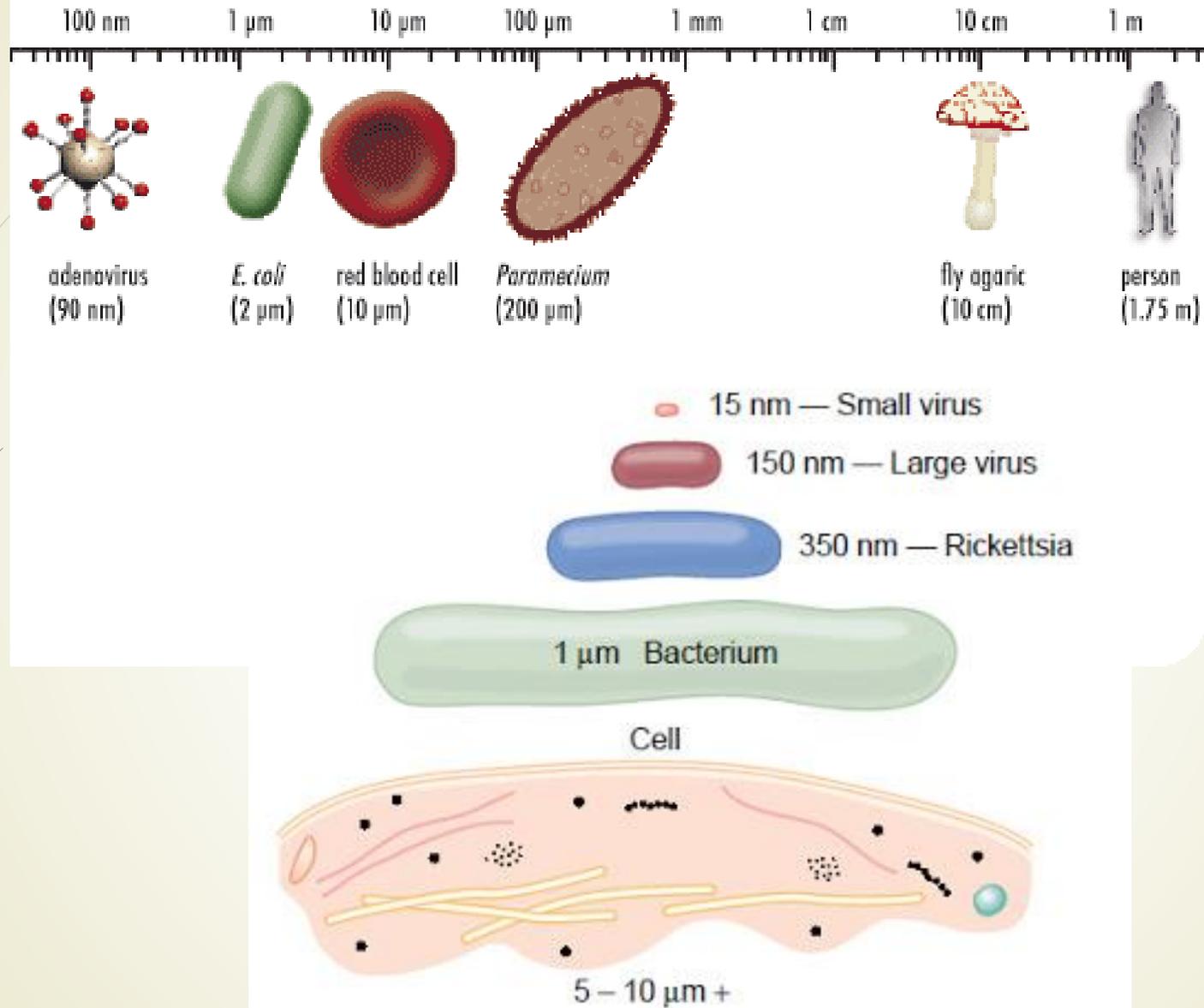
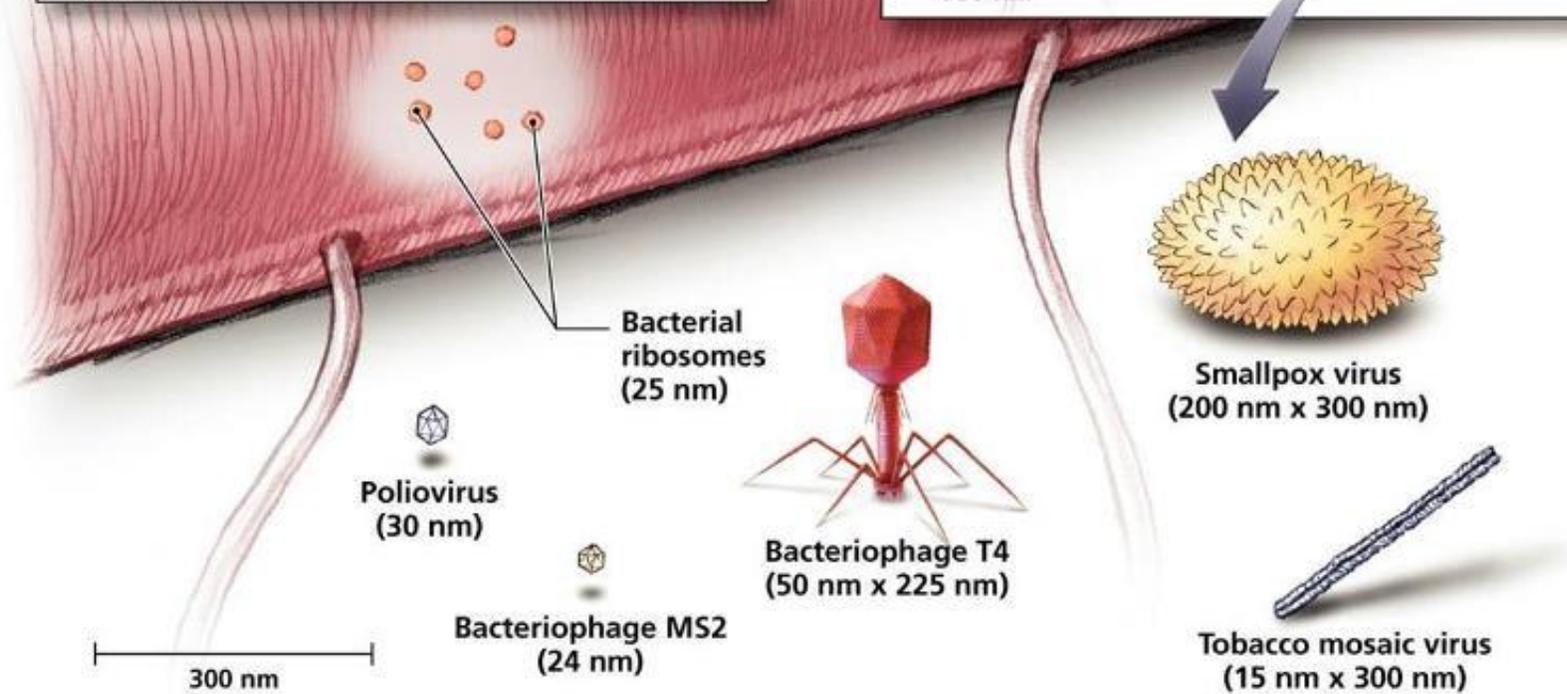
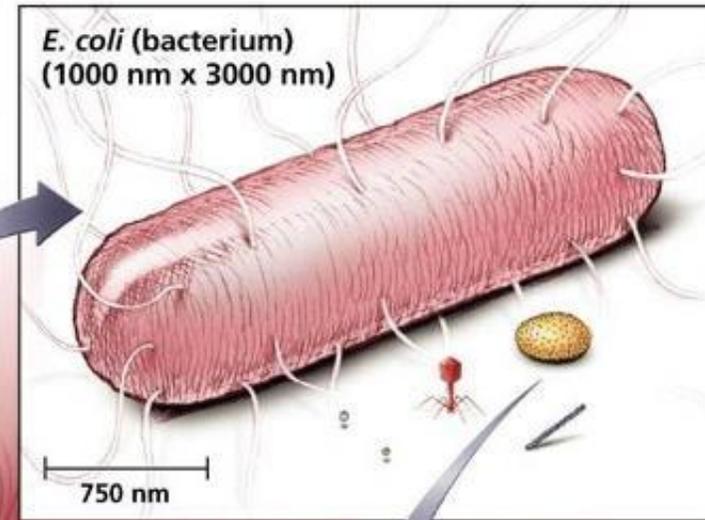
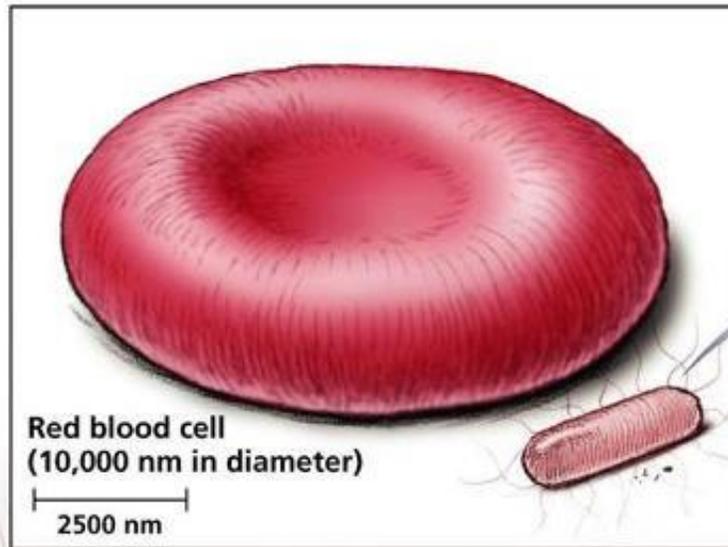
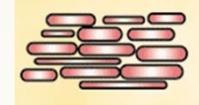
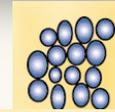


Figure 2-10



# VELIČINA BAKTERIJSKIH STANICA

- okruglaste bakterije:  $0,5 - 1,0 \mu\text{m}$  (promjer)
- štapićaste bakterije:  $0,5 \times 5,0 \mu\text{m}$
- jedne od najmanjih: *Dialister pneumosintens* (štapić  $0,15 \times 0,30 \mu\text{m}$ ), bakterije roda *Mycoplasma* i 'Candidate Phytoplasma' (pleomorfne stanice promjera od  $0,30 \mu\text{m}$ ) te riketije (rod *Rickettsia*; pleomorfne stanice promjera od  $0,30 - 0,80 \mu\text{m}$ )
- ultra-male bakterije otrivene u podzemnim vodama (promjer manji od  $0,20 \mu\text{m}$ ) (<https://www.nature.com/articles/ncomms7372>)
- Patescibacteria (Candidate Phyla Radiation) – CPR bakterije – filogenetska skupina ultra-malih bakterija – uglavnom simbionti
- jedna od najvećih vrsta: *Spirillum volutans* (spiril  $1,5 \times 15 \mu\text{m}$ )
- ekstremni primjer: *Epulopiscium fishelsoni* (u ribama iz porodice *Acanthuridae*) -  $80 \times 600 \mu\text{m}$  (milijun puta veći volumen od tipične bakterije kao što je *E. coli*), te *Thiomargarita namibiensis*, do nedavno najveća otkrivena bakterija – duga do  $750 \mu\text{m}$  (vidljiva golim okom)



- 2022. – '*Candidatus Thiomargarita magnifica*', filamentozna bakterija duga oko 9000 μm! – otkrivena u močvarnim šumama mangrova na karipskom otoku Guadaloupe

