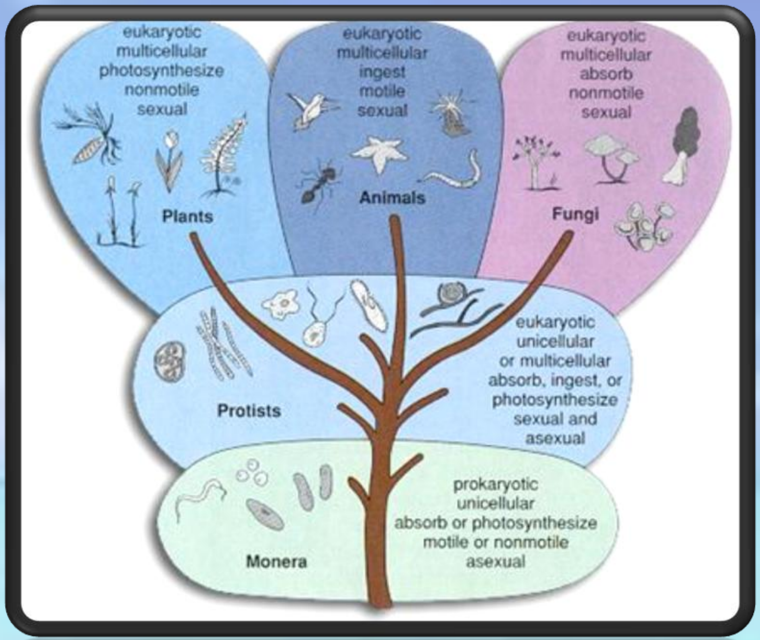


Taxonomy, Phylogeny, Classification of Microorganisms

DISKUSI

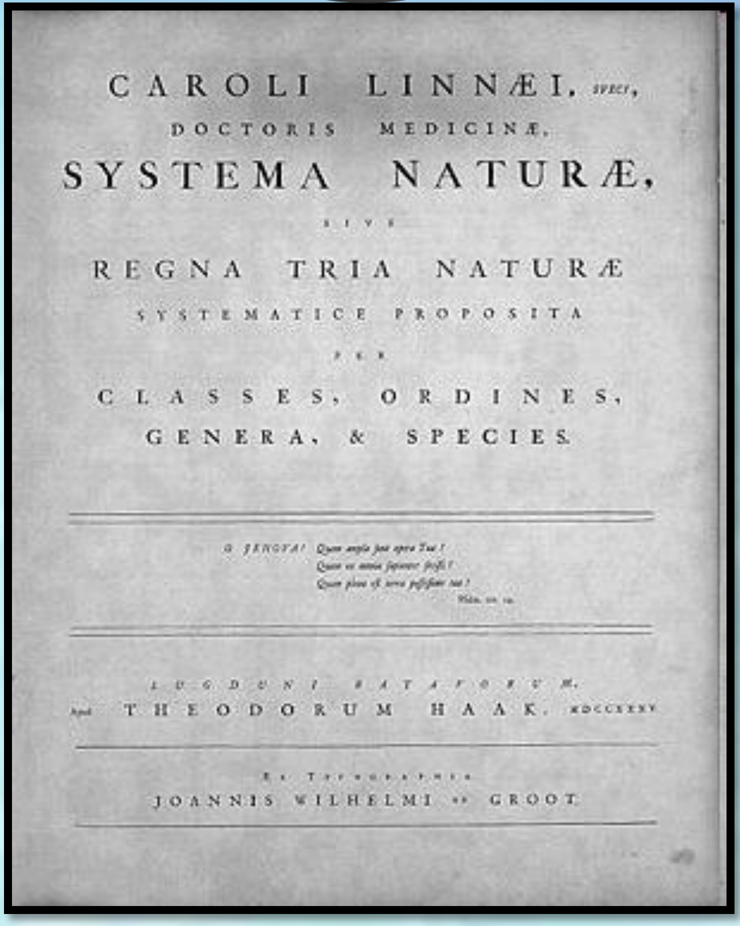
Jelaskan selengkap-lengkapnya mengenai:

1. Taksonomi 2 Kingdom
2. Taksonomi 3 Kingdom
3. Taksonomi 5 Kingdom
4. Klasifikasi fenetik dan filogenetik

- Taksonomi mikroorganisme
- Penggolongan organisme dan taksonomi mikroorganisme:
  - 2-, 3-, 5- kingdoms system dan 3 domain;
- Taksonomi modern (pilogeni) dan evolusi

Taksonomi

- Pioneer dibidang taksonomi organisme adalah ***Carolus Linnaeus***, ahli fisika dan botani (1707 - 1778, Sweden), yang pada tahun 1766 - 1768 mengajukan konsep sistem pemberian nama untuk makhluk hidup, yaitu **nomenklatur binomial** sebagai dasar dari ilmu biologi.



CAROLI LINNÆI, SVECI,
DOCTORIS MEDICINÆ,
SYSTEMA NATURÆ,
SIVE
REGNA TRIA NATURÆ
SYSTEMATICE PROPOSITA
PER
CLASSES, ORDINES,
GENERA, & SPECIES.

LUGDUNI BATAVORUM,
Apud THEODORUM HAAK, MDCCXXXV.

Ex Typographia
JOANNIS WILHELMI DE GROOT.

Taksonomi

- Analisis karakteristik suatu organisme dg tujuan untuk menempatkan organisme itu dalam takson.
- **Takson**= group suatu organisme dlm suatu tingkatan (spesies, genera, famili,…)

Taksonomi

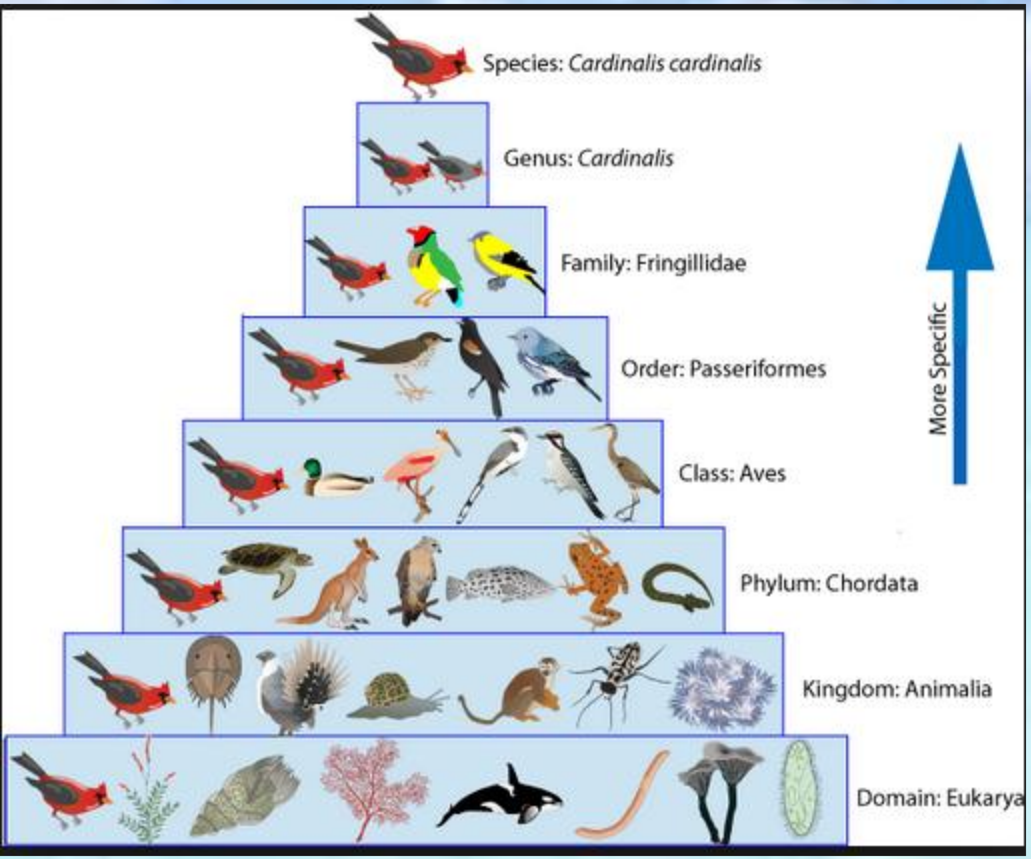
- Ilmu yang berkembang sesuai dengan perkembangan metoda-metoda penelitian, peralatan yang mendukung, komputer bersama programnya, dll
- Taksonomi ~ Konvensional
  - Klasifikasi
  - Nomenklatur
  - Identifikasi

Tiga aktivitas dalam taksonomi

1. Klasifikasi - pengaturan organisme ke dalam suatu grup / taksa
2. Nomenklatur – pemberian nama ilmiah pd suatu taksa
3. Identifikasi - analisis karakteristik suatu organisme baru, selanjutnya dialokasikan pd taksa yg ada

Klasifikasi

- Usaha untuk membedakan taksa mikrobia kedalam kelompok yg terstruktur, sehingga anggota dari suatu kelompok memiliki kesamaan yg lebih besar dibanding dengan anggota yg lain.
- Lebih mencerminkan hubungan diantara individu dan kelompok.
- Cara pengelompokan juga didasarkan pd kesamaan mereka.



- Sistem hierarki dalam taksonomi =

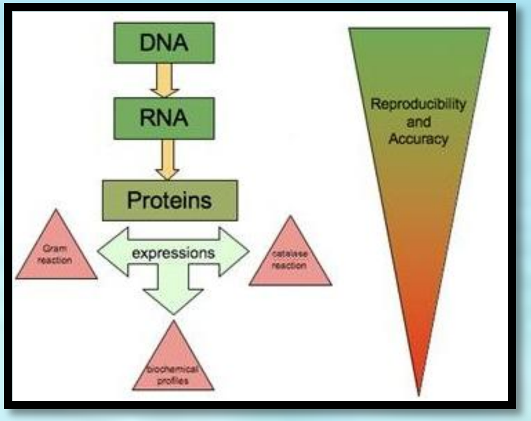
  Suatu cara untuk mengklasifikasikan organisme didasarkan tingkat kesamaan (similaritas)
- Hierarki = kingdom, divisi, klas, ordo, famili, genus, spesies

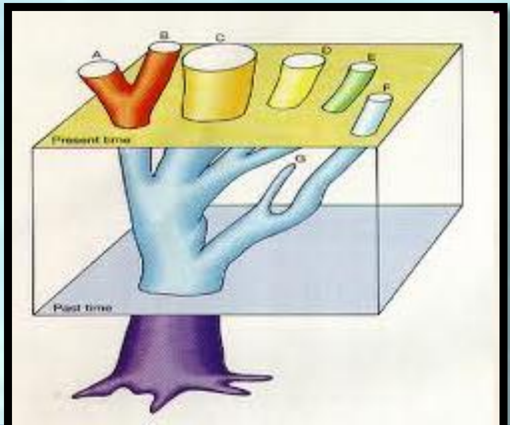
- Tata cara penulisan
  - *Rhizopus oligosporus* ←*(Italic)*
  - Saccharomyces cerevisiae ←(Straight-Underline)
  - *E. coli (Singkatan)*

- Tata cara penulisan ini dan perubahan penggolongan organisme dikomunikasikan pada
  - International Code of Nomenclature of Bacteria (ICNB)
  - International Code of Botanical Nomenclature (ICBN)

Taxonomy groups organisms by:

- Penotypic characters – morphology, physiology – conventional taxonomy
- Molecular composition – chemotaxonomy taxonomy
- Genetics - macromolecul (DNA, RNA, Protein) – molecular taxonomy
- Phylogenetic
- Evolutionary





Two kingdom system

Diperkenalkan pada tahun 1766 oleh **Linnaeus** :

- Plantae dengan ciri utama fotosintetik terdiri dari tanaman tingkat tinggi, berakar dan tidak bergerak - ahlinya disebut botanist
- Animalia dengan ciri utama mencerna makanan (*food ingesting*) terdiri dari hewan tingkat tinggi dan bergerak - ahlinya disebut zoologist

Dampak penemuan mikroskop

- Mikrobiologis mengusulkan perubahan pd level kingdom sehingga muncul konsep 3 kingdom system.
- Penggolongan mikrobia yg penting:

1. **Mikrobia uniseluler**:

   a. Motil, mencerna makanan, binatang bersel 1, protozoa

   b. Nonmotil, berflagela/pseudomotil: mencerna makanannya, berfotosintesis, penyerapan nutrisi.

