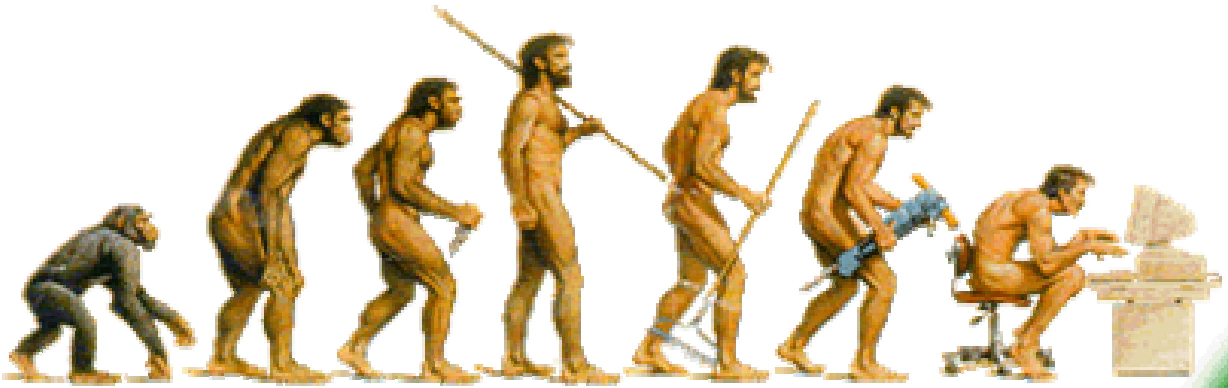
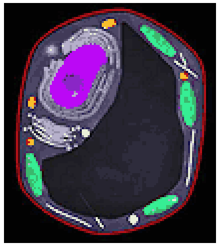
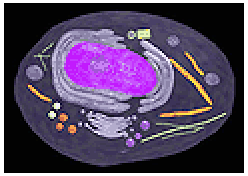
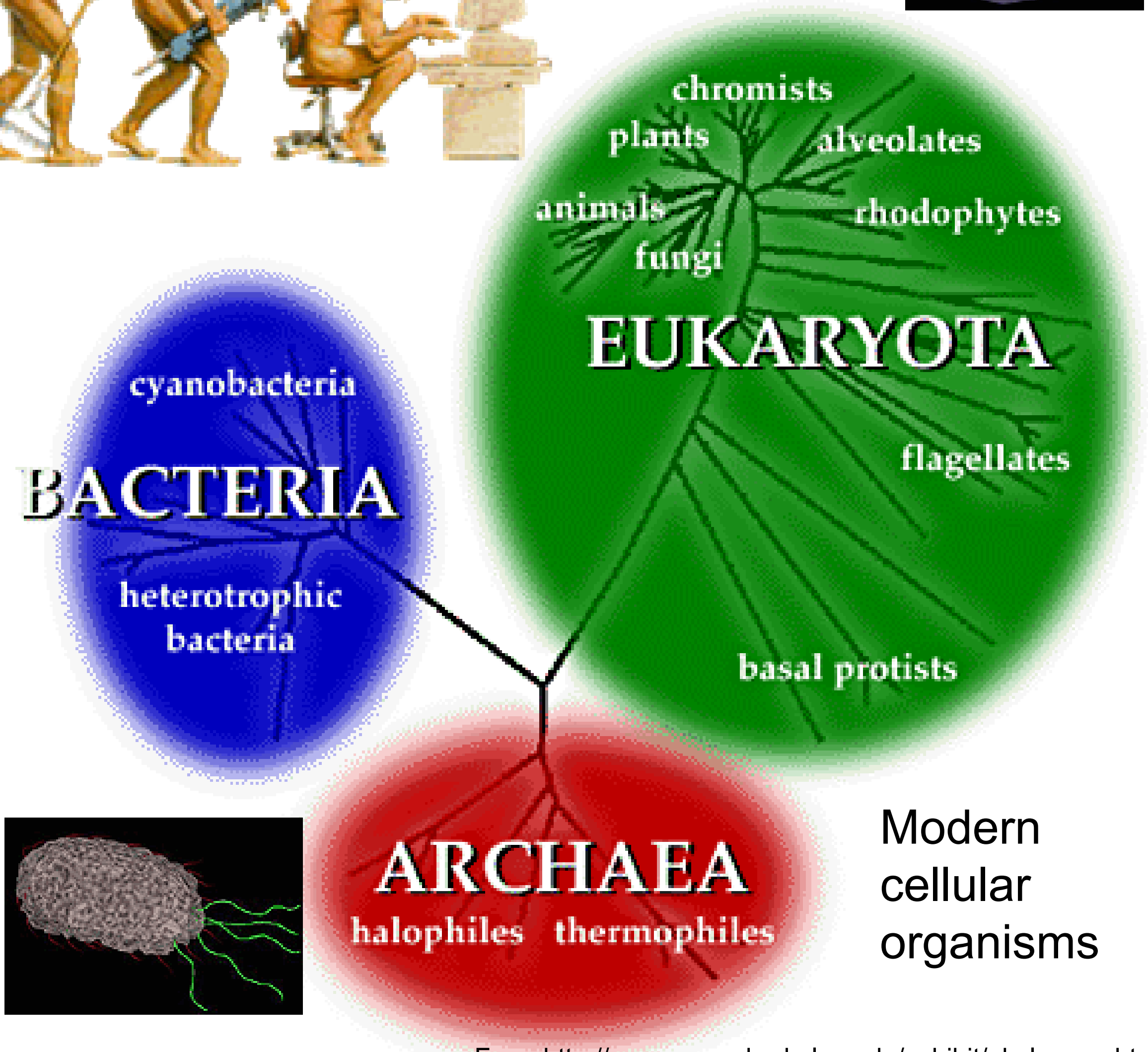