RESEARCH ARTICLE | MICROBIOLOGY

f t in r w e

## A centimeter-long bacterium with DNA contained in metabolically active, membrane-bound organelles

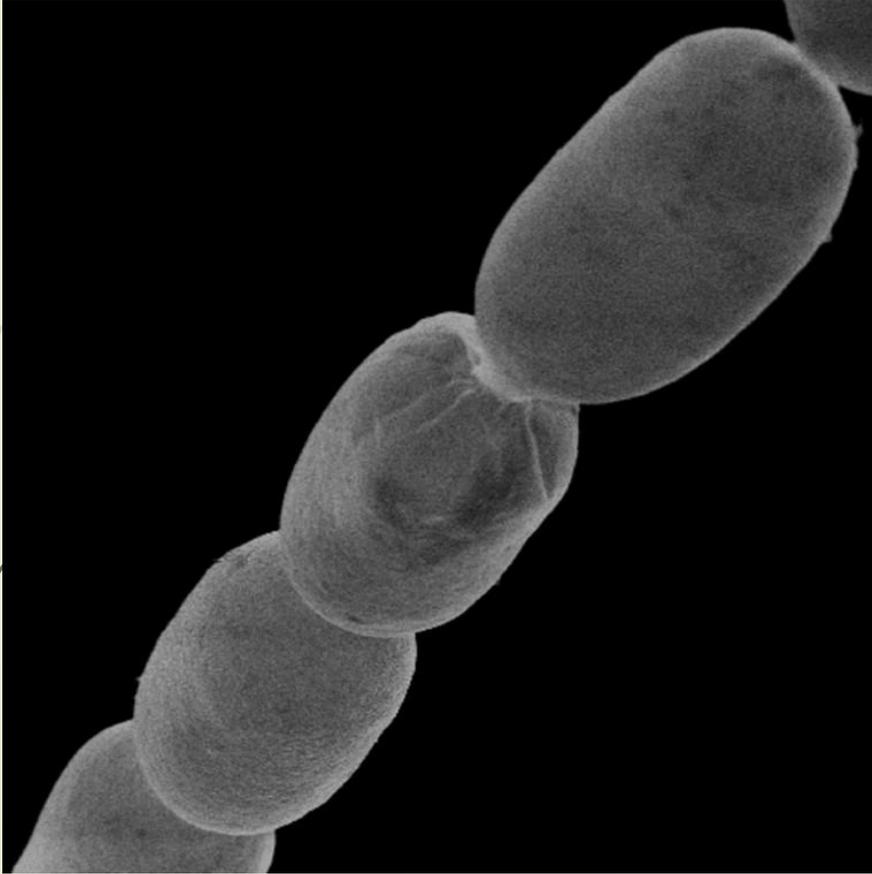
JEAN-MARIE VOLLAND  , SILVINA GONZALEZ-RIZZO  , OLIVIER GROS  , TOMÁŠ TYML  , NATALIA IVANOVA  , FREDERIK SCHULZ  , DANIELLE GOUDEAU  ,  
NATHALIE H. ELISABETH  , NANDITA NATH, [...] AND SHAILESH V. DATE  [+10 authors](#) [Authors Info & Affiliations](#)

SCIENCE • 23 Jun 2022 • Vol 376, Issue 6600 • pp. 1453-1458 • DOI: 10.1126/science.abb3634

NEWS | 23 June 2022

## Largest bacterium ever found is surprisingly complex

'Microorganism' is a misnomer when it comes to centimetre-long *Thiomargarita magnifica*.

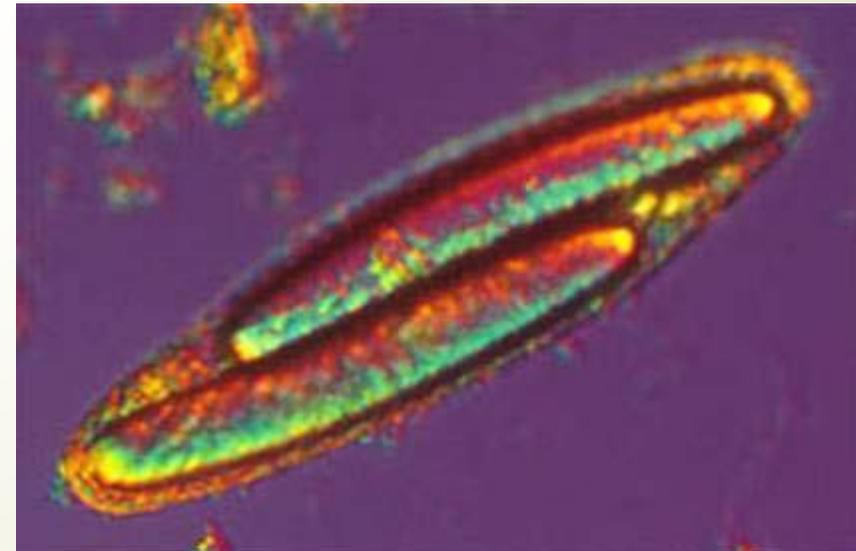
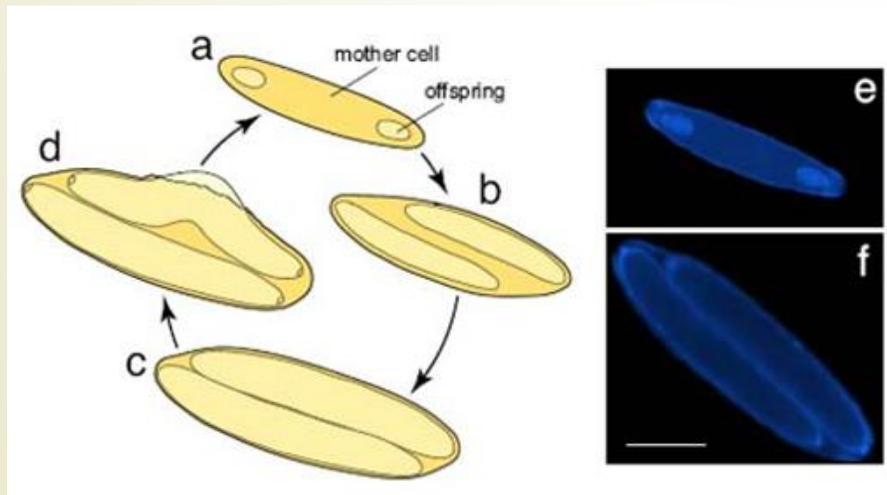
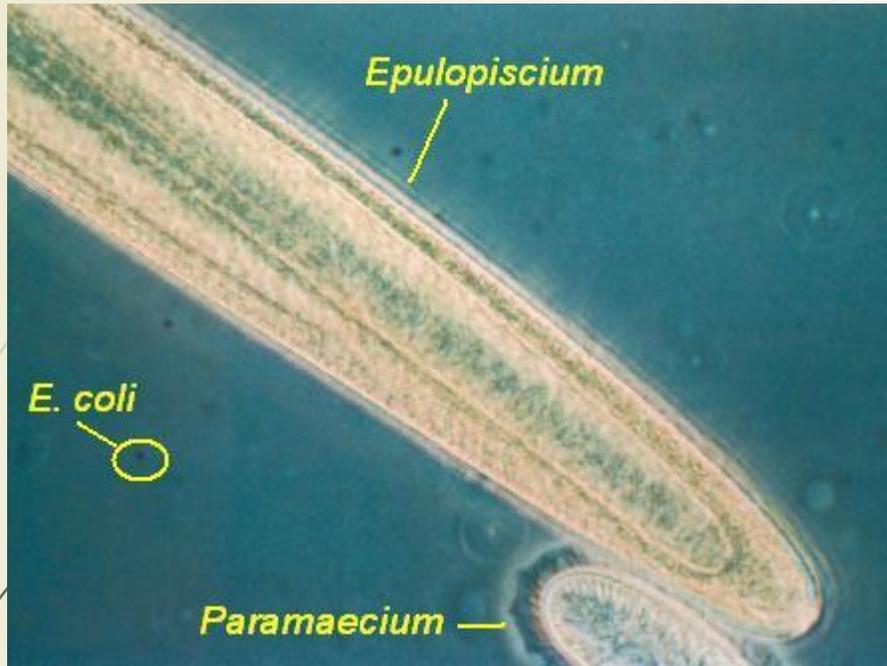


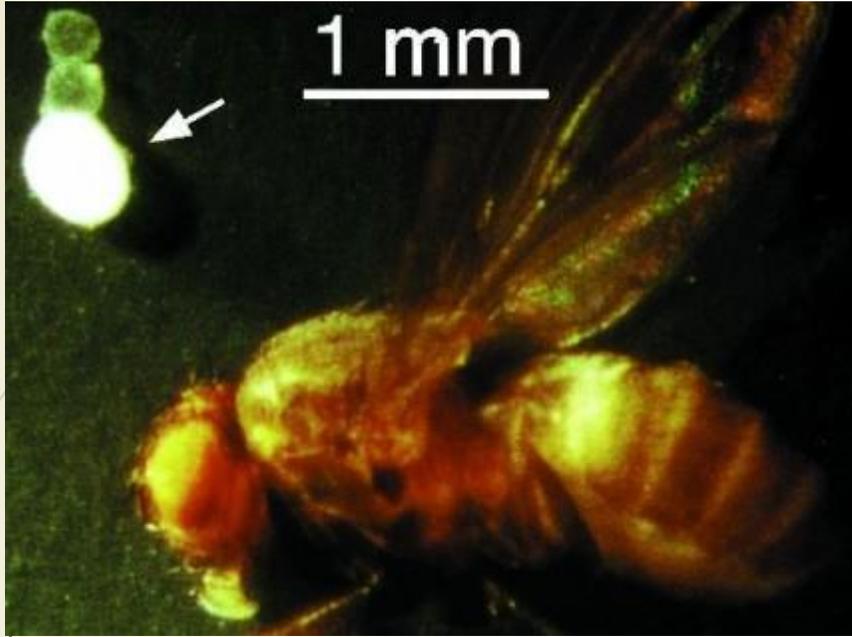
The filamentous *Thiomargarita magnifica* cells have more complex internal organization than do typical bacteria. Credit: Olivier Gros/Lawrence Berkeley National Laboratory