2. **Mikrobia multiseluler**

   Fungi: tidak berfotosintesis, tdk motil, mirip berakar, mengambil nutrisi dg penyerapan

Three- kingdom system :

- Plantae - fotosintetik - tanaman tingkat tinggi, berakar dan tidak bergerak - ahlinya disebut botanist
- Animalia - mencerna makanan (*food ingesting*), hewan tingkat tinggi dan bergerak - ahlinya disebut zoologist
- Protoctista (Hogg, 1860) atau protista (Ernst Haeckel, 1866) terdiri dari :

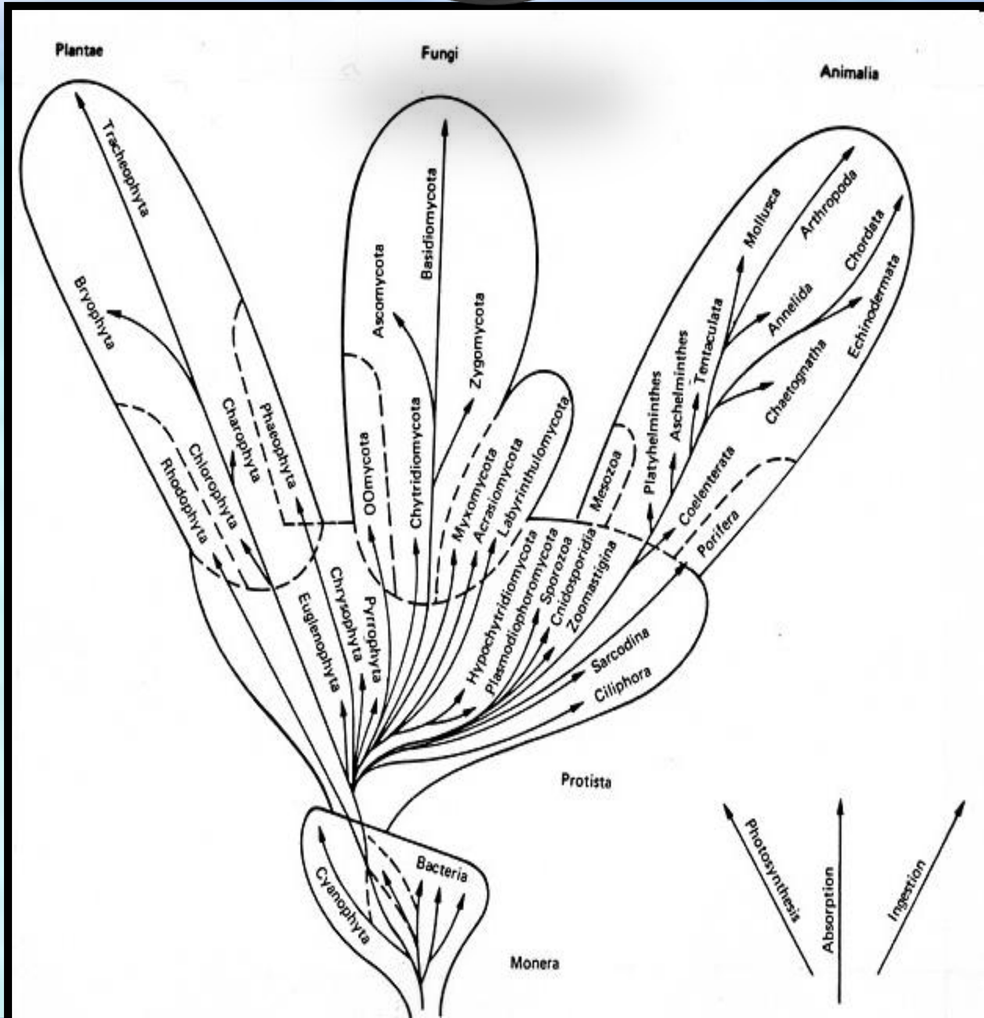
  Uniseluler : bakteri

  Multiseluler (namun tidak memiliki diferensiasi jaringan seperti halnya tanaman/hewan atau tidak membentuk jaringan) : algae dan fungi

Whittaker's phylogenetic Tree of 1967.


1.3.4. R.H. Whittaker (1969)

The 5-Kingdom system is based on :
three levels of organization- procaryotic (Kingdom Monera), eucaryotic unicellular (Kingdom Protista), and eucaryotic multicellular (Kingdoms Plantae, Fungi and Animalia).

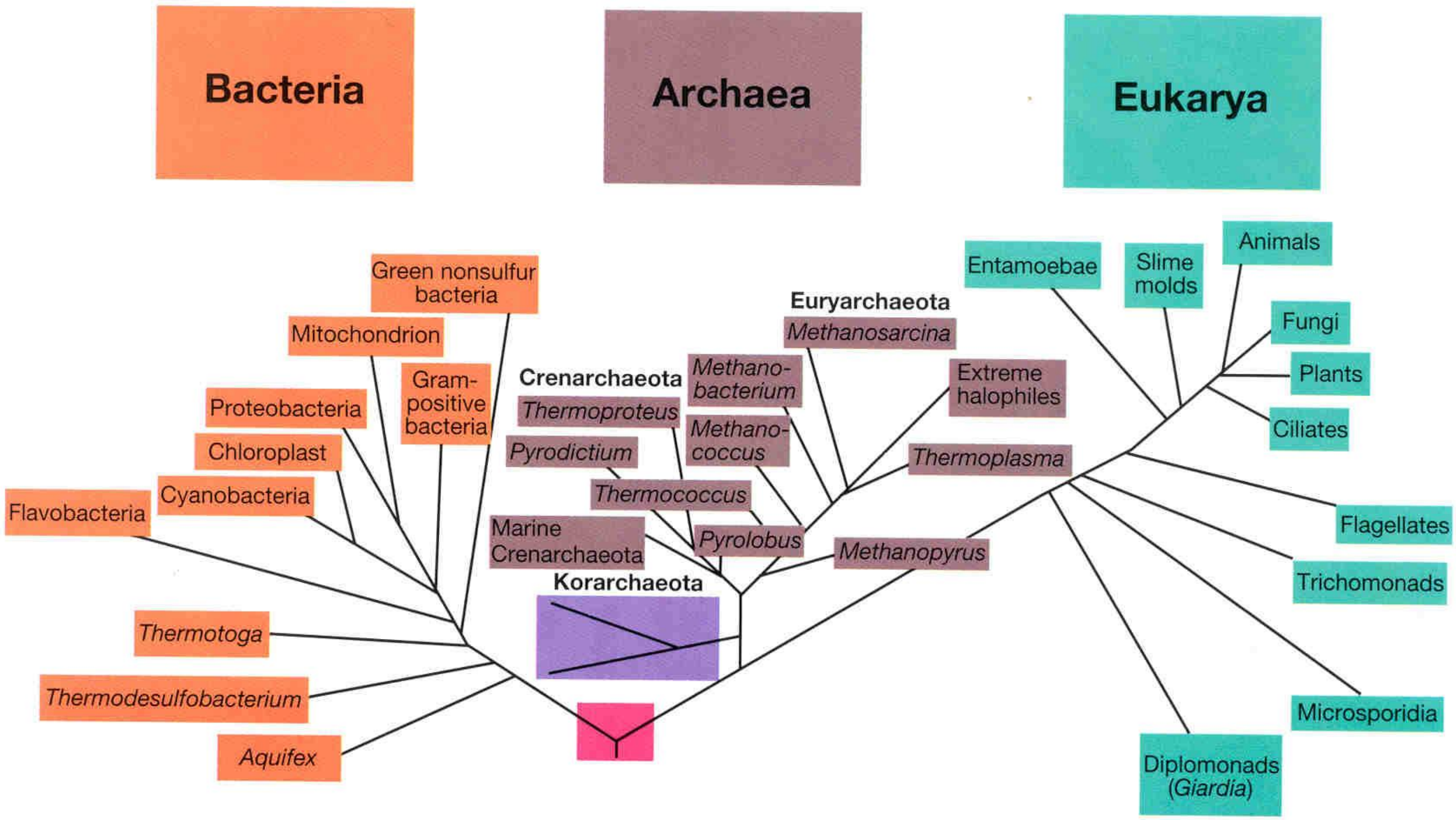


Five Kingdom System

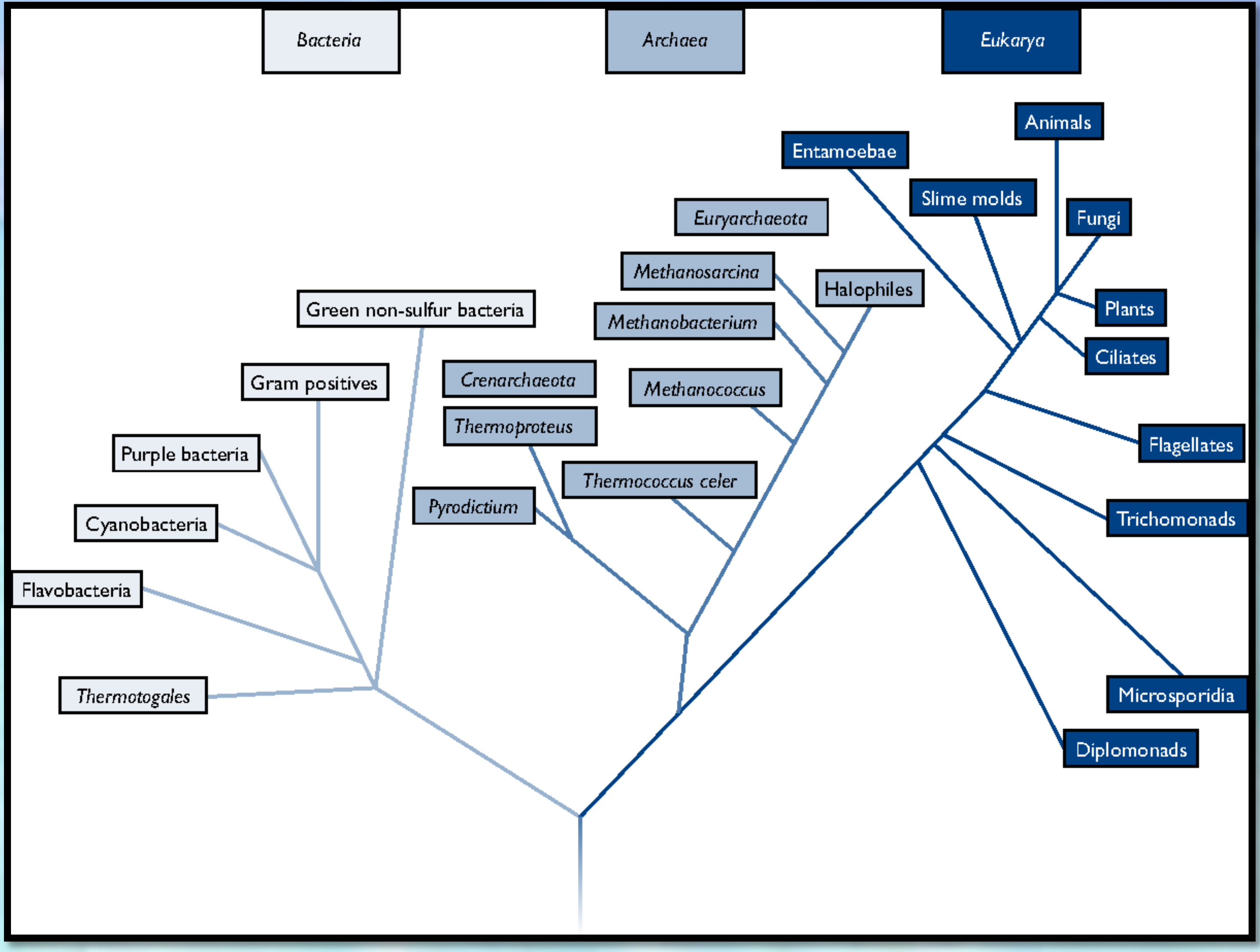
R.H. Whittaker, 1959

- Kingdom Monera or Prokaryotes, contoh : archaebacteria (paling primitif) dan eubacteria (bakteri)
- Kingdom Protista (uniseluler eukariot) contoh : algae, protozoa, slime mold, organisme aquatic dan parasit
- Kingdom Fungi (multiseluler eukariot) contohnya : yeast, mold and mushrom
- Kingdom Animalia
- Kingdom Plantae

12.13 The universal phylogenetic tree



The three-domain view of life.



Microbiology: Diversity, Disease, and the Environment, Salyers and Whitt, 2001

Kemotaksonomi

- Didasarkan pada <u>komposisi kimia sel</u>
- Asam lemak sel, asam mikolat, polar lipid
- Quinon – ubiquinon, poliamine
- Komposisi dinding sel – (Diaminopimelic acid) DAP, eksopolisakarida

Molekular taksonomi

- Didasarkan pada makromolekul (DNA, RNA, protein)
- Dapat digunakan untuk menyusun pilogeni
- DNA DNA similariti/homologi;
- Mol % G+C;
- Pola restriksi (RLFP, PFGE); Ukuran genom
- Segmen DNA : *PCR based DNA finger printing* (ribotyping, ARDRA, RAPD, AFLP)
- DNA probe
- DNA sequensing

Konsep spesies

- Dua strain dengan similaritas DNA di atas 70 % dapat dimasukkan ke dalam spesies yang sama.
- Subspesies atau tipe yang mencerminkan klon spesifik dari sel.
- Biovar apabila subspesies ini dibedakan atas sifat fisiologinya,
- morfovar apabila dibedakan atas morfologinya, dan
- serovar apabila dibedakan atas antigennya.
- Strain adalah populasi sel yang berasal dari strain tunggal.

Keuntungan klasifikasi berdasar sifat genetik

1. Konsep spesies lebih seragam
2. Klasifikasi lebih stabil
3. Cara identifikasi lebih realibel
4. Teori evolusi dapat disusun-pilogeni

Sistem klasifikasi:

- **Fenetik:** berdasarkan kemiripan sifat
- **Filogenetik:** berdasarkan hubungan evolusi

Phylogeny

- Klasifikasi yg didasarkan pd hubungan pilogenetik antara organisme
- Sehingga dapat disusun garis turun temurunnya (ansenstornya)

Pilogeni

- **Pilogeni** – sejarah evolusi dari organisme. Istilah pilogeni berasal dari bahasa Greek, *phylon* artinya *tribe* dan genesis artinya asal usul (*origin*).

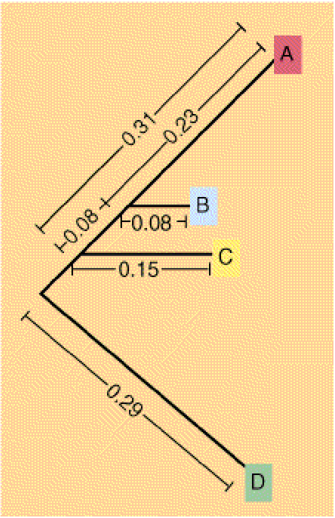
- Zukerkandl dan Pauling (1965) yaitu dengan penjelasannya tentang *Molecules as documents of evolutionary history*.