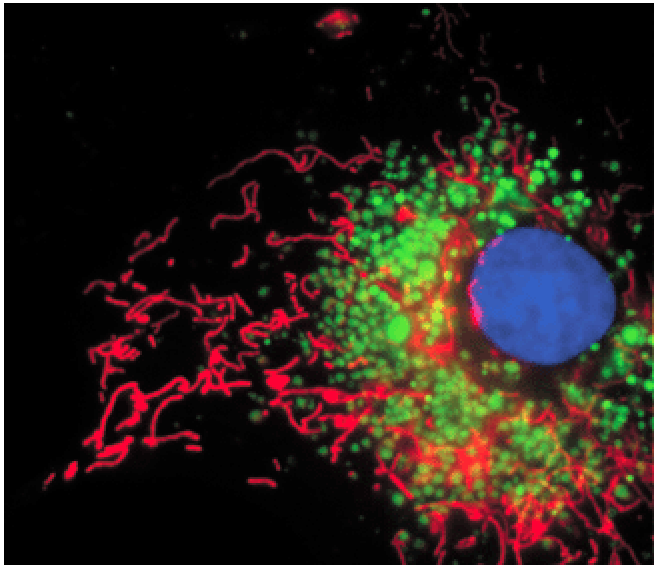




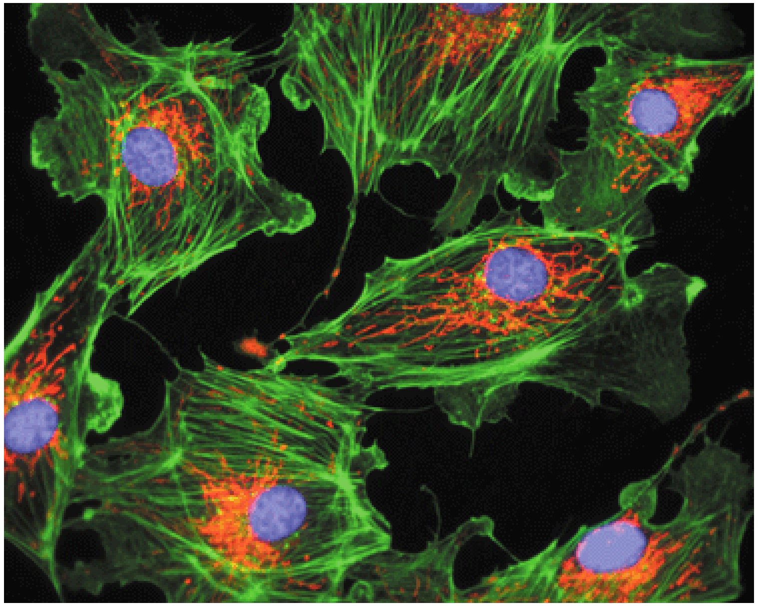


Modern cellular organisms

From http://www.ucmp.berkeley.edu/exhibit/phylogeny.html

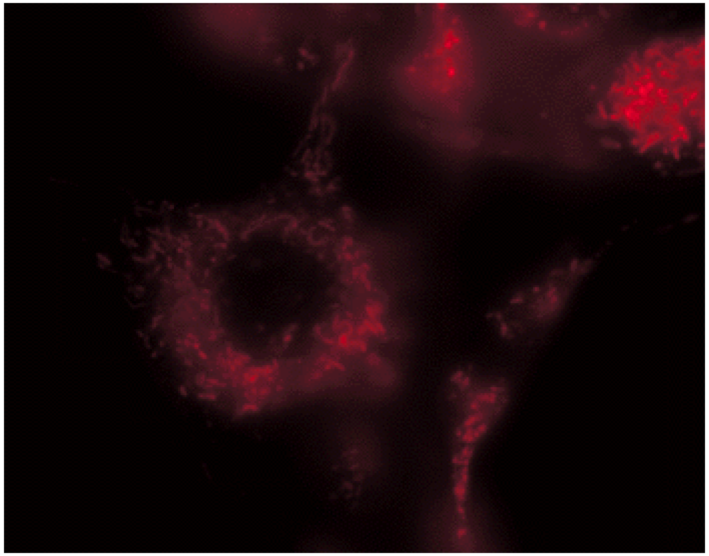


Endothelial cell
Lysosomes, mitochondria and nucleus