<https://www.youtube.com/watch?v=woG-y1Y1vOY>

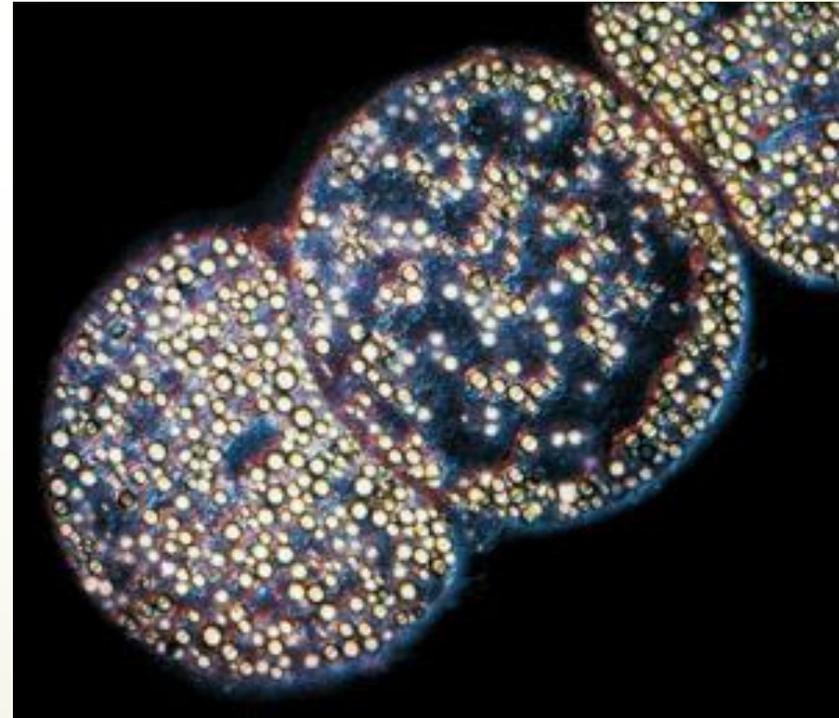


*Epulopiscium fishelsoni*





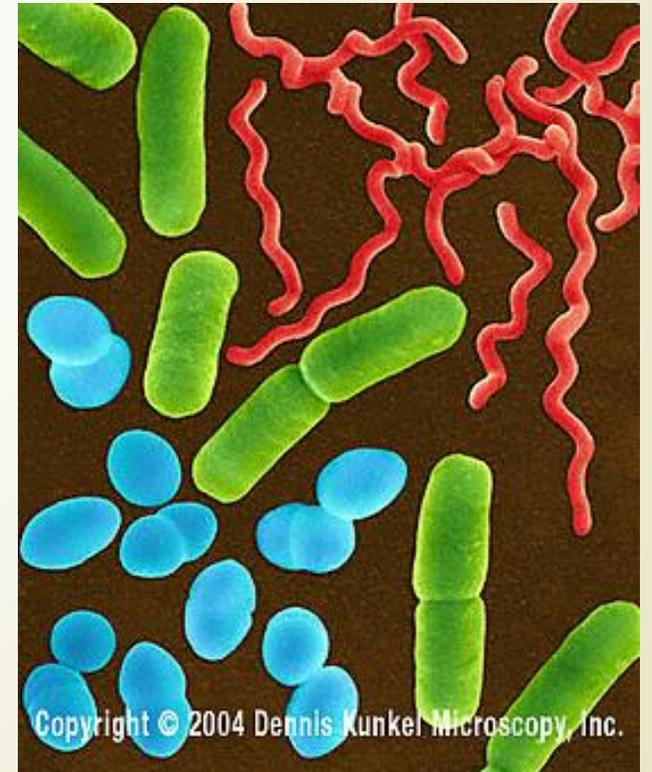
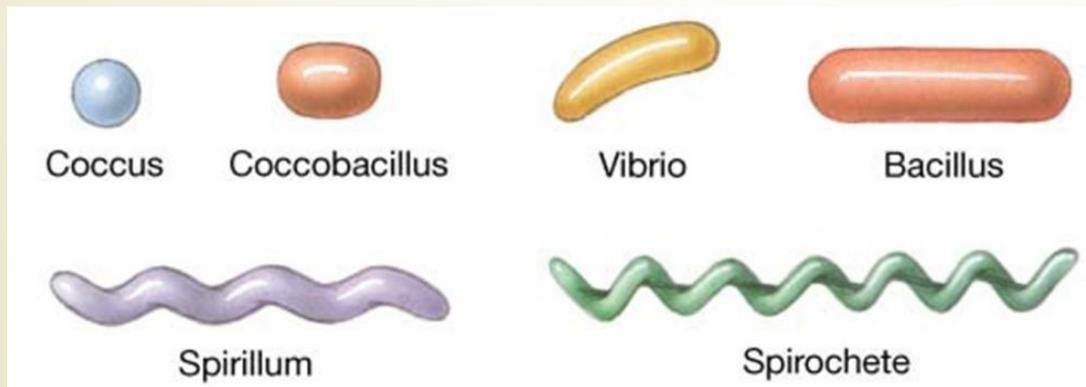
*Thiomargarita namibiensis*



# MORFOLOGIJA BAKTERIJSKIH STANICA

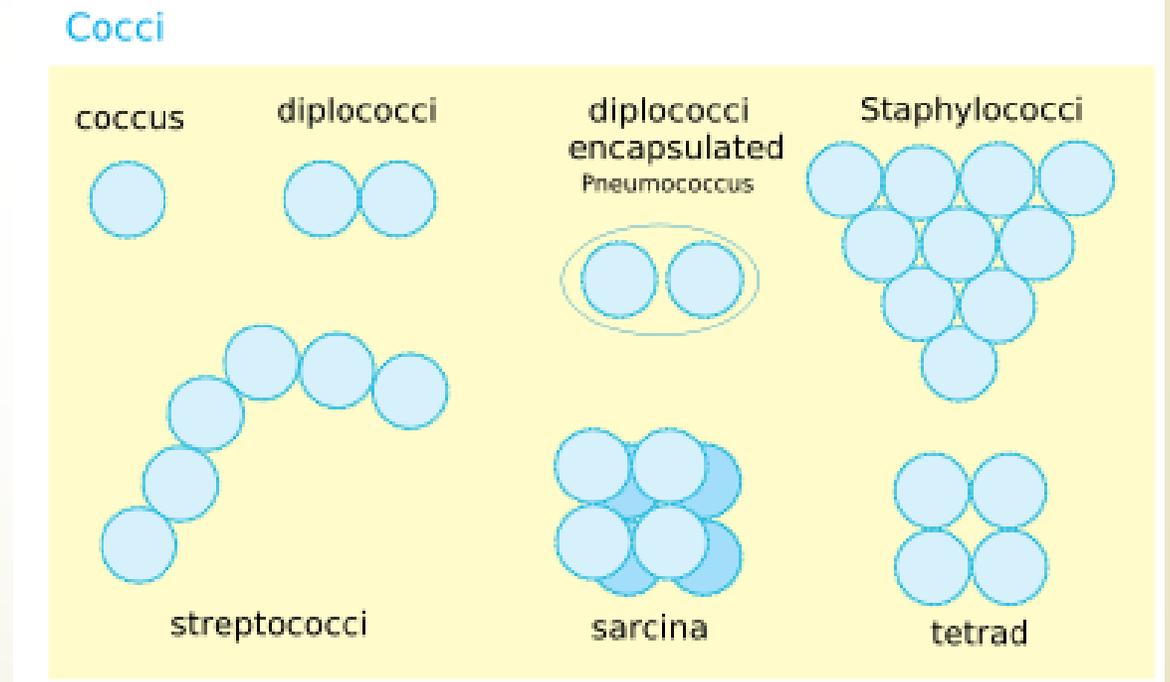
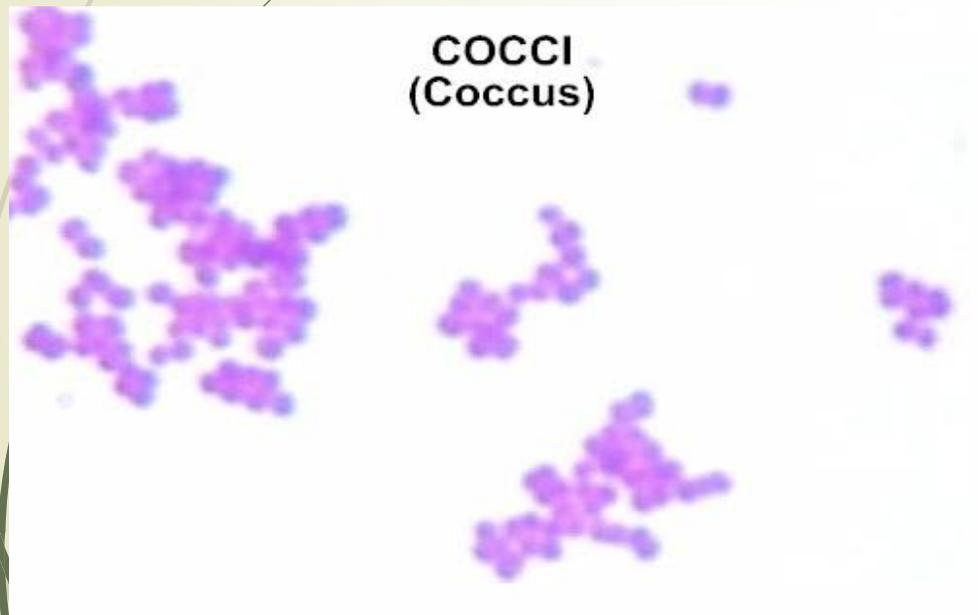
prema obliku bakterijskih stanica razlikujemo tri glavne skupine:

1. okruglaste
2. štapićaste
3. zavojite (spiralne)

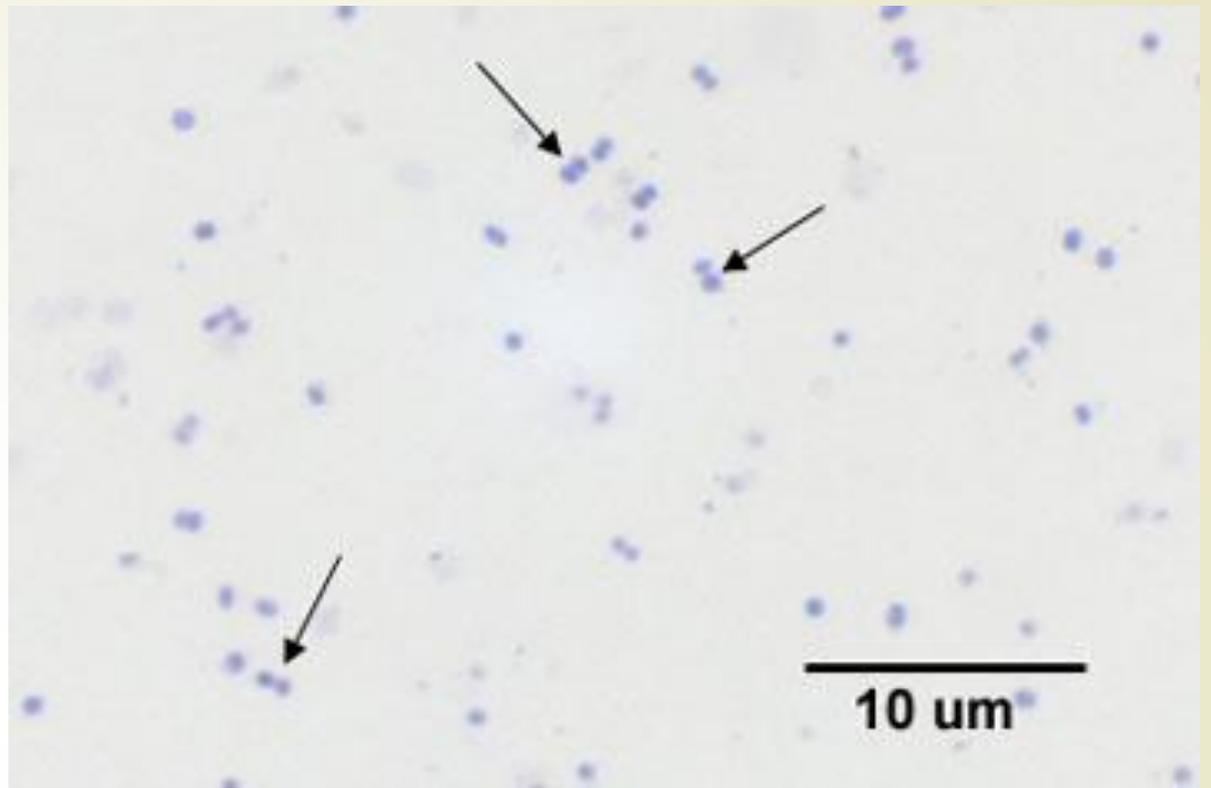
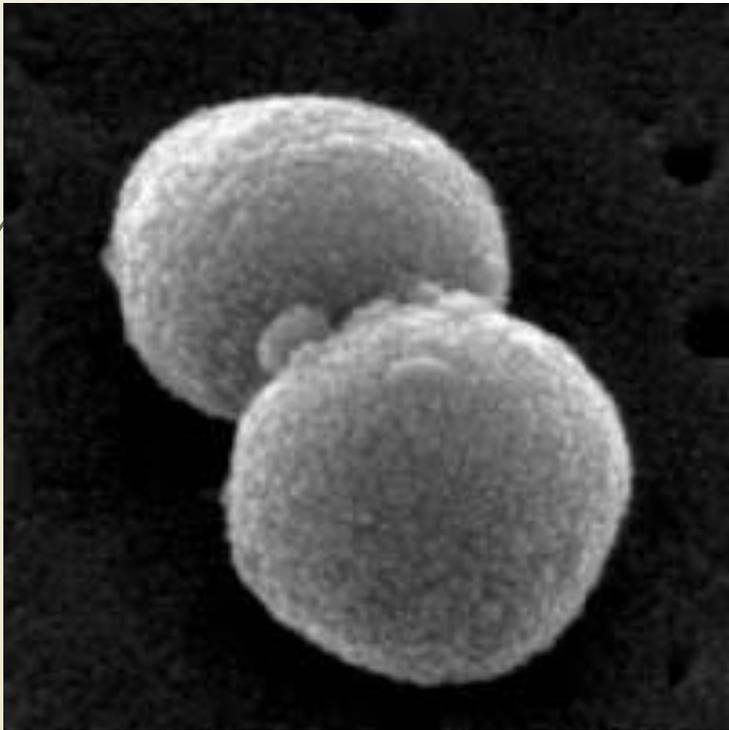