Phylogenetic Tree

Organism	Sequence
A	C G U A G A C C U G A C
B	C C U A G A G C U G G C
C	C C A A G A C G U G G C
D	G C U A G A U G U G C C

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

Phylogenetic tree (computer-generated best fit to corrected evolutionary distances)

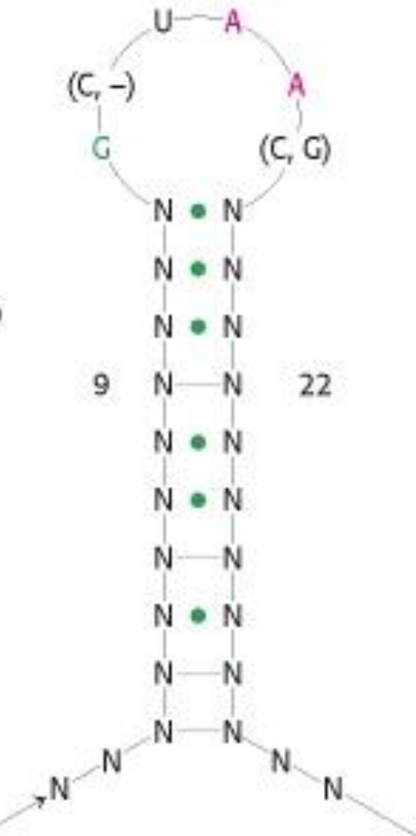


(A)

↓9 ↓22 (arrows marking positions 9 and 22 above the alignment)

BACTERIA	*Escherichia coli*	C A C A C G G C G G G U G C U A A C G U C C G U C G U G A A
	Pseudomonas aeruginosa	A C C A C G G C G G G U G C U A A C G U C C G U C G U G A A
ARCHAEA	*Halobacterium halobium*	C C G G U G U G C G G G G – U A A G C C U G U G C A C C G U
	Methanococcus vannielii	G A G G G C A U A C G G G – U A A G C U G U A U G U C C G A
EUKARYA	*Homo sapiens*	G G G C C A C U U U U G G – U A A G C A G A A C U G G C G C
	Saccharomyces cerevisiae	G G G C C A U U U U U G G – U A A G C A G A A C U G G C G A

(B)



1

S typhimurium -------AGA GTTTGATCCT GGCTCAGATT GAACGCTGGC GGCAGGCCTA ACACATGCAA
S typhi -------AGA GTTTGATCCT GGCTCAGATT GAACGCTGGC GGCAGGCCTA ACACATGCAA
E coli K-12 AAATTGAAGA GTTTGATCAT GGCTCAGATT GAACGCTGGC GGCAGGCCTA ACACATGCAA
Isolate ---------A GTTTGATCAT GGCTCAGATT GAACGCTGGC GGCAGGCCTA ACACATGCAA

61

S typhimurium GTCGAACGGT AACAGGAAGC AGCTTGCTGC TTTGCTGACG AGTGGCGGAC GGGTGAGTAA
S typhi GTCGAACGGT AACAGGAAGC AGCTTGCTGC TTTGCTGACG AGTGGCGGAC GGGTGAGTAA
E coli K-12 GTCGAACGGT AACAGGAAGA AGCTTGCTTC TTTGCTGACG AGTGGCGGAC GGGTGAGTAA
Isolate GTCGAACGGT AACAGGAAGA AGCTTGCTGC TTTGCTGACG AGTGGCGGAC GGGTGAGTAA

121

S typhimurium TGTCTGGGAA ACTGCCTGAT GGAGGGGGAT AACTACTGGA AACGGTGGCT AATACCGCAT
S typhi TGTCTGGGAA ACTGCCTGAT GGAGGGGGAT AACTACTGGA AACGGTGGCT AATACCGCAT
E coli K-12 TGTCTGGGAA ACTGCCTGAT GGAGGGGGAT AACTACTGGA AACGGTAGCT AATACCGCAT
Isolate TGTCTGGGAA ACTGCCTGAT GGAGGGGGAT AACTACTGGA AACGGTAGCT AATACCGCAT

181

S typhimurium AACGTCGCAA GACCAAAGAG GGGGACCTTC GGGCCTCTTG CCATCAGATG TGCCCAGATG
S typhi AACGTCGCAA GACCAAAGAG GGGGACCTTC GGGCCTCTTG CCATCAGATG TGCCCAGATG
E coli K-12 AACGTCGCAA GACCAAAGAG GGGGACCTTC GGGCCTCTTG CCATCGGATG TGCCCAGATG
Isolate AACGTCGCAA GACCAAAGAG GGGGACCTTC GGGCCTCTTG CCATCGGATG TGCCCAGATG

241

S typhimurium GGATTAGCTT GTTGGTGAGG TAACGGCTCA CCAAGGCGAC GATCCCTAGC TGGTCTGAGA
S typhi GGATTAGCTT GTTGGTGAGG TAACGGCTCA CCAAGGCGAC GATCCCTAGC TGGTCTGAGA
E coli K-12 GGATTAGCTA GTAGGTGGGG TAACGGCTCA CCTAGGCGAC GATCCCTAGC TGGTCTGAGA
Isolate GGATTAGCTA GTAGGTGGGG TAACGGCTCA CCTAGGCGAC GATCCCTAGC TGGTCTGAGA

301

S typhimurium GGATGACCAG CCACACTGGA ACTGAGACAC GGTCCAGACT CCTACGGGAG GCAGCAGTGG
S typhi GGATGACCAG CCACACTGGA ACTGAGACAC GGTCCAGACT CCTACGGGAG GCAGCAGTGG
E coli K-12 GGATGACCAG CCACACTGGA ACTGAGACAC GGTCCAGACT CCTACGGGAG GCAGCAGTGG
Isolate GGATGACCAG CCACACTGGA ACTGAGACAC GGTCCAGACT CCTACGGGAG GCAGCAGTGG

361

S typhimurium GGAATATTGC ACAATGGGCG CAAGCCTGAT GCAGCCATGC CGCGTGTATG AAGAAGGCCT
S typhi GGAATATTGC ACAATGGGCG CAAGCCTGAT GCAGCCATGC CGCGTGTATG AAGAAGGCCT
E coli K-12 GGAATATTGC ACAATGGGCG CAAGCCTGAT GCAGCCATGC CGCGTGTATG AAGAAGGCCT
Isolate GGAATATTGC ACAATGGGCG CAAGCCTGAT GCAGCCATGC CGCGTGTATG AAGAAGGCCT

421

S typhimurium TCGGGTTGTA AAGTACTTTC AGCGGGGAGG AAGGTGTTGT GGTTAATAAC CGCAGCAATT
S typhi TCGGGTTGTA AAGTACTTTC AGCGGGGAGG AAGGTGTTGT GGTTAATAAC CGCAGCAATT
E coli K-12 TCGGGTTGTA AAGTACTTTC AGCGGGGAGG AAGGGAGTAA AGTTAATACC TTTGCTCATT
Isolate TCGGGTTGTA AAGTACTTTC AGCGGGGAGG AAGGGAGTAA AGTTAATACC TTTGCTCATT

481

S typhimurium GACGTTACCC GCAGAAGAAG CACCGGCTAA CTCCGTGCCA GCAGCCGCGG TAATACGGAG
S typhi GACGTTACCC GCAGAAGAAG CACCGGCTAA CTCCGTGCCA GCAGCCGCGG TAATACGGAG
E coli K-12 GACGTTACCC GCAGAAGAAG CACCGGCTAA CTCCGTGCCA GCAGCCGCGG TAATACGGAG
Isolate GACGTTACCC GCAGAAGAAG CACCGGCTAA CTCCGTGCCA GCAGCCGCGG TAATACGGAG

541

S typhimurium GGTGCAAGCG TTAATCGGAA TTACTGGGCG TAAAGCGCAC GCAGGCGCTC TGTCAAGTCG
S typhi GGTGCAAGCG TTAATCGGAA TTACTGGGCG TGAAGCGCAC GCAGGCGGTC TGTCAAGTCG
E coli K-12 GGTGCAAGCG TTAATCGGAA TTACTGGGCG TAAAGCGCAC GCAGGCGGTT TGTTAAGTCA
Isolate GGTGCAAGCG TTAATCGGAA TTACTGGGCG TAAAGCGCAC GCAGGCGGTT TGTTAAGTCA

601

S typhimurium GATGTGAAAT CCCCGGGCTC AACCTGGGAA CTGCATTCGA AACTGGCAGG CTTGAGTCTT
S typhi GATGTGAAGT CCCCGGGCTC AACCTGGGAA CTGCATTCGA AACTGGCAGG CTTGAGTCTT
E coli K-12 GATGTGAAAT CCCCGGGCTC AACCTGGGAA CTGCATCTGA TACTGGCAAG CTTGAGTCTC
Isolate GATGTGAAAT CCCCGGGCTC AACCTGGGAA CTGCATCTGA TACTGGCAAG CTTGAGTCTC

661

S typhimurium GTAGAGGGGG GTAGAATTCC AGGTGTAGCG GTGAAATGCG TAGAGATCTG GAGGAATACC
S typhi GTAGAGGGGG GTAGAATTCC AGGTGTAGCG GTGAAATGCG TAGAGATCTG GAGGAATACC
E coli K-12 GTAGAGGGGG GTAGAATTCC AGGTGTAGCG GTGAAATGCG TAGAGATCTG GAGGAATACC
Isolate GTAGAGGGGG GTAGAATTCC AGGTGTAGCG GTGAAATGCG TAGAGATCTG GAGGAATACC

721

S typhimurium GGTGGCGAAG GCGGCCCCCT GGACAAAGAC TGACGCTCAG GTGCGAAAGC GTGGGGAGCA
S typhi GGTGGCGAAG GCGGCCCCCT GGACAAAGAC TGACGCTCAG GTGCGAAAGC GTGGGGAGCA
E coli K-12 GGTGGCGAAG GCGGCCCCCT GGACGAAGAC TGACGCTCAG GTGCGAAAGC GTGGGGAGCA
Isolate GGTGGCGAAG GCGGCCCCCT GGACGAAGAC TGACGCTCAG GTGCGAAAGC GTGGGGAGCA

781

S typhimurium AACAGGATTA GATACCCTGG TAGTCCACGC CGTAAACGAT GTCTACTTGG AGGTTGTGCC
S typhi AACAGGATTA GATACCCTGG TAGTCCACGC CGTAAACGAT GTCTACTTGG AGGTTGTGCC
E coli K-12 AACAGGATTA GATACCCTGG TAGTCCACGC CGTAAACGAT GTCGACTTGG AGGTTGTGCC
Isolate AACAGGATTA GATACCCTGG TAGTCCACGC CGTAAACGAT GTCGACTTGG AGGTTGTGCC

841

S typhimurium CTTGAGGCGT GGCTTCCGGA GCTAACGCGT TAAGTAGACC GCCTGGGGAG TACGGCCGCA
S typhi CTTGAGGCGT GGCTTCCGGA GCTAACGCGT TAAGTAGACC GCCTGGGGAG TACGGCCGCA
E coli K-12 CTTGAGGCGT GGCTTCCGGA GCTAACGCGT TAAGTCGACC GCCTGGGGAG TACGGCCGCA
Isolate CTTGAGGCGT GGCTTCCGGA GCTAACGCGT TAAGTCGACC GCCTGGGGAG TACGGCCGCA

901

S typhimurium AGGTTAAAAC TCAAATGAAT TGACGGGGGC CCGCACAAGC GGTGGAGCAT GTGGTTTAAT
S typhi AGGTTAAAAC TCAAATGAAT TGACGGGGGC CCGCACAAGC GGTGGAGCAT GTGGTTTAAT
E coli K-12 AGGTTAAAAC TCAAATGAAT TGACGGGGGC CCGCACAAGC GGTGGAGCAT GTGGTTTAAT
Isolate AGGTTAAAAC TCAAATGAAT TGACGGGGGC CCGCACAAGC GGTGGAGCAT GTGGTTTAAT

961

S typhimurium TCGATGCAAC GCGAAGAACC TTACCTGGTC TTGACATCCA CAGAACTTTC CAGAGATGGA
S typhi TCGATGCAAC GCGAAGAACC TTACCTGGTC TTGACATCCA CAGAACTTTC CAGAGATGGA
E coli K-12 TCGATGCAAC GCGAAGAACC TTACCTGGTC TTGACATCCA CGGAAGTTTT CAGAGATGAG
Isolate TCGATGCAAC GCGAAGAACC TTACCTGGTC TTGACATCCA CGGAAGTTTT CAGAGATGAG

1021

S typhimurium TTGGTTCCTT CGGGAACTGT GAGACAGGTG CTGCATGGCT GTCGTCAGCT CGTGTTGTGA
S typhi TTGGTGCCTT CGGGAACTGT GAGACAGGTG CTGCATGGCT GTCGTCAGCT CGTGTTGTGA
E coli K-12 AATGTGCCTT CGGGAACCGT GAGACAGGTG CTGCATGGCT GTCGTCAGCT CGTGTTGTGA
Isolate AATGTGCCTT CGGGAACCGT GAGACAGGTG CTGCATGGCT GTCGTCAGCT CGTGTTGTGA

1081

S typhimurium AATGTCGGGT TAAGTCCCGC AACGAGCGCA ACCCTTATCC TTTGTTGCCA GCGGTTAGGC
S typhi AATGTCGGGT TAAGTCCCGC AACGAGCGCA ACCCTTATCC TTTGTTGCCA GCGGTCCGGC
E coli K-12 AATGTTGGGT TAAGTCCCGC AACGAGCGCA ACCCTTATCC TTTGTTGCCA GCGGTCCGGC
Isolate AATGTTGGGT TAAGTCCCGC AACGAGCGCA ACCCTTATCC TTTGTTGCCA GCGGTCCGGC

1141

S typhimurium CGGGAACTCA AAGGAGACTG CCAGTGATAA ACTGGAGGAA GGTGGGGATG ACGTCAAGTC
S typhi CGGGAACTCA AAGGAGACTG CCAGTGATAA ACTGGAGGAA GGTGGGGATG ACGTCAAGTC
E coli K-12 CGGGAACTCA AAGGAGACTG CCAGTGATAA ACTGGAGGAA GGTGGGGATG ACGTCAAGTC
Isolate CGGGAACTCA AAGGAGACTG CCAGTGATAA ACTGGAGGAA GGTGGGGATG ACGTCAAGTC

1201

S typhimurium ATCATGGCCC TTACGACCAG GGCTACACAC GTGCTACAAT GGCGCATACA AAGAGAAGCG
S typhi ATCATGGCCC TTACGACCAG GGCTACACAC GTGCTACAAT GGCGCATACA AAGAGAAGCG
E coli K-12 ATCATGGCCC TTACGACCAG GGCTACACAC GTGCTACAAT GGCGCATACA AAGAGAAGCG
Isolate ATCATGGCCC TTACGACCAG GGCTACACAC GTGCTACAAT GGCGCATACA AAGAGAAGCG

1261

S typhimurium ACCTCGCGAG AGCAAGCGGA CCTCATAAAG TGCGTCGTAG TCCGGATTGG AGTCTGCAAC
S typhi ACCTCGTGAG AGCAAGCGGA CCTCATAAAG TGCGTCGTAG TCCGGATTGG AGTCTGCAAC
E coli K-12 ACCTCGCGAG AGCAAGCGGA CCTCATAAAG TGCGTCGTAG TCCGGATTGG AGTCTGCAAC
Isolate ACCTCGCGAG AGCAAGCGGA CCTCATAAAG TGCGTCGTAG TCCGGATTGG AGTCTGCAAC

1321

S typhimurium TCGACTCCAT GAAGTCGGAA TCGCTAGTAA TCGTGGATCA GAATGCCACG GTGAATACGT
S typhi TCGACTCCAT GAAGTCGGAA TCGCTAGTAA TCGTGGATCA GAATGCCACG GTGAATACGT
E coli K-12 TCGACTCCAT GAAGTCGGAA TCGCTAGTAA TCGTGGATCA GAATGCCACG GTGAATACGT
Isolate TCGACTCCAT GAAGTCGGAA TCGCTAGTAA TCGTGGATCA GAATGCCACG GTGAATACGT

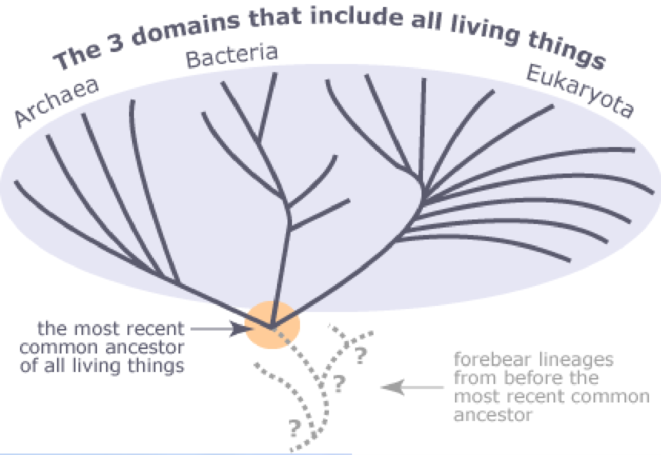
1381

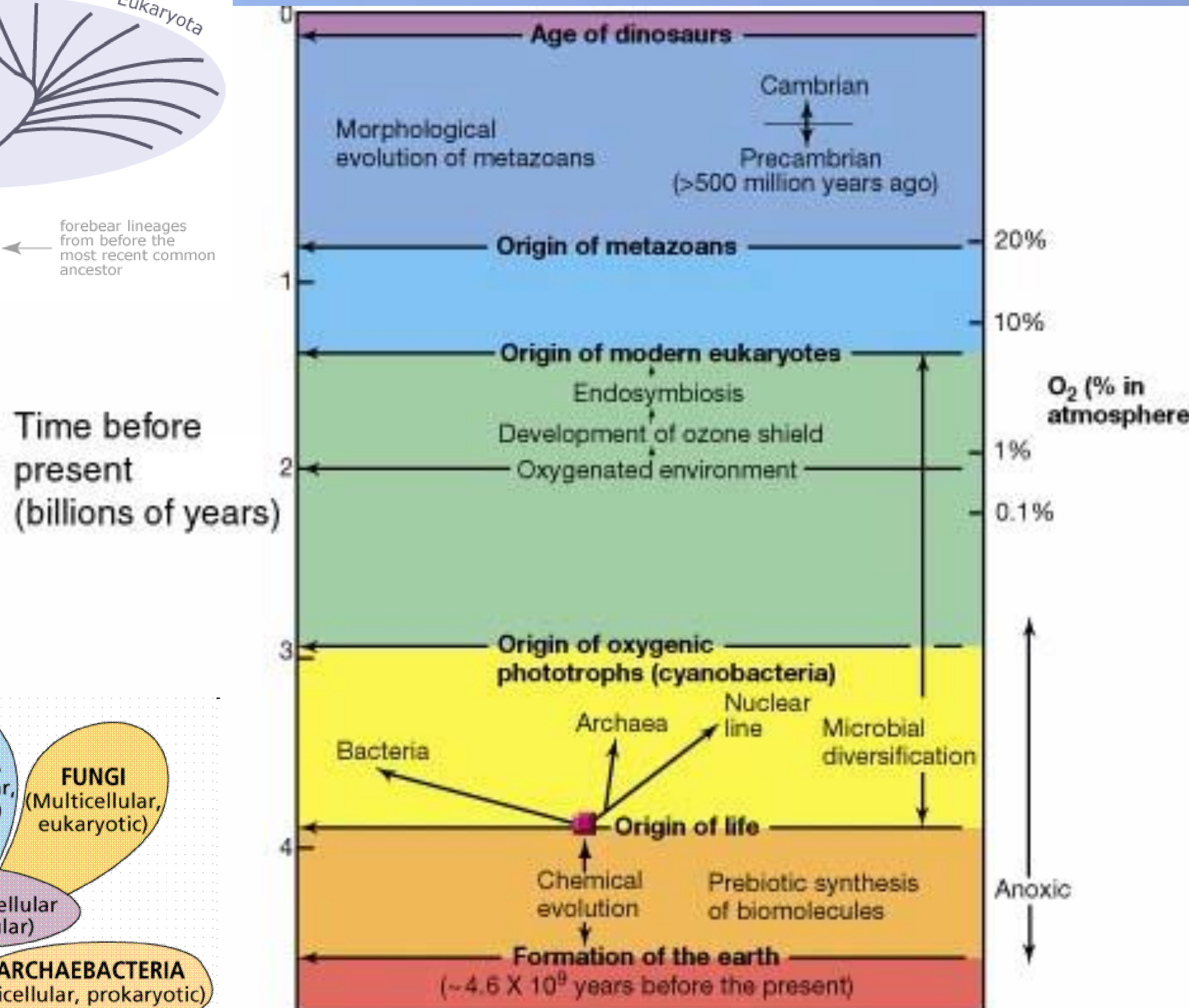
S typhimurium TCCCGGGCCT
S typhi TCCCGGGCCT
E coli K-12 TCCCGGGCCT
Isolate TCCCGGGCCT

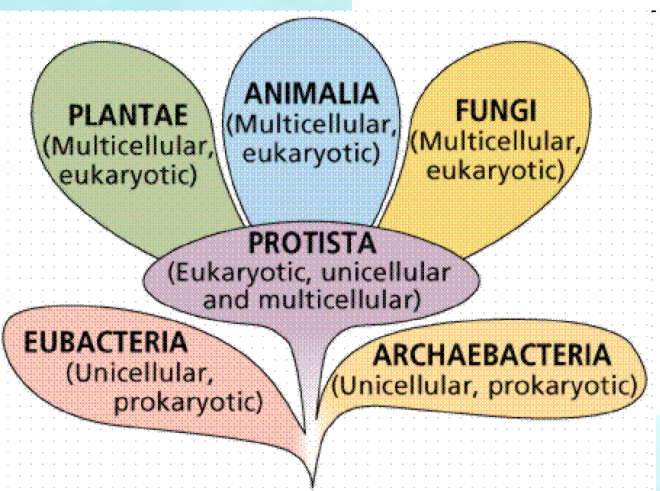
TABLE 12.1 Signature sequences from 16S or 18S rRNA defining the three domains of life

Oligonucleotide signatures[a]	Approximate position[b]	Occurrence among[c]: Archaea	Bacteria	Eukarya
CACYYG	315	0	>95	0
CYAAYUNYG	510	0	>95	0
AAACUCAAA	910	3	100	0
AAACUUAAAG	910	100	0	100
NUUAAUUCG	960	0	>95	0
YUYAAUUG	960	100	<1	100
CAACCYYCR	1110	0	>95	0
UUCCCG	1380	0	>95	0
UCCCUG	1380	>95	0	100
CUCCUUG	1390	>95	0	0
UACACACCG	1400	0	>99	100
CACACACCG	1400	100	0	0

a Y, Any pyrimidine; R, any purine; N, any purine or pyrimidine.
b Refer to Figure 12.7*c* for numbering scheme of 16S rRNA.
c Occurrence refers to percentage of organisms examined in any domain that contain that sequence.

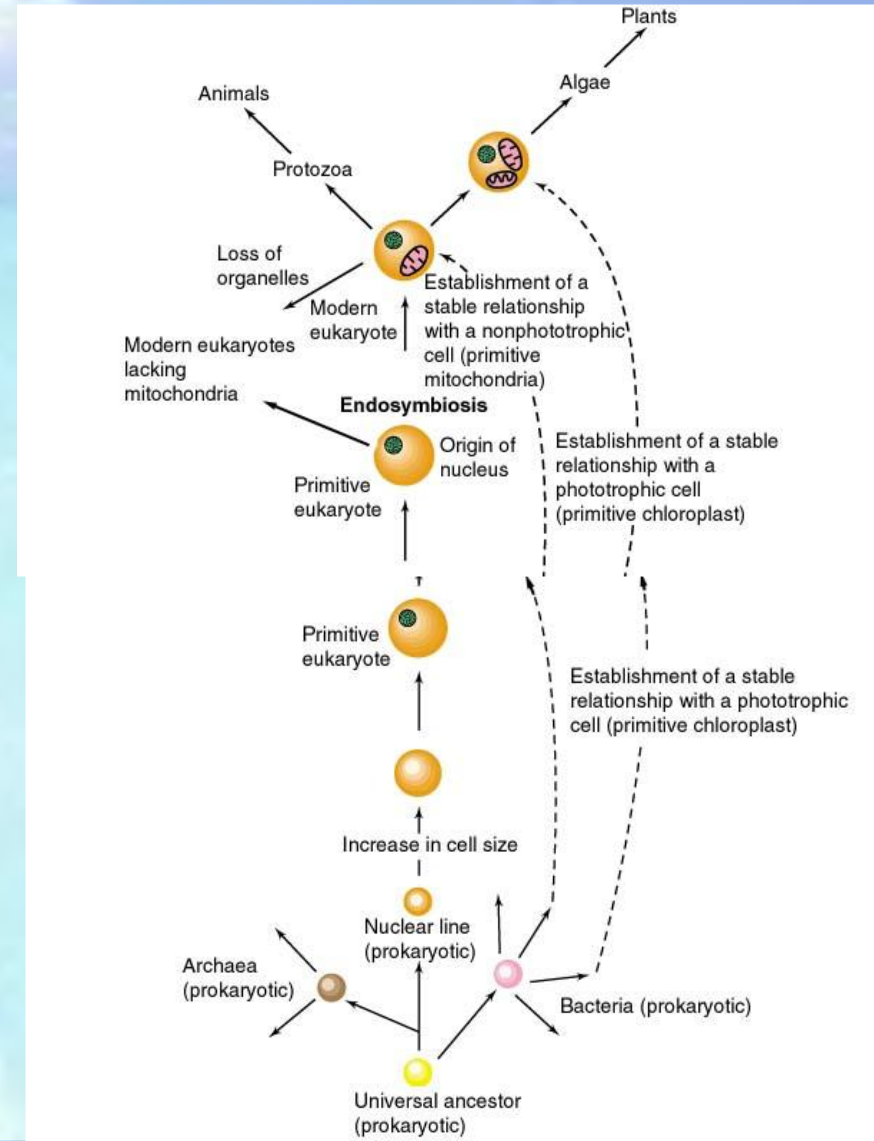

The 3 domains that include all living things
Archaea
Bacteria
Eukaryota
the most recent common ancestor of all living things
forebear lineages from before the most recent common ancestor
?
?
?
?