# 1. okruglaste bakterije ili koki (lat. *coccus*, od grč. *kokkos* - zrno)

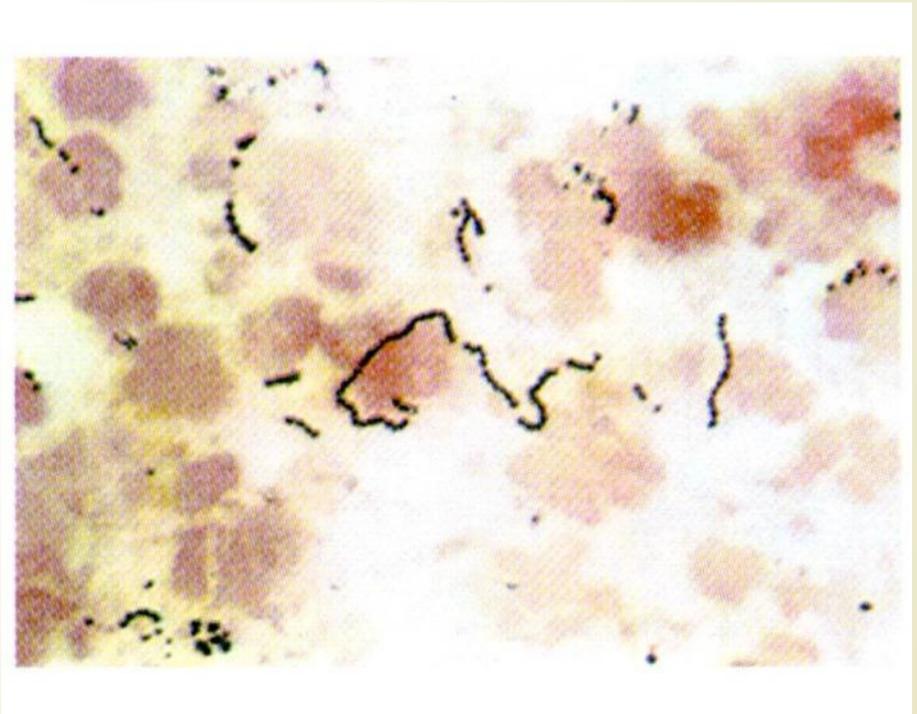
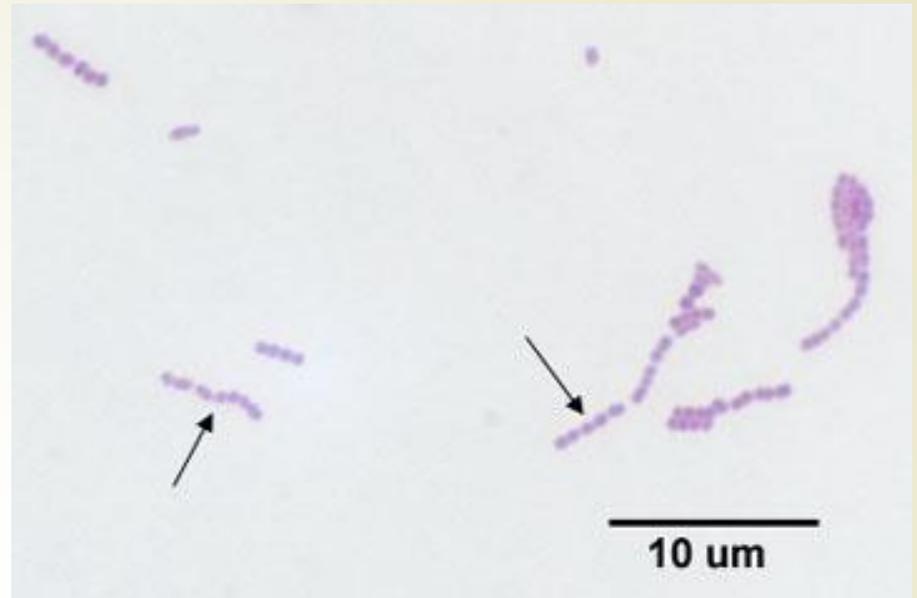
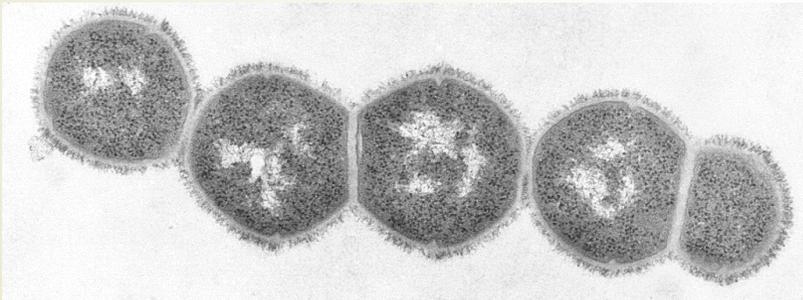
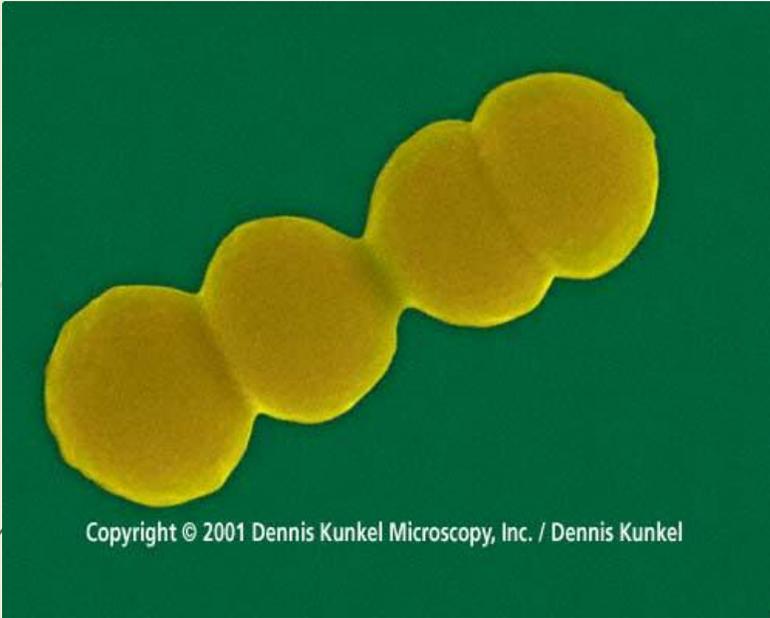
- sferične, ovalne, oblika jajeta, oblika graha
- združeni oblici: **diplokoki**, **streptokoki**, **stafilokoki**, **tetrakoki (tetrade)**, **sarcine**