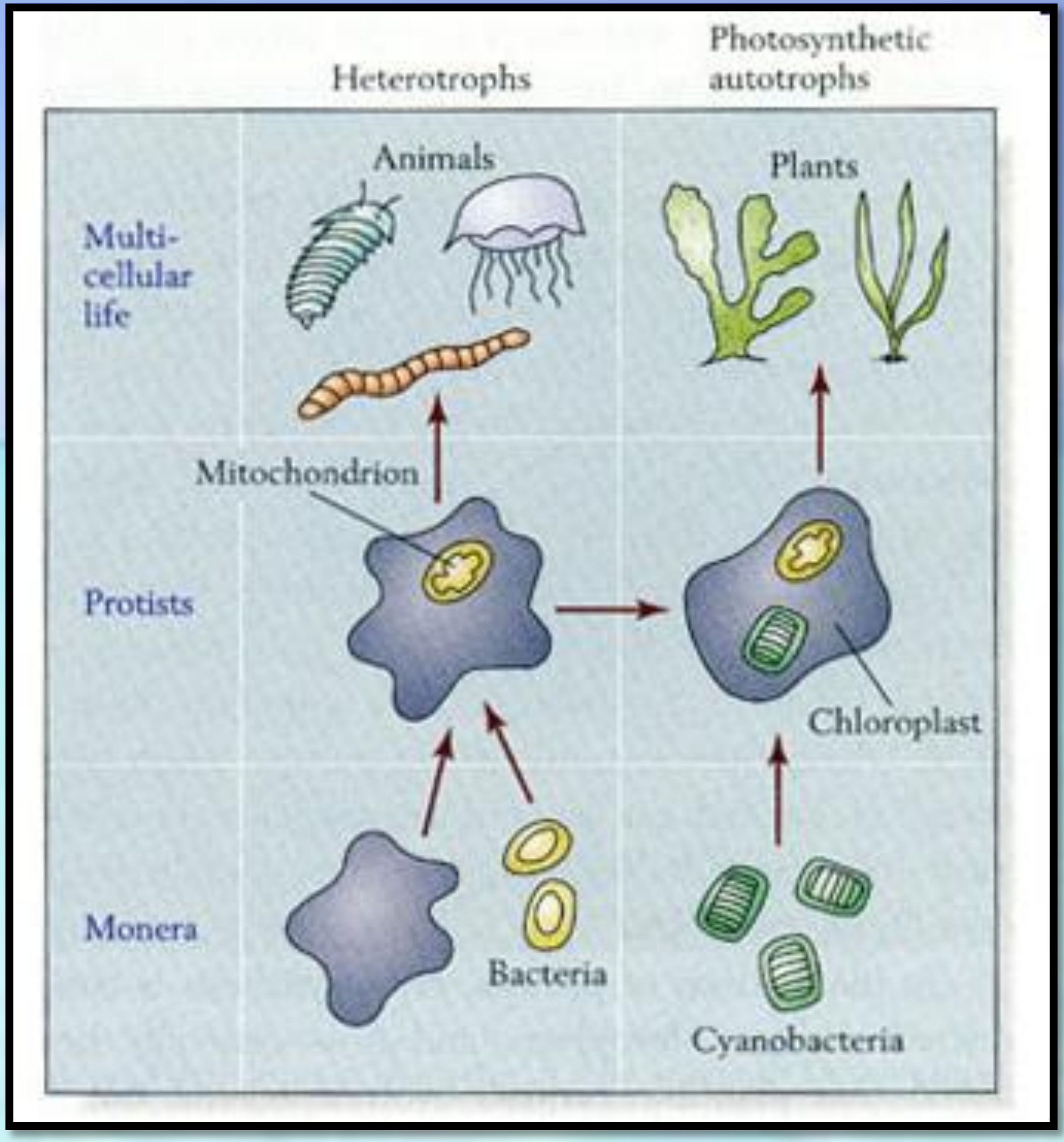

0
1
2
3
4
Time before present (billions of years)
Age of dinosaurs
Cambrian
Precambrian (>500 million years ago)
Morphological evolution of metazoans
Origin of metazoans
Origin of modern eukaryotes
Endosymbiosis
Development of ozone shield
Oxygenated environment
Origin of oxygenic phototrophs (cyanobacteria)
Bacteria
Archaea
Nuclear line
Microbial diversification
Origin of life
Chemical evolution
Prebiotic synthesis of biomolecules
Formation of the earth
(~4.6 X 10⁹ years before the present)
20%
10%
1%
0.1%
O₂ (% in atmosphere)
Anoxic


PLANTAE (Multicellular, eukaryotic)
ANIMALIA (Multicellular, eukaryotic)
FUNGI (Multicellular, eukaryotic)
PROTISTA (Eukaryotic, unicellular and multicellular)
EUBACTERIA (Unicellular, prokaryotic)
ARCHAEBACTERIA (Unicellular, prokaryotic)

Endosymbiosis

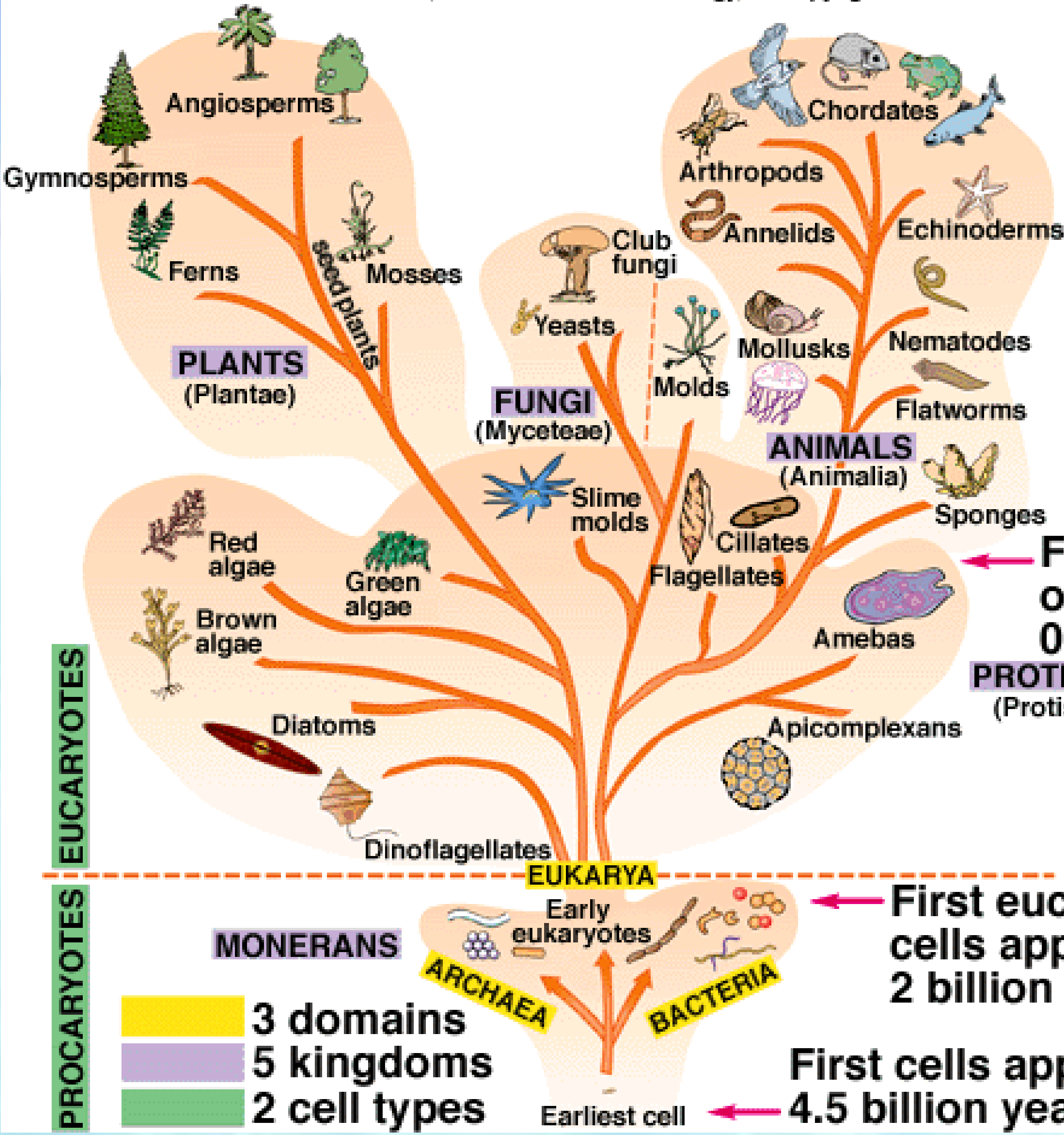
Endosymbiosis
the hypothesis that
mitochondria and
chloroplast
are descendant of
ancient
prokaryotic organisms
from
domain bacteria





The probable events of endosymbiosis that gave rise to the chloroplasts and mitochondria of eucaryotic cells