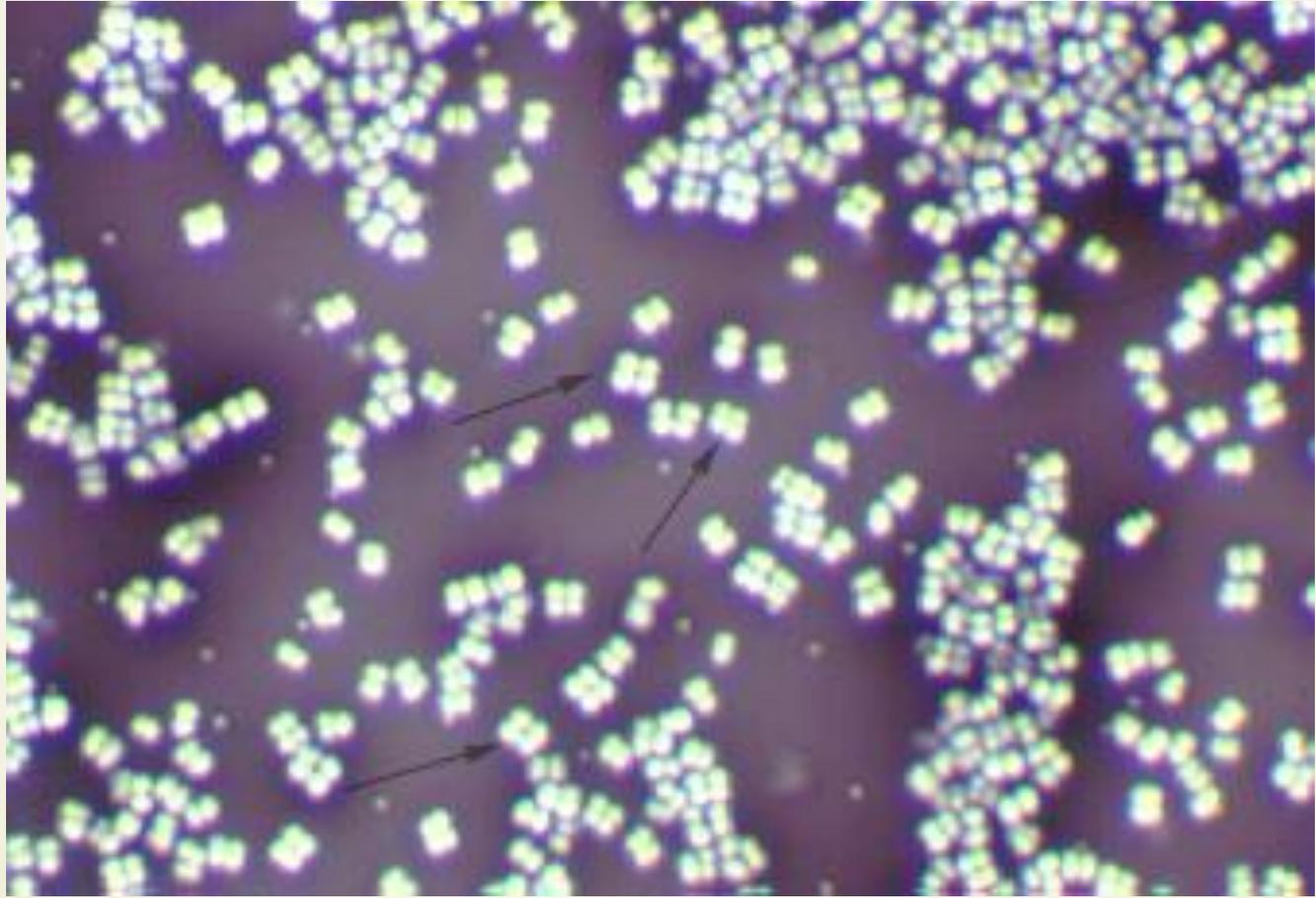
diplokokki



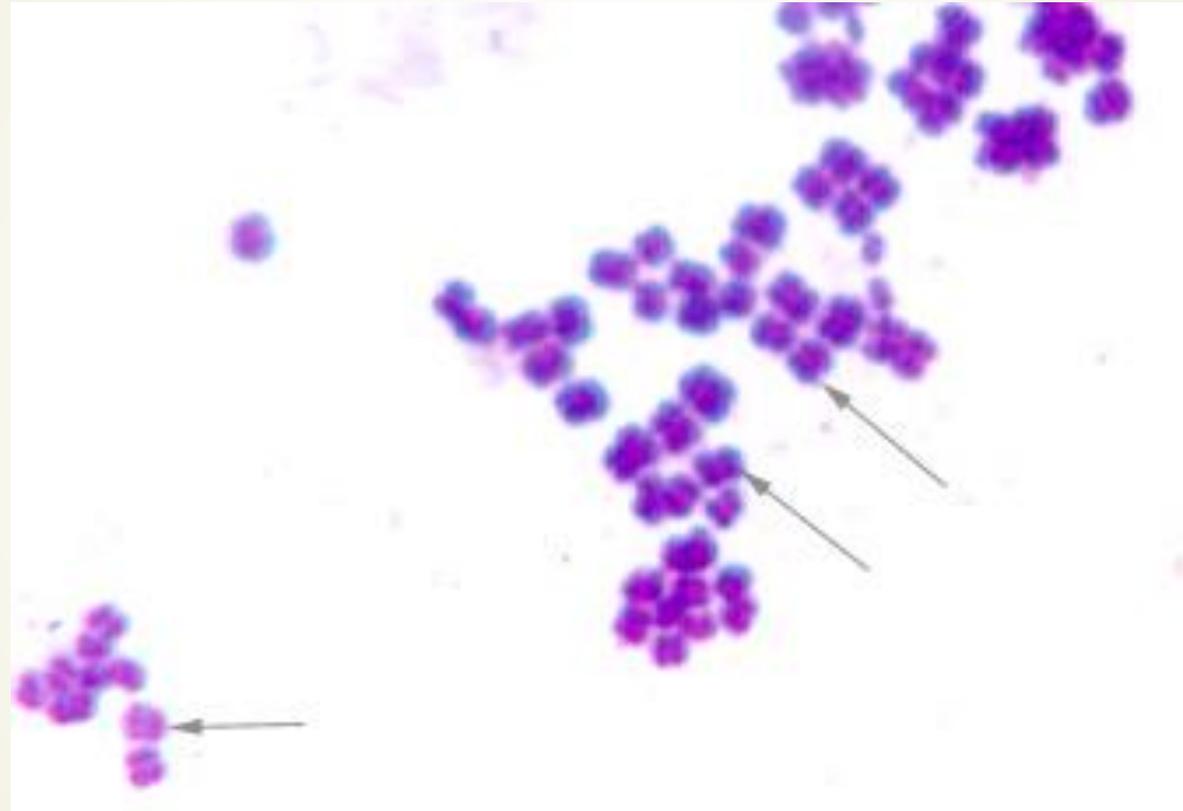
# streptokoki



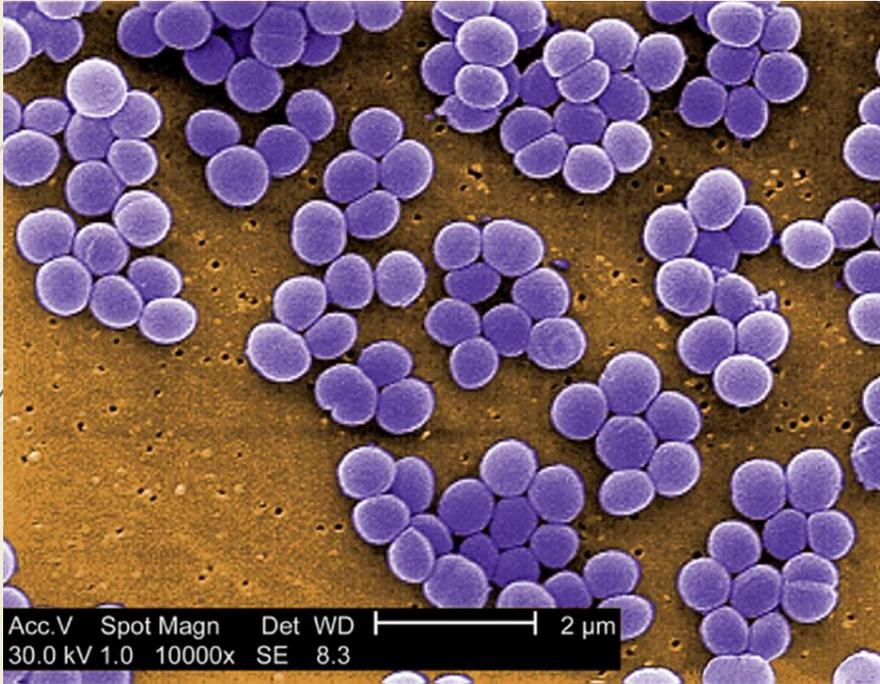
tetrakoki  
(tettrade)



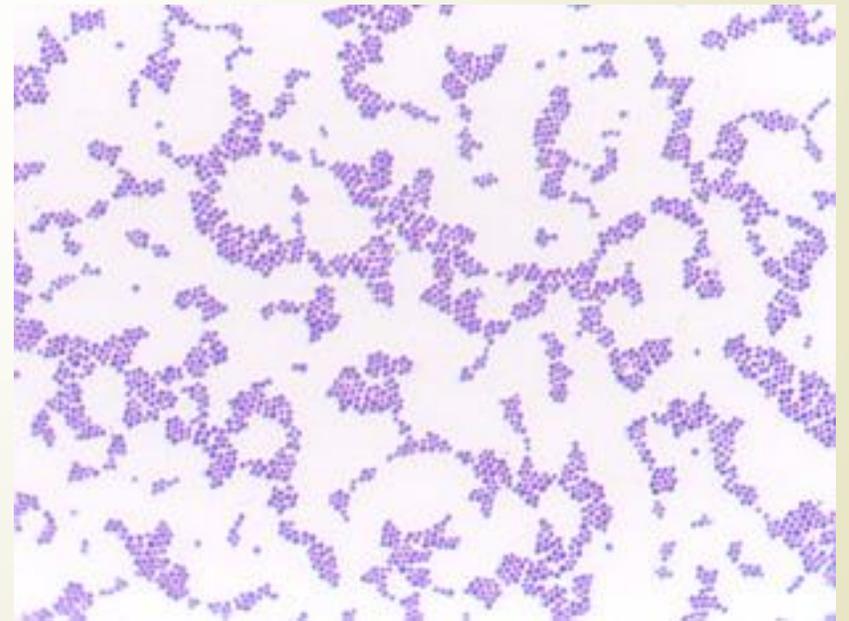
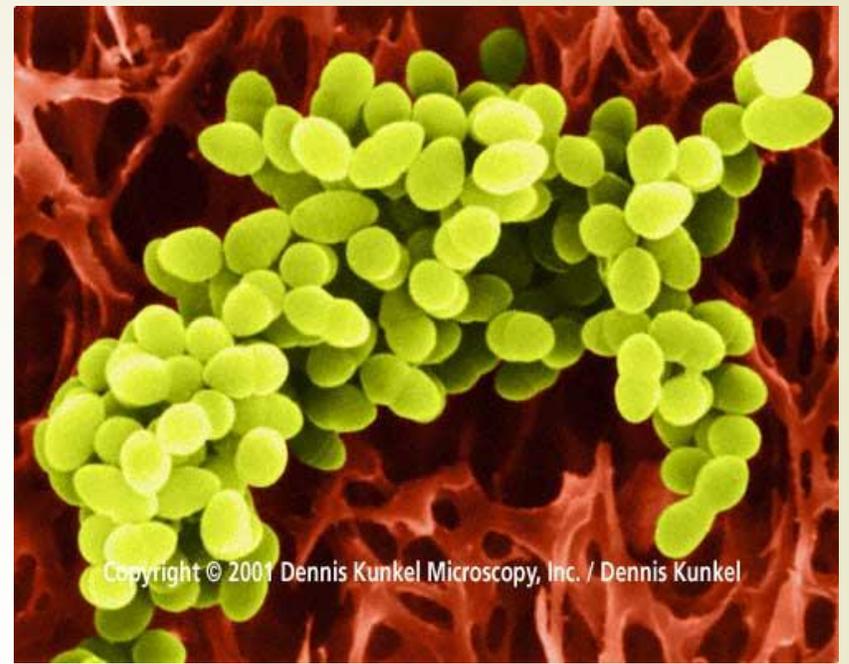
sarcine



# stafilokoki

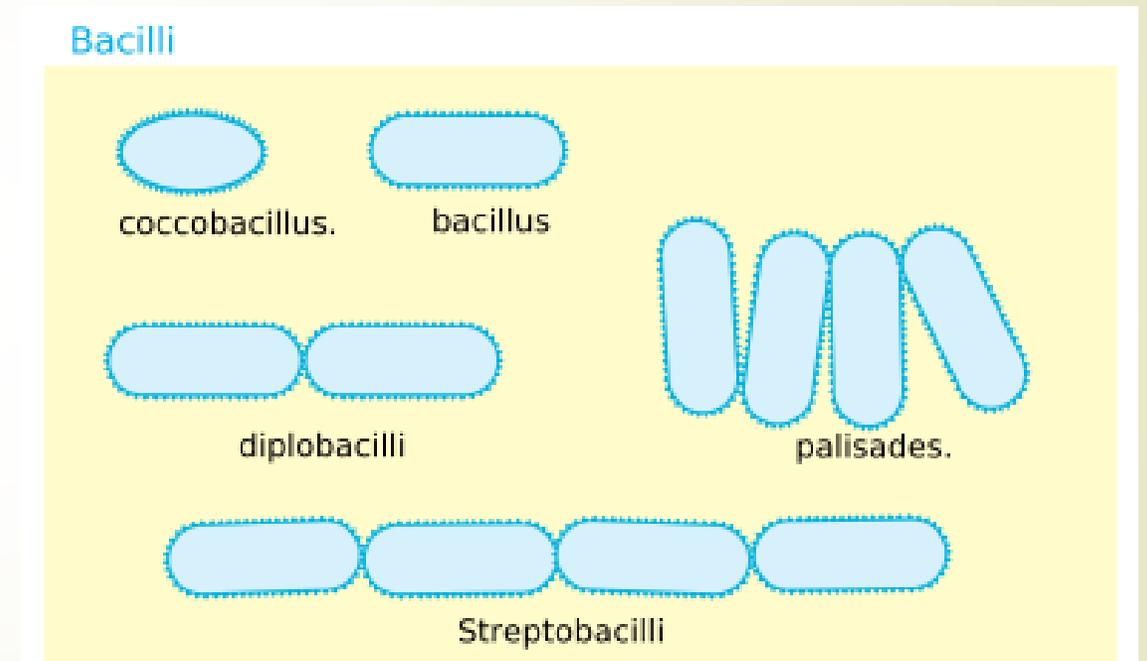
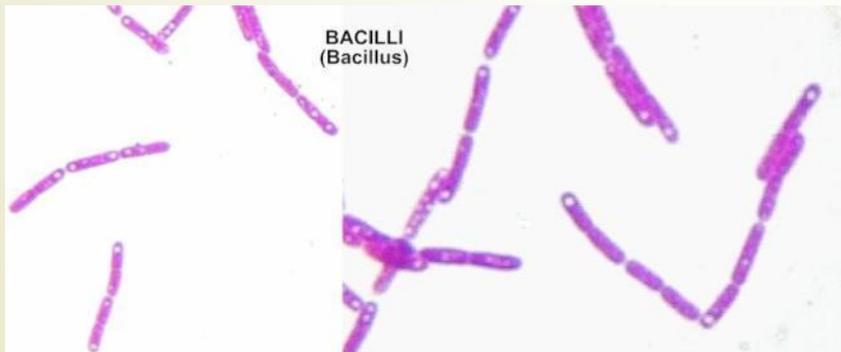
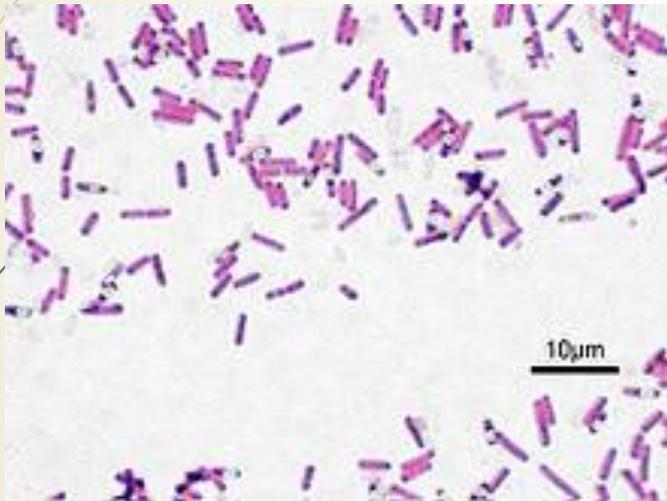


**(a)** *S. aureus*—cocci in clusters

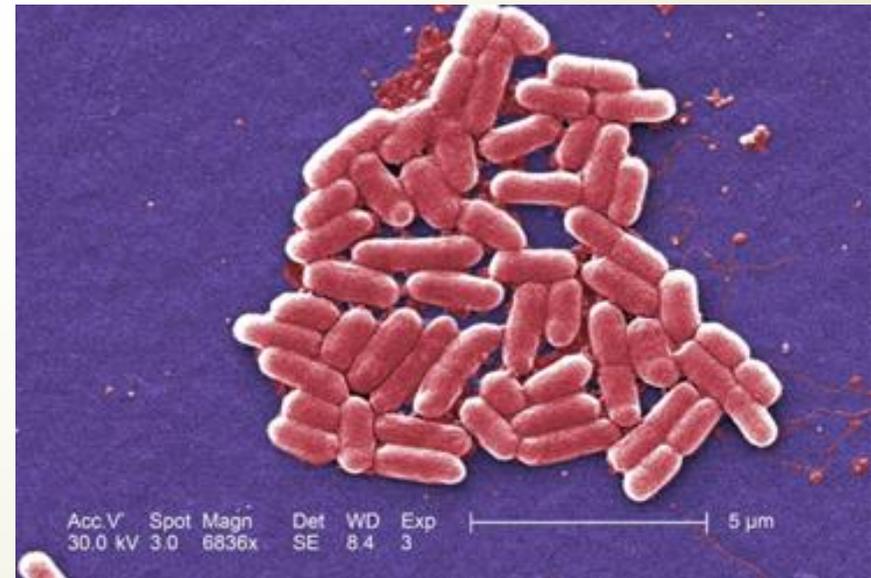
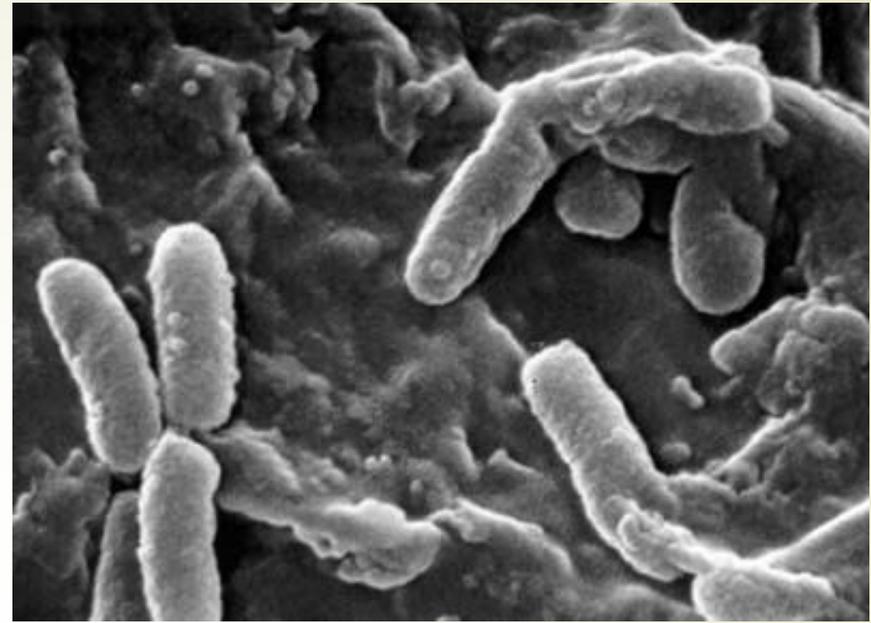
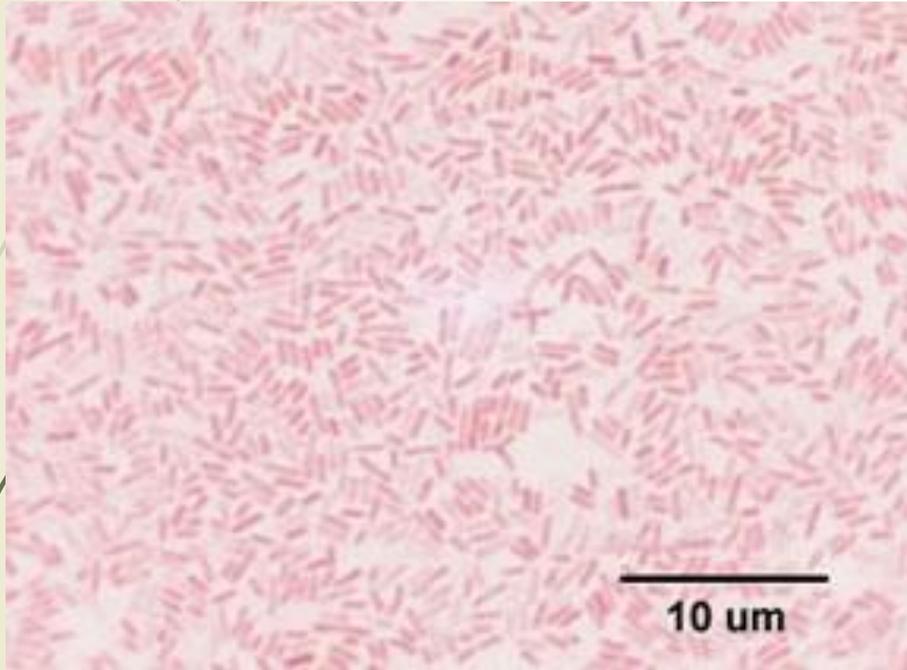


## 2. štapičaste bakterije ili bacili (*bacillus*, od lat. *baculus* – štapić)

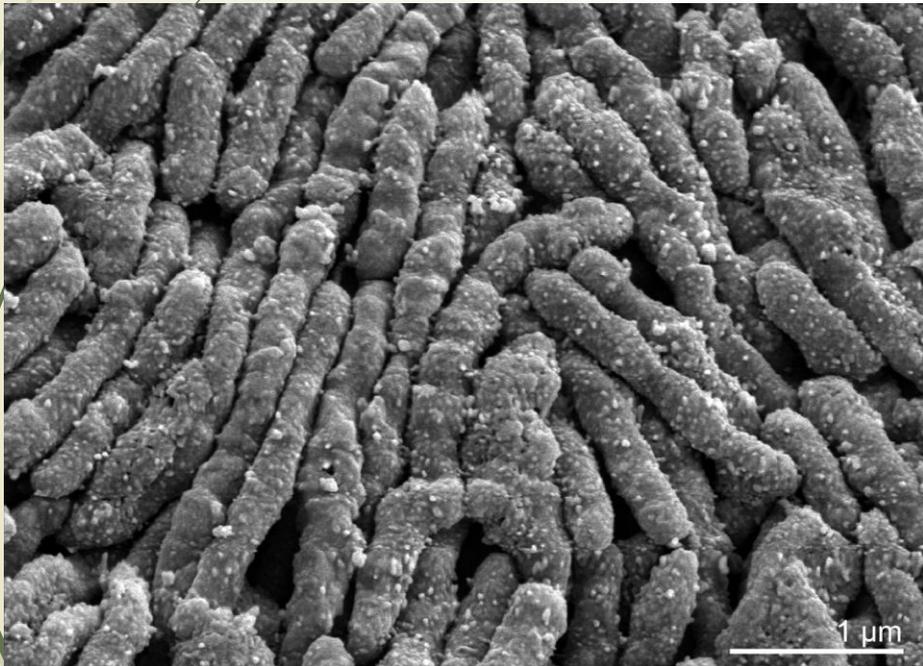
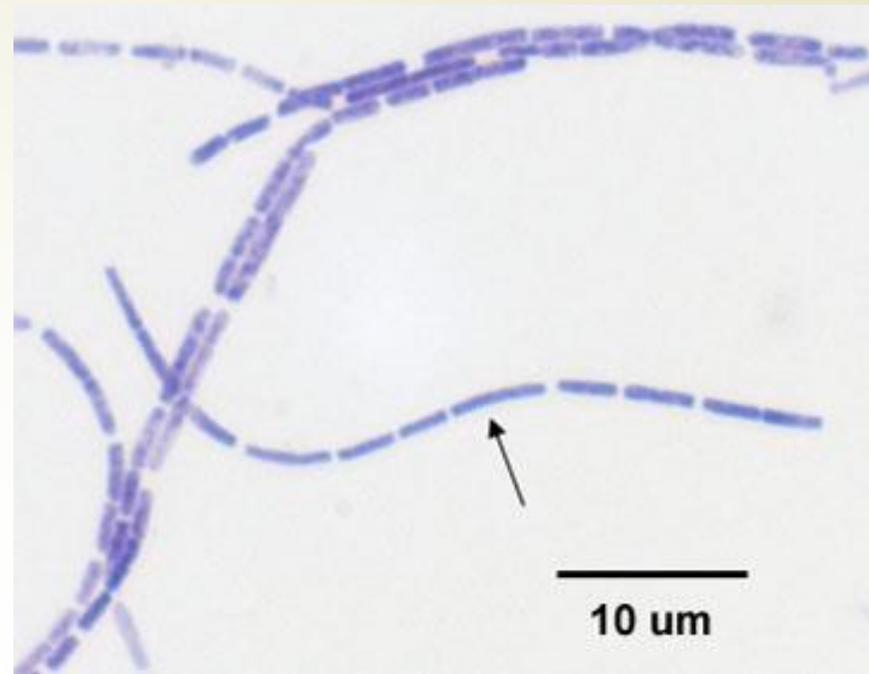
- izdužene, cilindrične, štapičaste
- združeni oblici: **diplobacili**, **streptobacili**, **palisade**, **kokobacili**