Family tree of major groups of organisms

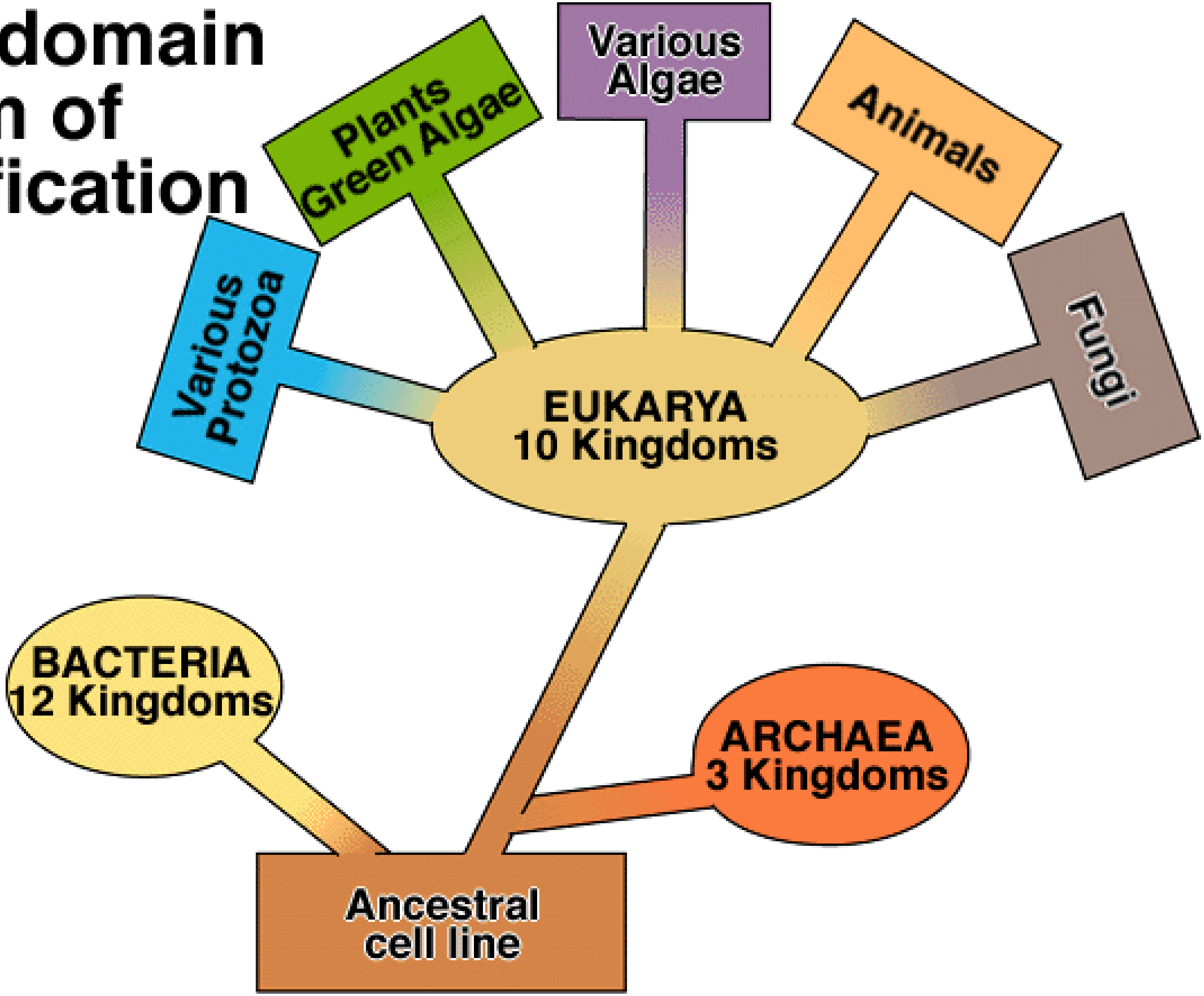


First multicellular organisms appear 0.6 billion years ago

First eucaryotic cells appear 2 billion years ago

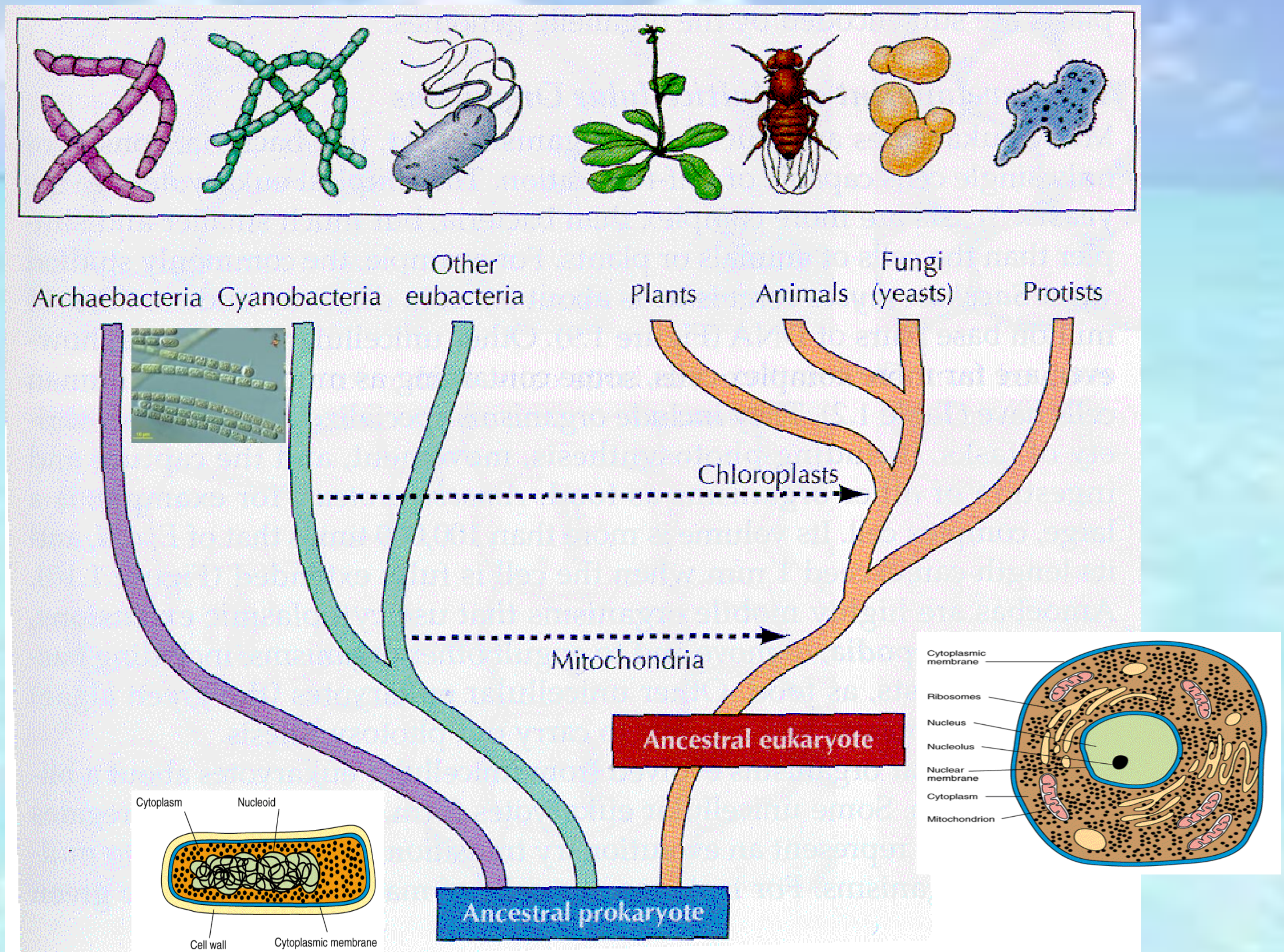
First cells appear 4.5 billion years ago

Three domain system of classification



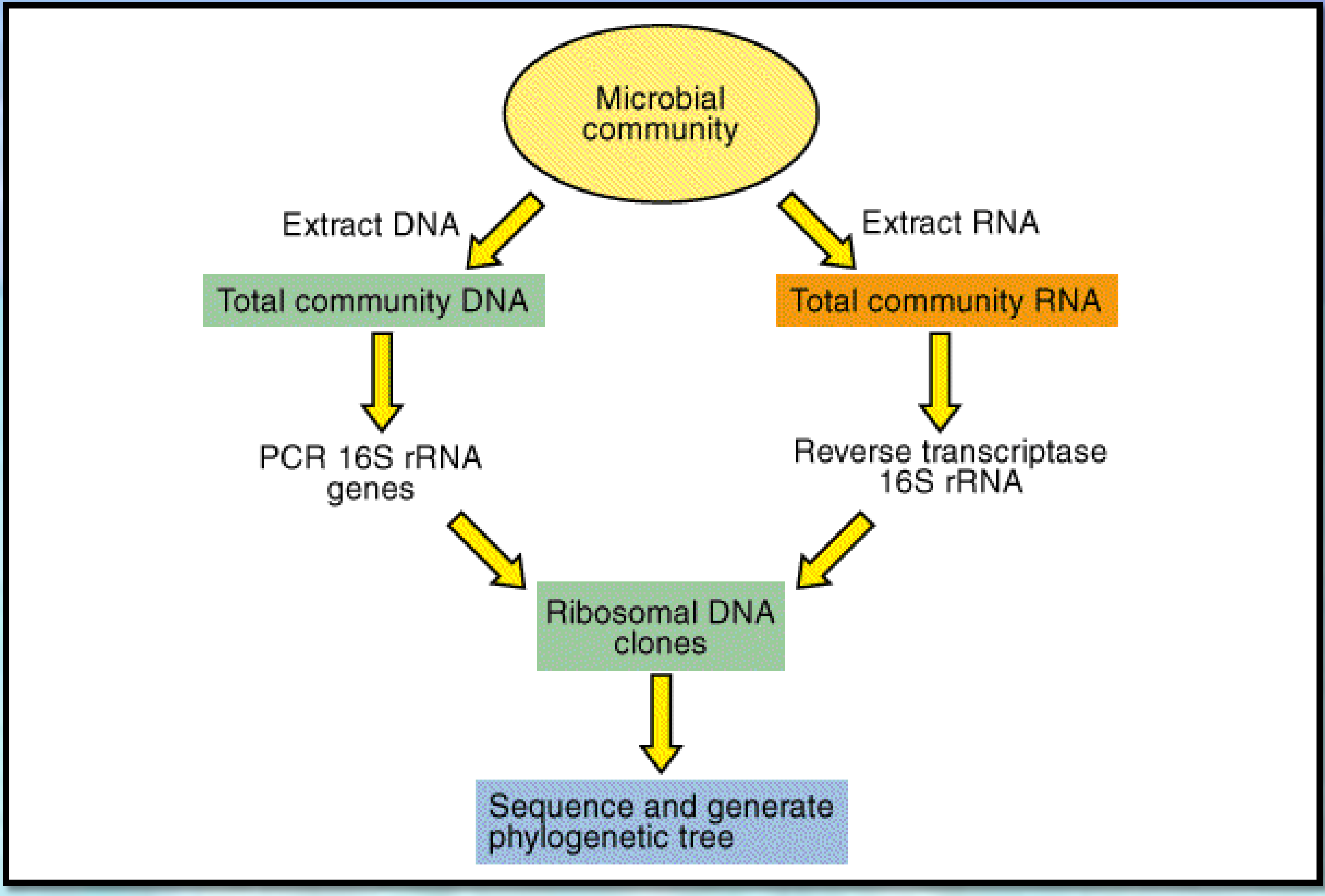
3 cell types, showing relationship with domains and kingdoms

All cells of the present time organisms share a common ancestor
An evolutionary phylogenetic tree:



A Revolution in Microbiology

1. Understanding of evolutionary relatednesss (= phylogeny) between organisms
   - quite different than what was originally thought
2. Microbial Ecology
   - ability to probe community structure without the need for culturing

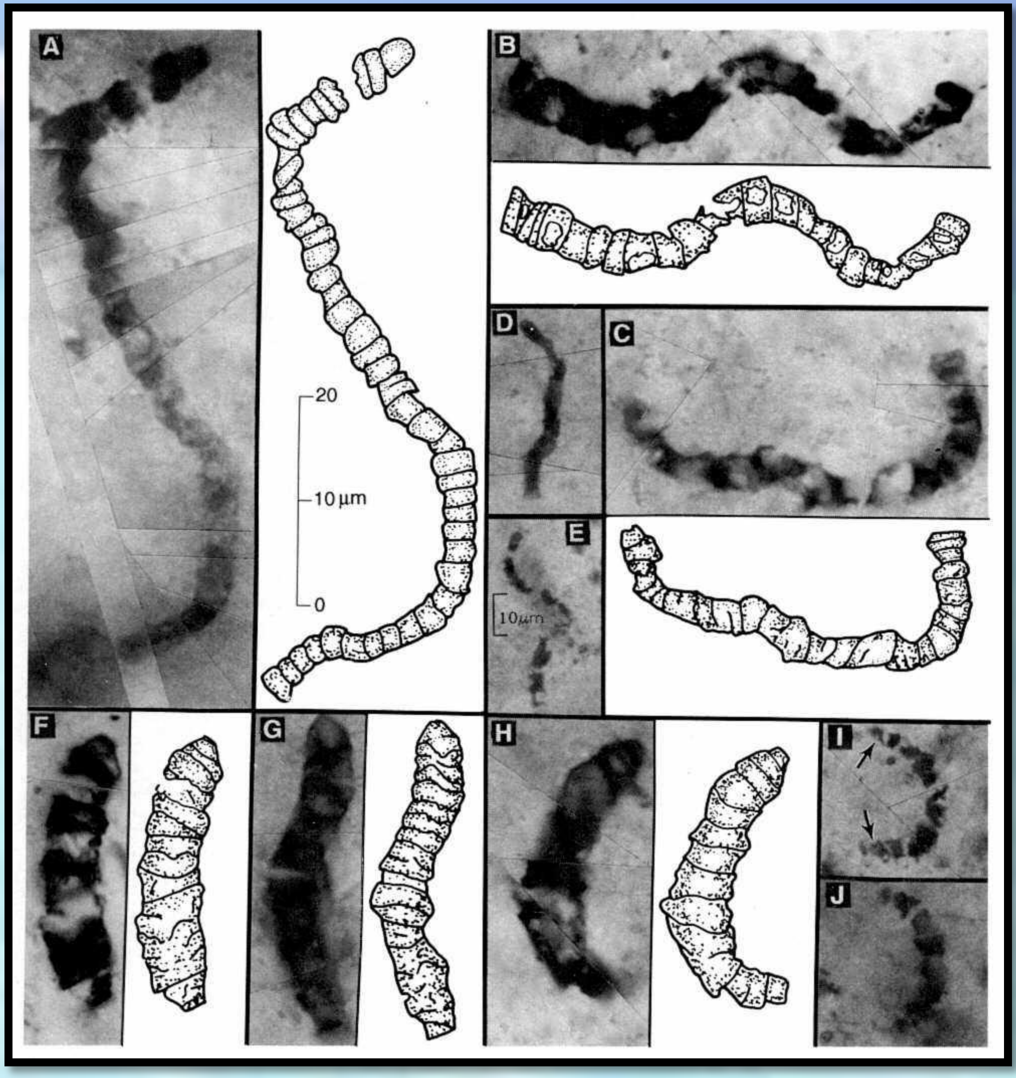

Microbial community
Extract DNA
Extract RNA
Total community DNA
Total community RNA
PCR 16S rRNA genes
Reverse transcriptase 16S rRNA
Ribosomal DNA clones
Sequence and generate phylogenetic tree

Characteristics of Primary Domains

- Cell Walls
- Lipids
- RNA Polymerase
- Protein Synthesis
- Summary

3.465 billion year old microfossils

Apex Chert,
Western Australia



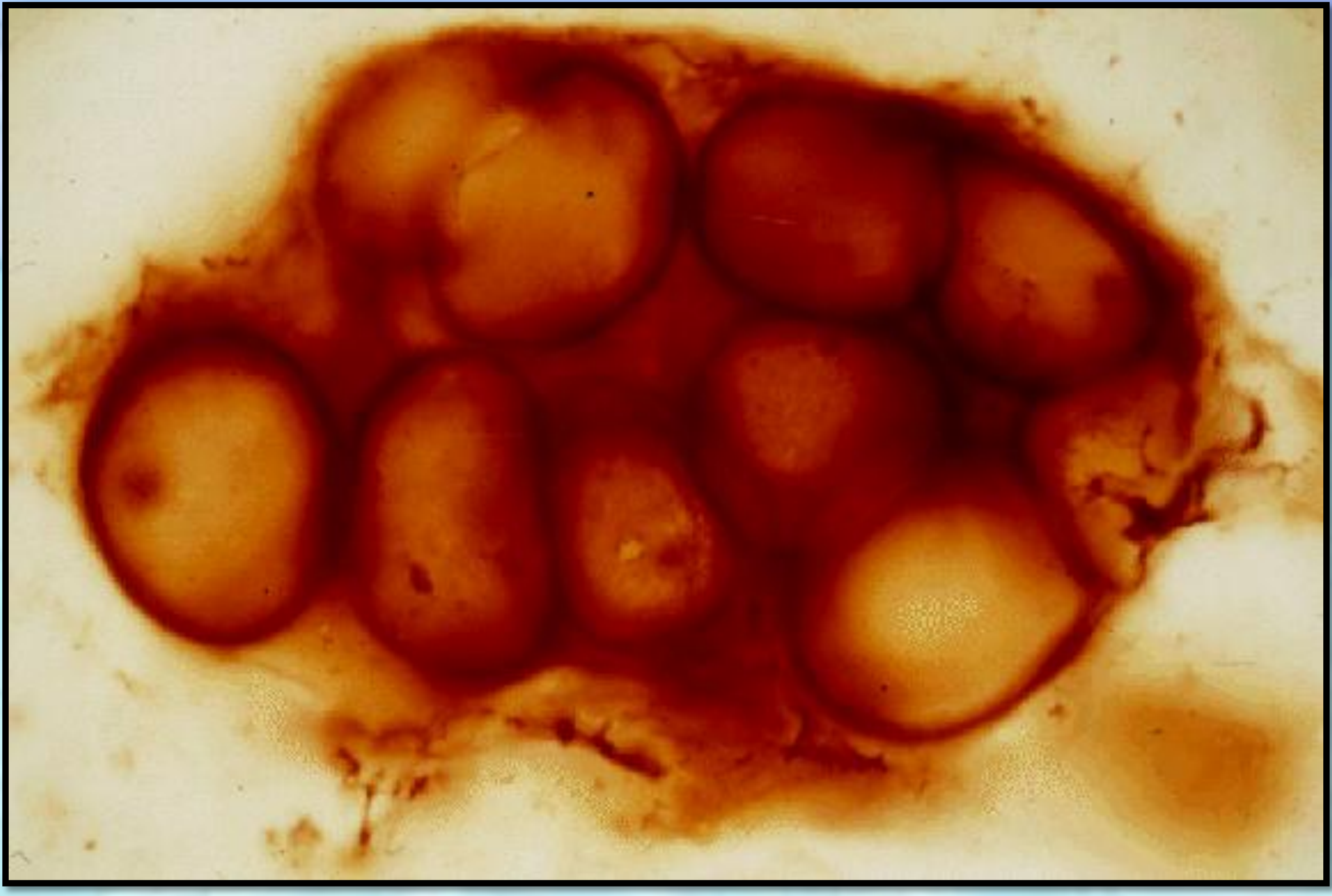
Schopf, J.W. 1993. Microfossils of the early Archaean Apex Chert: new evidence of the antiquity of life. Science 260:640-646