bacili



streptobacili

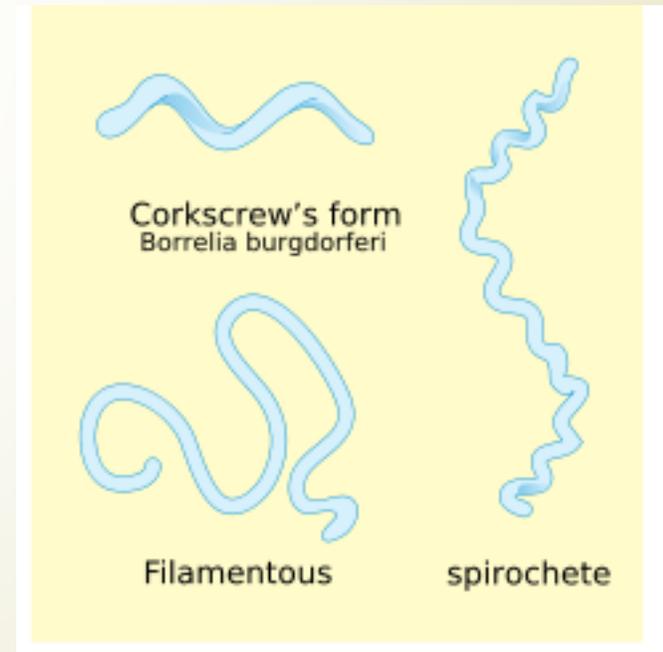
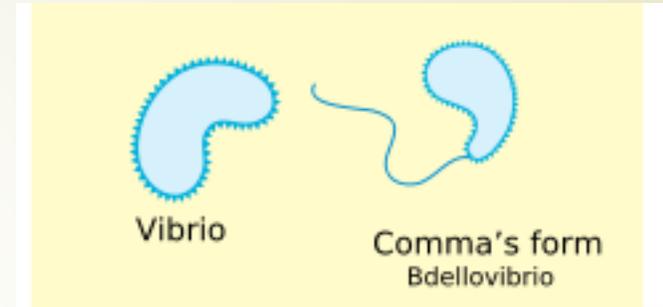
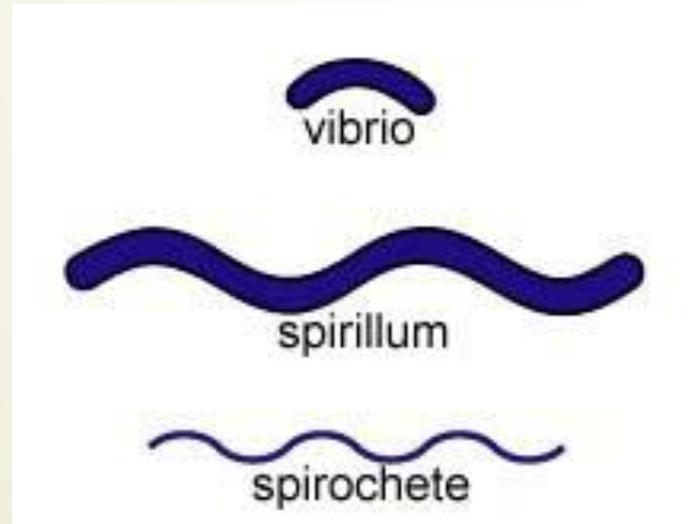




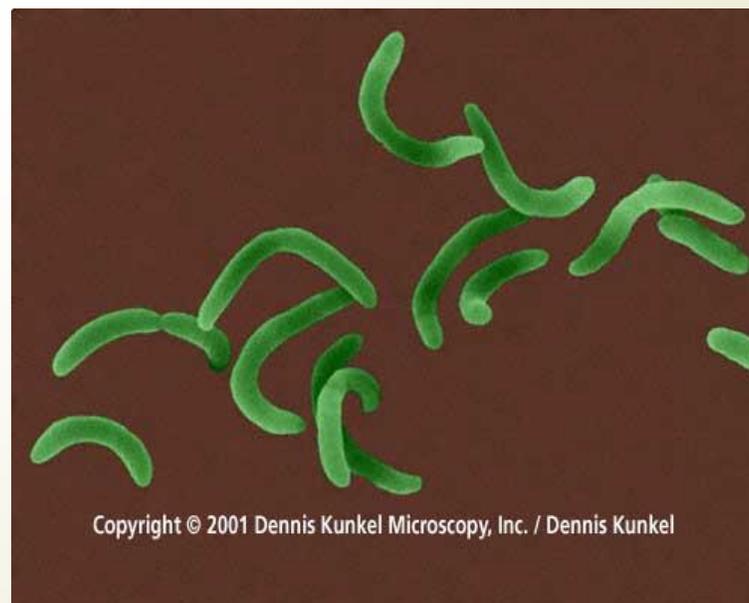
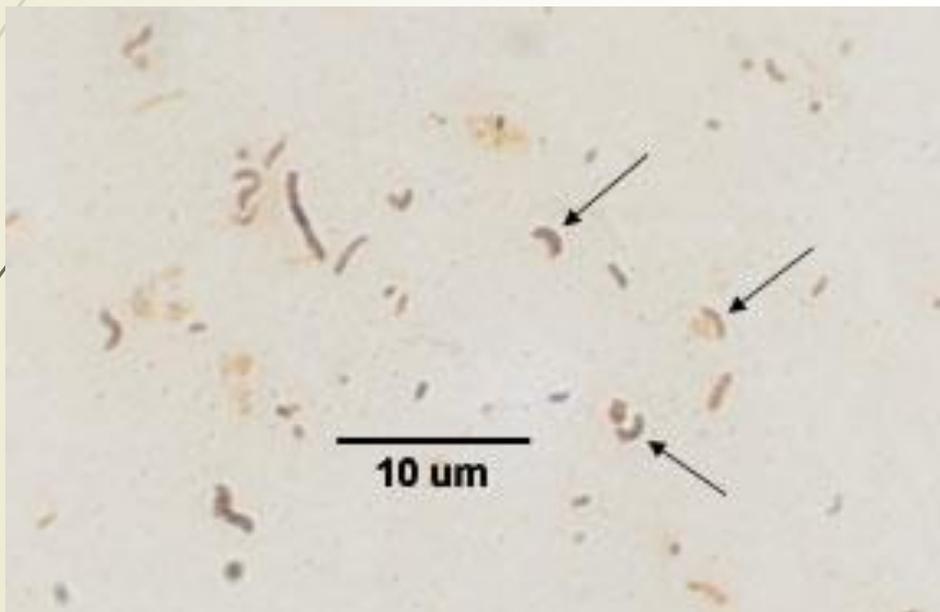
**(b)** *L. pneumophila*—rods in chains

### 3. zavojite (spiralne) bakterije

- **vibriji** – savijeni štapići ili oblika zareza
- **spirili** – čvrste, rigidne spirale
- **spirohete** (borelije, treponeme, leptospire)

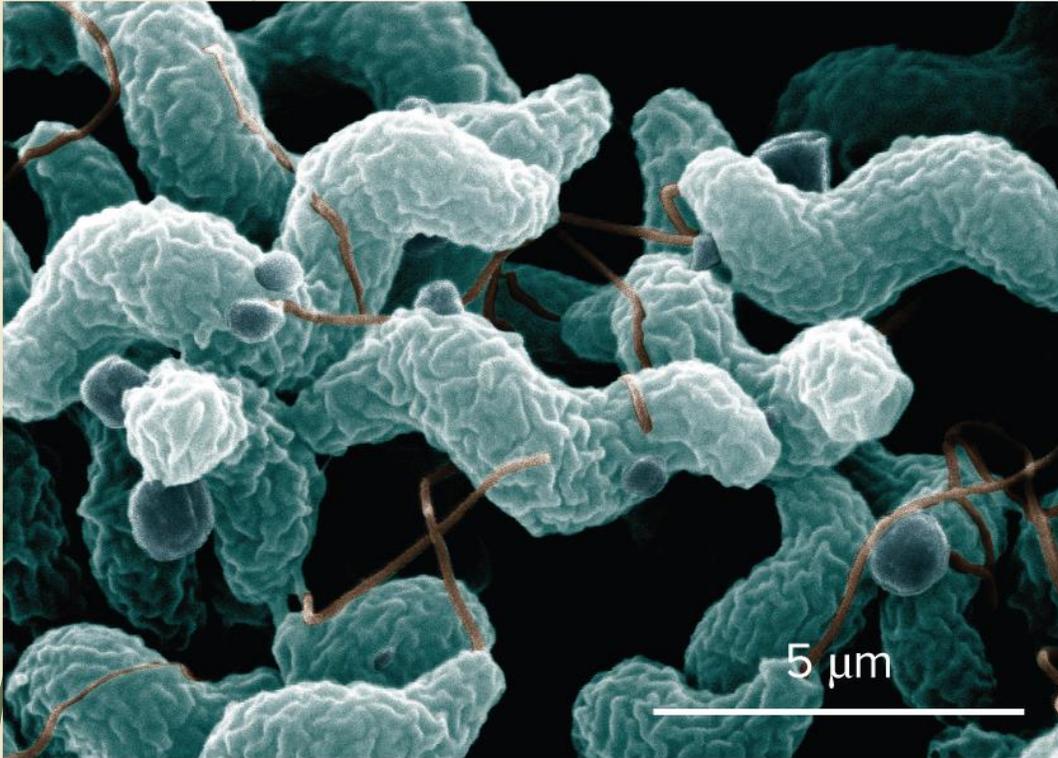


vibrio (množ. vibriji)

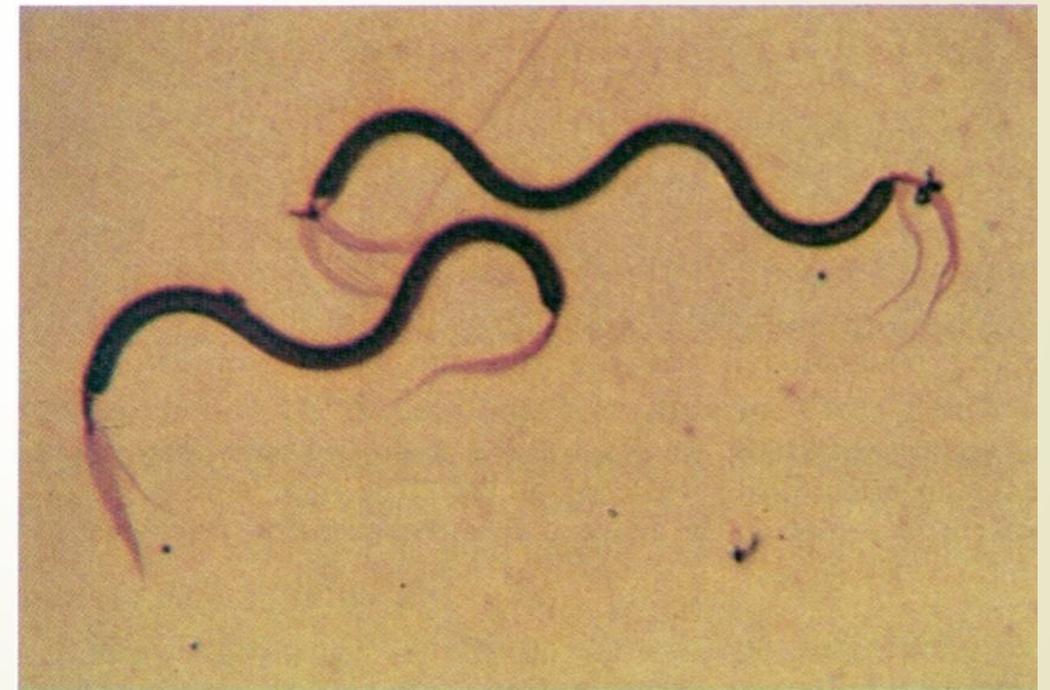
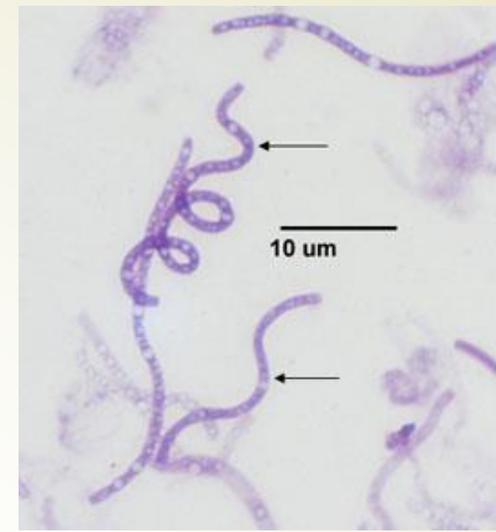


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spirili

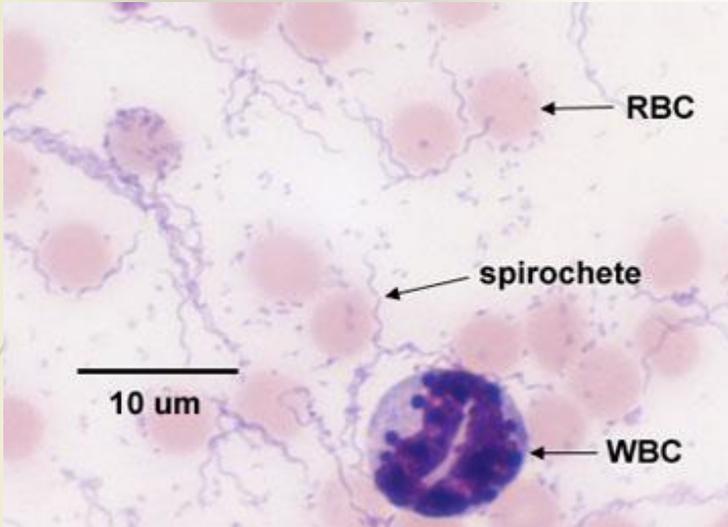


(a) *Campylobacter jejuni*—spiral-shaped

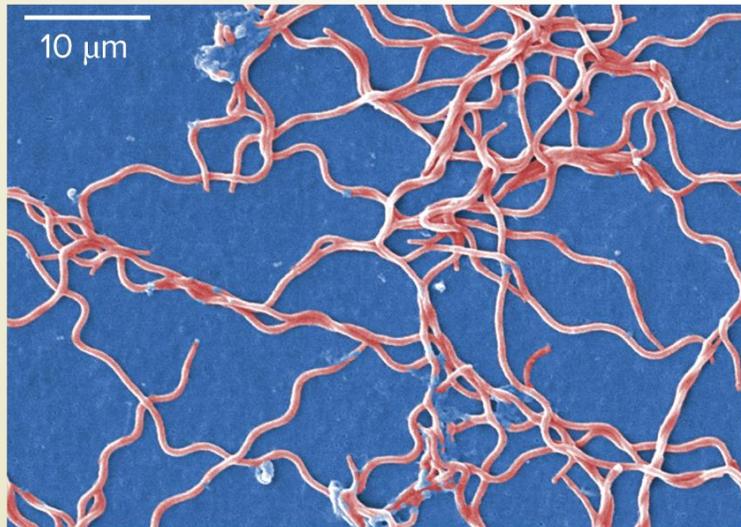


**Figure 2.18** Example of Flagella Staining. *Spirillum volutans* with bipolar tufts of flagella ( $\times 400$ ). (See also figure 3.33.)

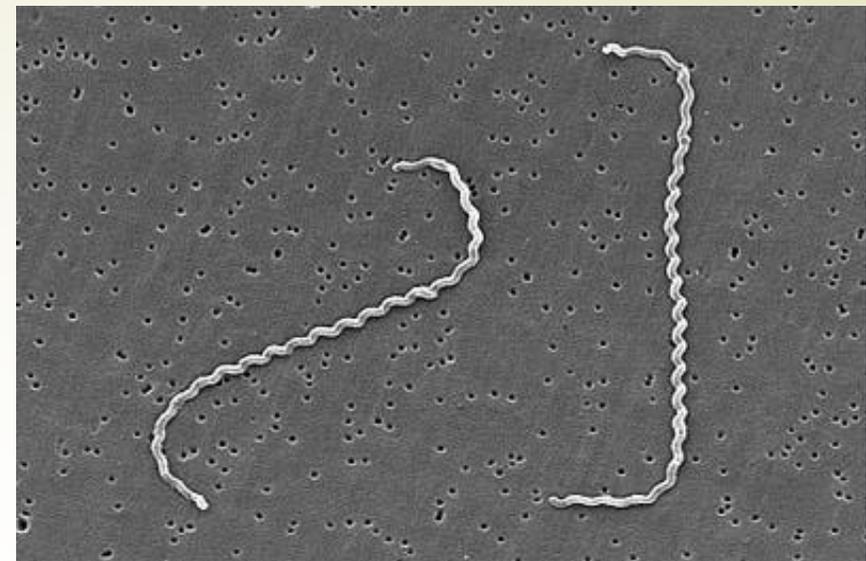
spirochete



*Borelia, sp.*



(b) *Borrelia burgdorferi*—a spirochete



*Leptospira interrogans*



*Treponema pallidum*



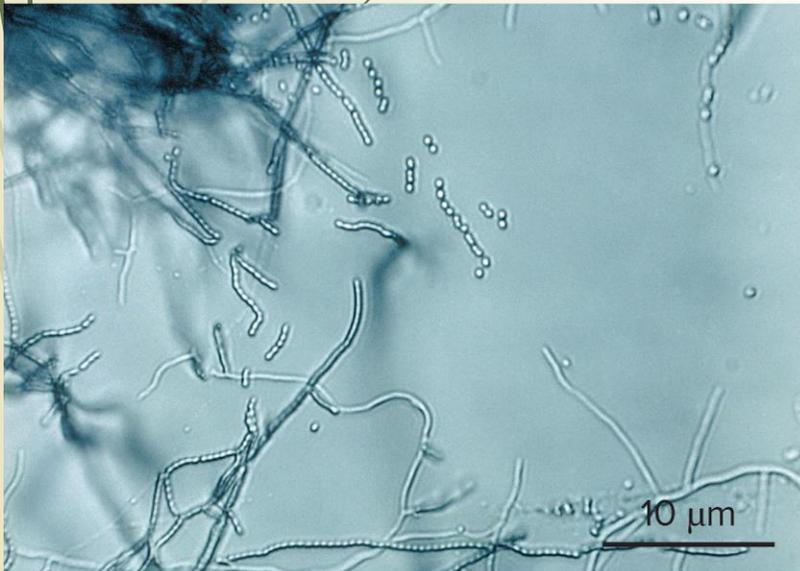
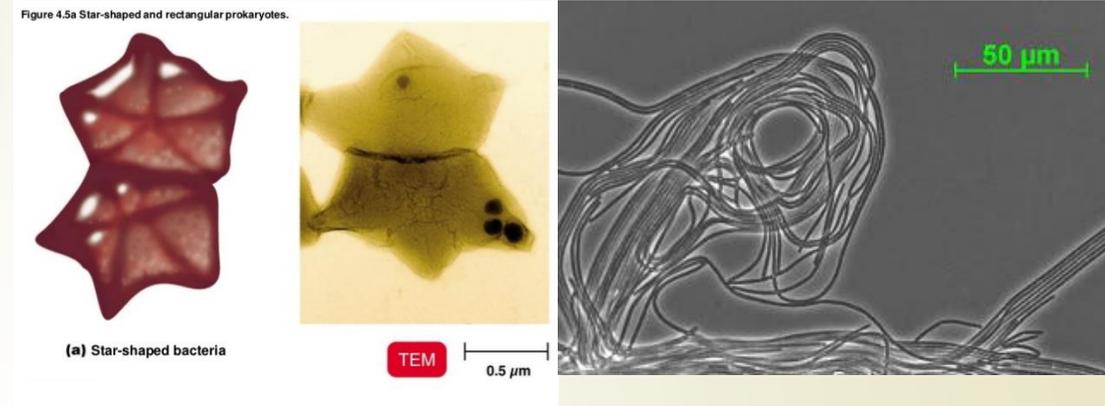
**Slika I-20.** Razmaz iz kulture bakterije *Leptospira icterohaemorrhagiae* [*Leptospira* ikterohemoragije]. Vide se brojni mali zavoji, a na kraju su kukice.



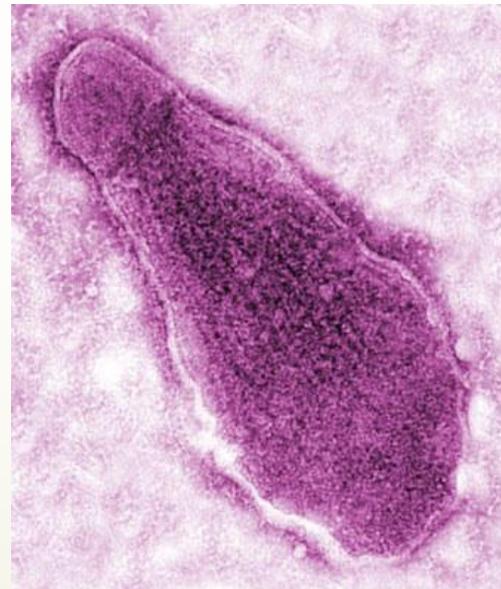
*Treponema pallidum*

## 4. ostali oblici

- **arkule** (oblik spljoštenih kutija)
- **astre** (zvjezdastog oblika)
- **filamentozne** (končaste; nitaste) – stvaraju hife
- **bakterije bez stanične stijenke - pleomorfne** ili polimorfne (pojavljuju se u različitim oblicima: mikoplazme, fitoplazme, neke arheje)

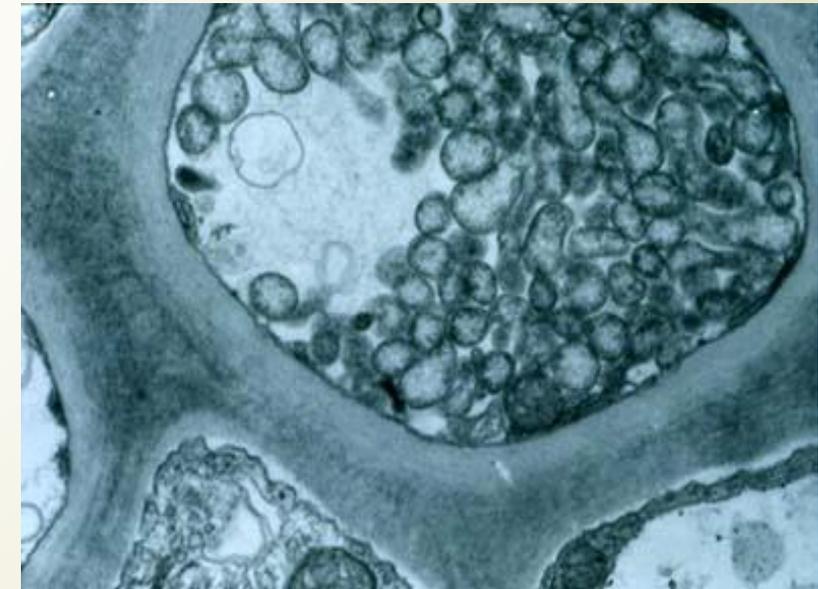


(c) *Streptomyces*—a filamentous bacterium



*Mycoplasma mobile*

<https://www.youtube.com/watch?v=IOUGvQa4aVA>



<http://www.oardc.ohio-state.edu>

'*Candidatus Phytoplasma asteris*'

# NOMENKLATURA BAKTERIJA

- ▶ **prema morfologiji:** *Staphylococcus aureus*, *Staphylococcus epidermis*, *Methanosarcina mazei*, *Treponema pallidum*, *Borrelia sp.*, *Bdellovibrio bacteriovorus*, *Leptospira interrogans*, *Vibrio cholerae*, *Sreptococcus pneumoniae*, *Bacillus thuringiensis*, *Bacillus anthracis*, *Spirillum sp.*
- ▶ **prema istraživačima:** *Escherichia coli*, *Pasteurella sp.*

International Committee on Systematics of **Prokaryotes (ICSP)**