850 million year old fossil cyanobacteria

Bitter Springs Chert, Central Australia

http://www.ucmp.berkeley.edu/bacteria

850 million year old fossil cyanobacteria

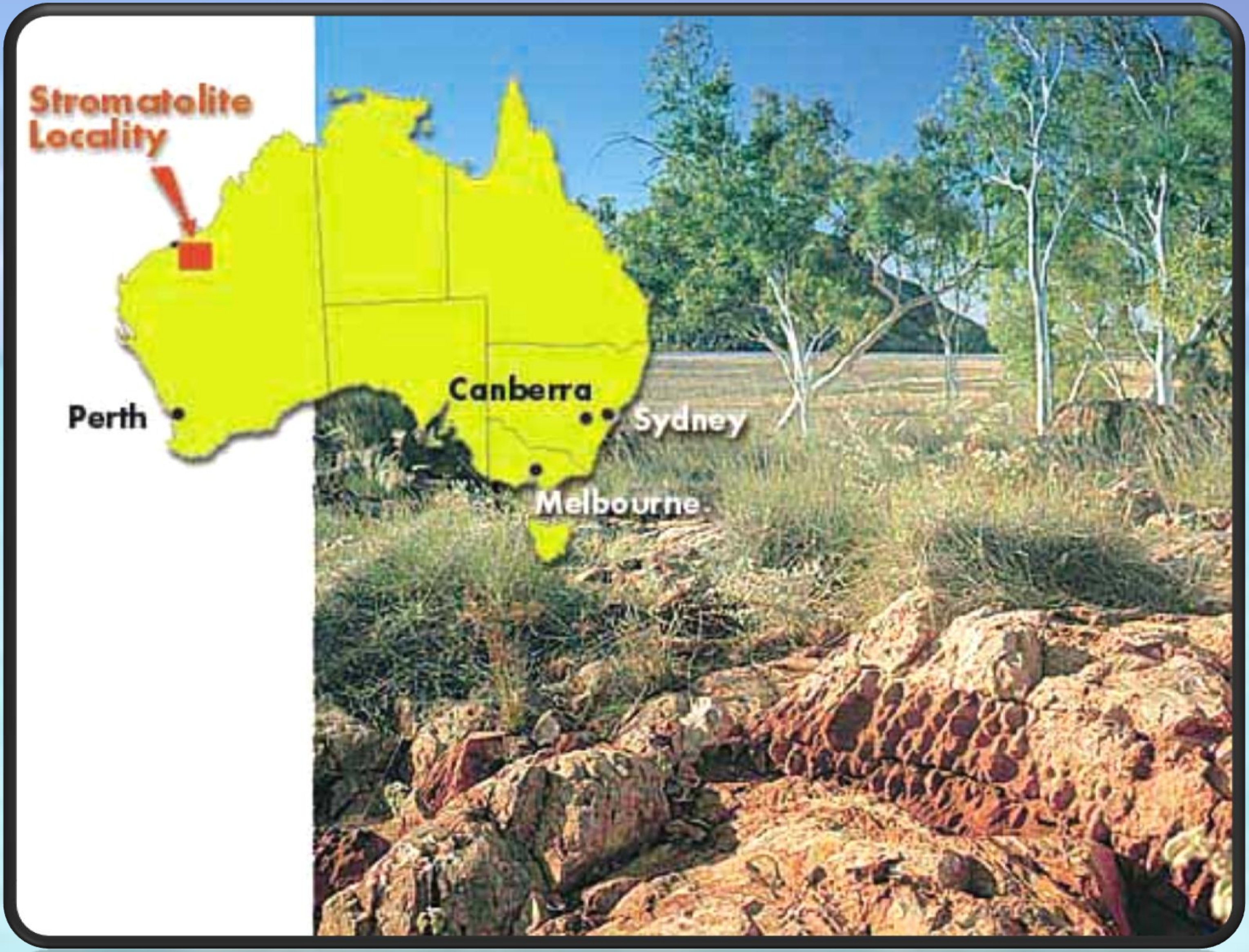


Bitter Springs Chert, Central Australia

http://www.ucmp.berkeley.edu/bacteria

Stromatolites

- Laminated microbial mats, typically built from layers of filamentous and other microorganisms which can become fossilized



http://www.dme.wa.gov.au/ancientfossils

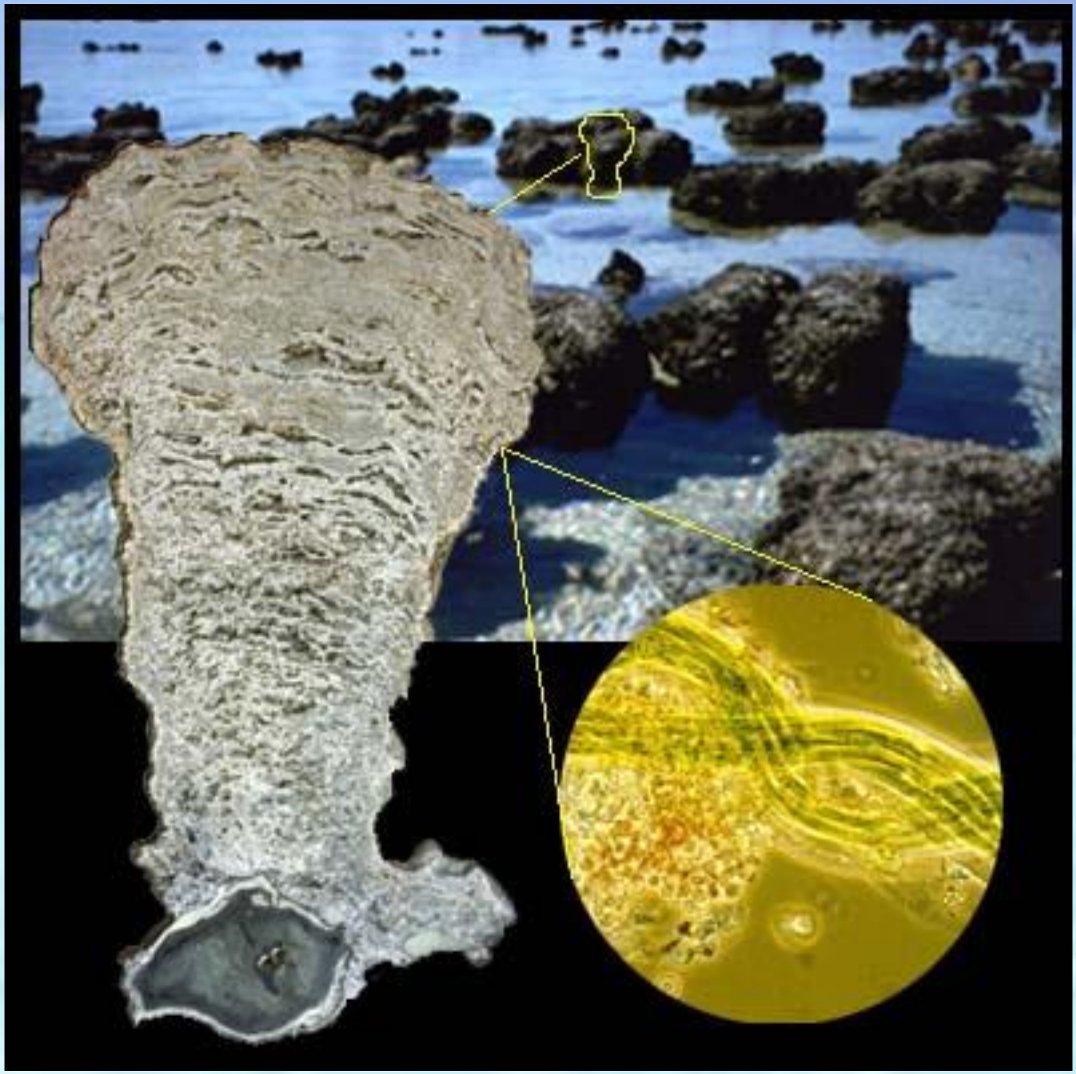
Ancient Stromatolites

http://www.dme.wa.gov.au/ancientfossils

Layered stromatolite

Calcium carbonate precipitate

http://www.ucmp.berkeley.edu/bacteria



Shark Bay living stromatolites

http://www.dme.wa.gov.au/ancientfossils

Stromatolites, Hamelin Pool, Western Australia

http://www.discoverwest.com.au/hablin.html

Stromatolites, Hamelin Pool, Western Australia

http://www.discoverwest.com.au/hablin.html

Living Organisms

Prokaryotic

Eukaryotic

Archae-bacteria

Eubacteria

Simple Unicells or Multicells

Multicellular

Kingdom Protista

Autotrophic (Photosynthetic)

Heterotrophic

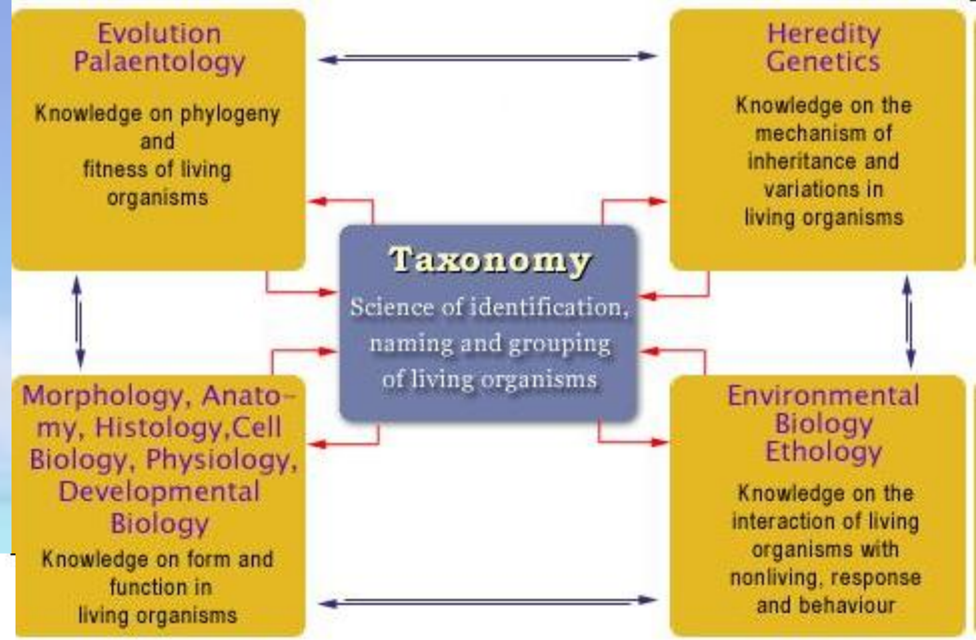
Kingdom Plantae

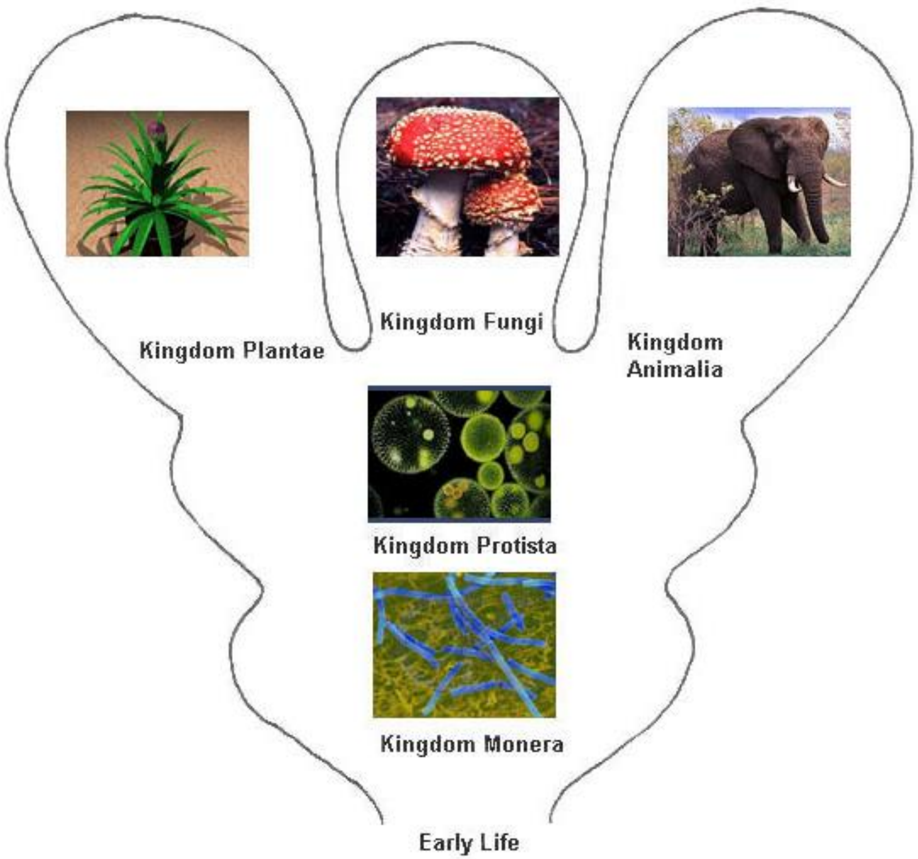
Absorptive nutrition

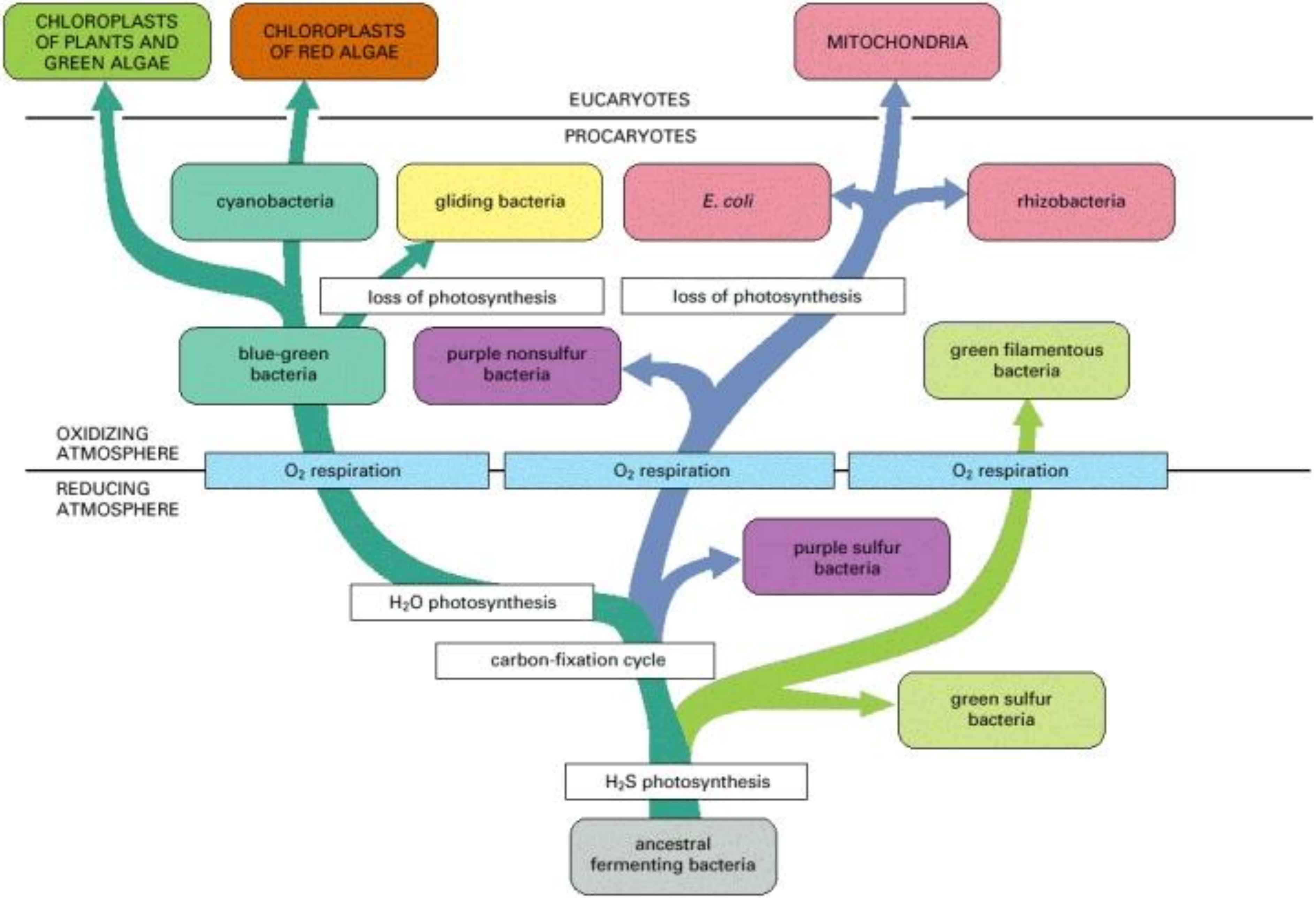
Digestive nutrition

Kingdom Fungi

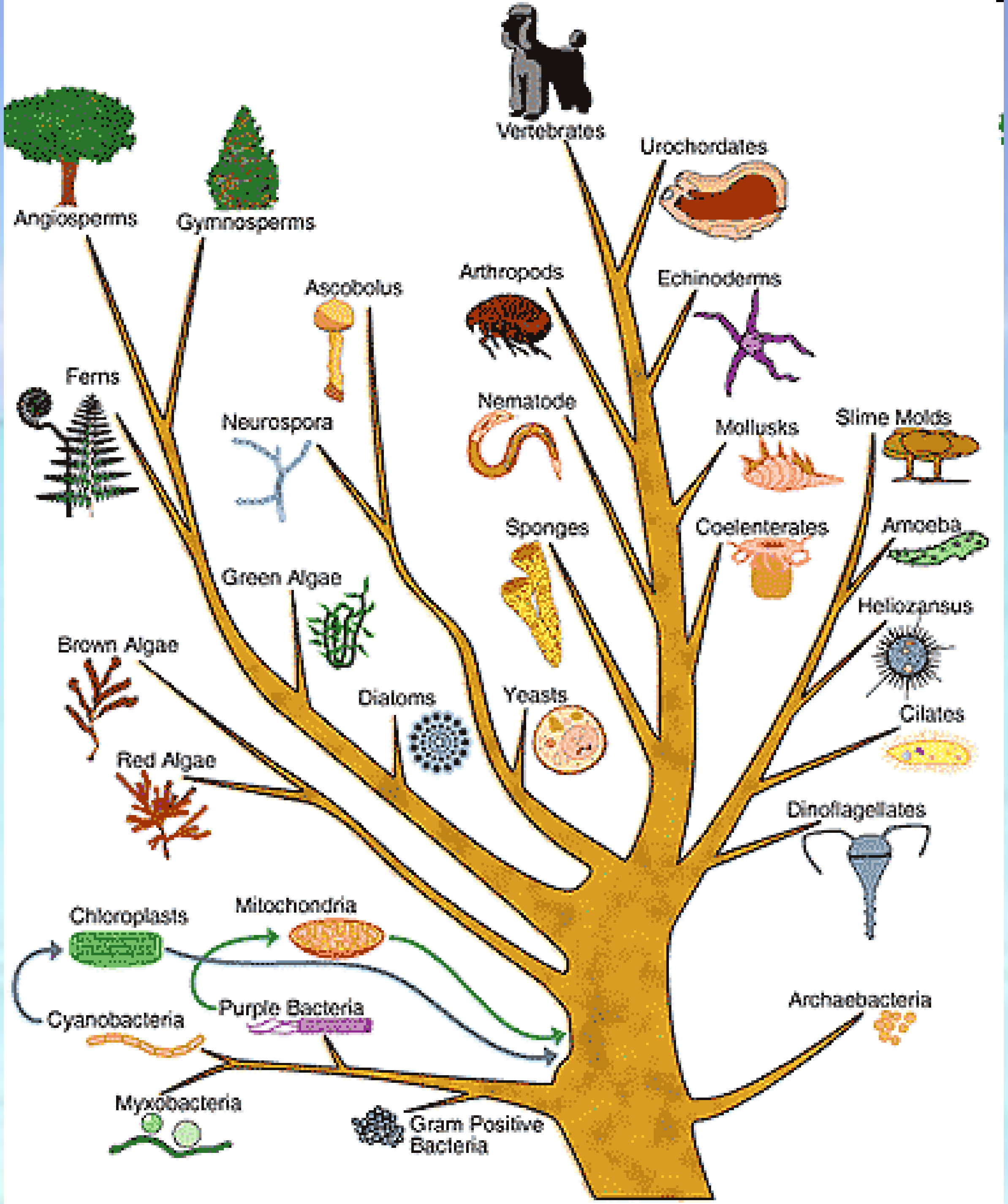
Kingdom Animalia


Evolution
Palaentology
Knowledge on phylogeny and fitness of living organisms
Heredity
Genetics
Knowledge on the mechanism of inheritance and variations in living organisms
Taxonomy
Science of identification, naming and grouping of living organisms
Morphology, Anatomy, Histology, Cell Biology, Physiology, Developmental Biology
Knowledge on form and function in living organisms
Environmental Biology
Ethology
Knowledge on the interaction of living organisms with nonliving, response and behaviour

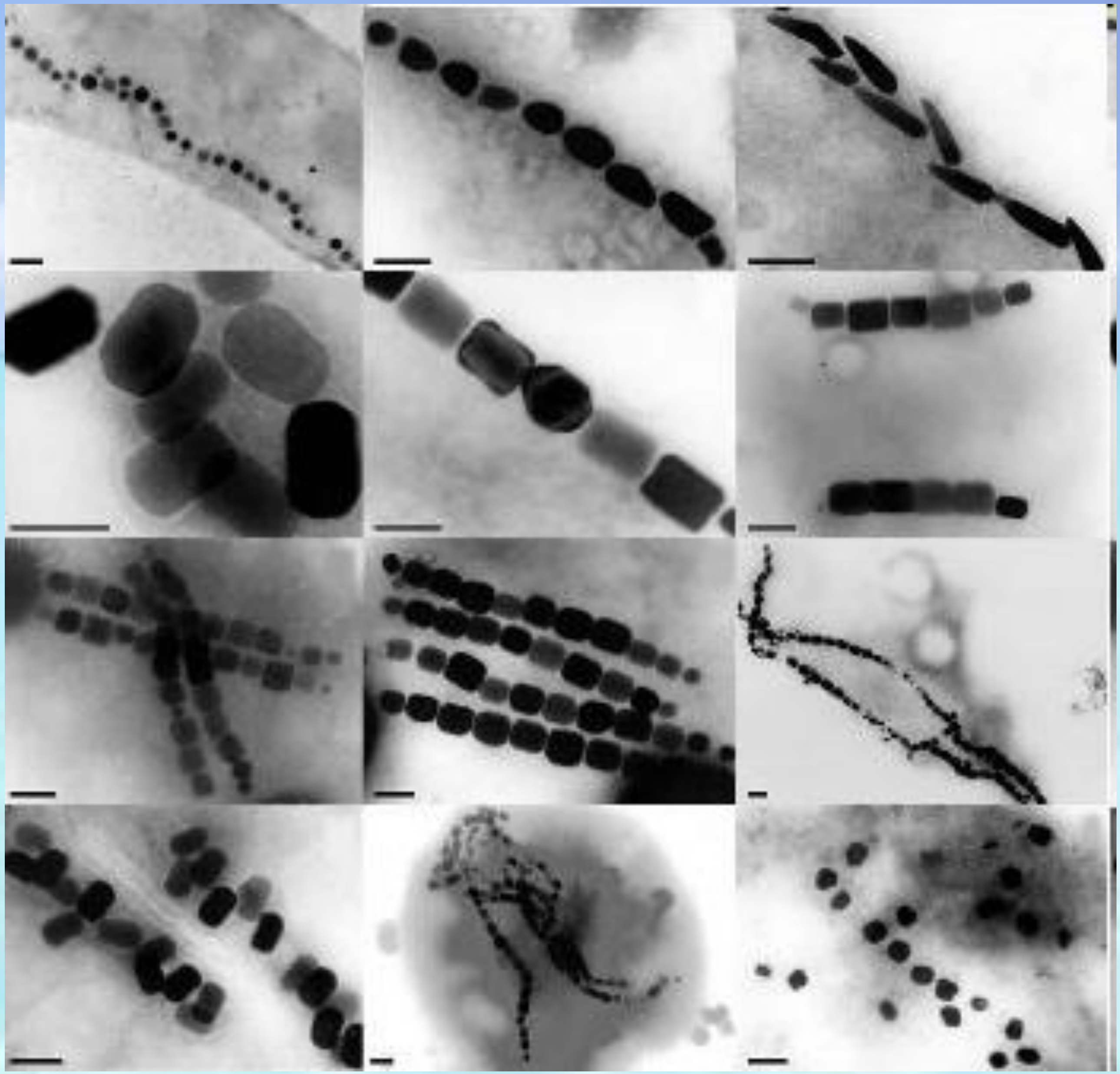

Kingdom Plantae
Kingdom Fungi
Kingdom Animalia
Kingdom Protista
Kingdom Monera
Early Life



CHLOROPLASTS OF PLANTS AND GREEN ALGAE
CHLOROPLASTS OF RED ALGAE
MITOCHONDRIA
EUCARYOTES
PROCARYOTES
cyanobacteria
gliding bacteria
E. coli
rhizobacteria
loss of photosynthesis
loss of photosynthesis
blue-green bacteria
purple nonsulfur bacteria
green filamentous bacteria
OXIDIZING ATMOSPHERE
REDUCING ATMOSPHERE
O2 respiration
O2 respiration
O2 respiration
purple sulfur bacteria
H2O photosynthesis
carbon-fixation cycle
green sulfur bacteria
H2S photosynthesis
ancestral fermenting bacteria



Vertebrates
Urochordates
Angiosperms
Gymnosperms
Ascobolus
Arthropods
Echinoderms
Ferns
Nematode
Neurospora
Mollusks
Slime Molds
Sponges
Coelenterates
Amoeba
Green Algae
Heliozansus
Brown Algae
Diatoms
Yeasts
Cilates
Red Algae
Dinoflagellates
Chloroplasts
Mitochondria
Archaebacteria
Purple Bacteria
Cyanobacteria
Myxobacteria
Gram Positive Bacteria




THANK YOU