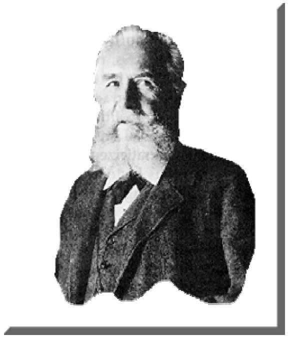


See the cellular cytoskeleton,
ER and nucleus

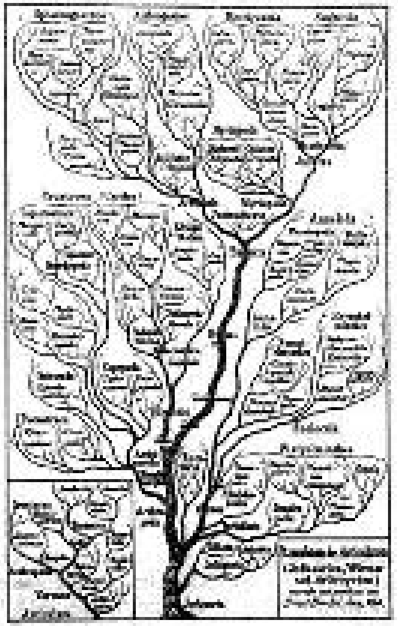
Modern cells are complex with lots of structure and organelles

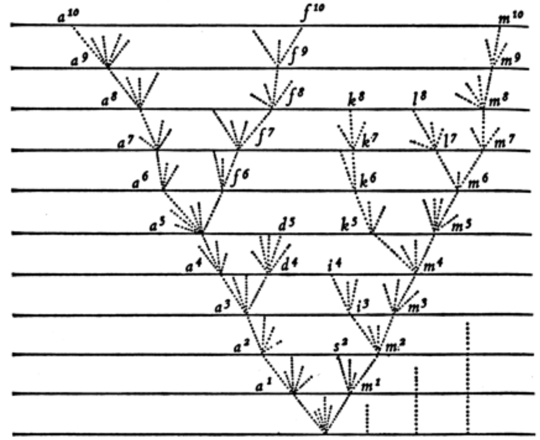


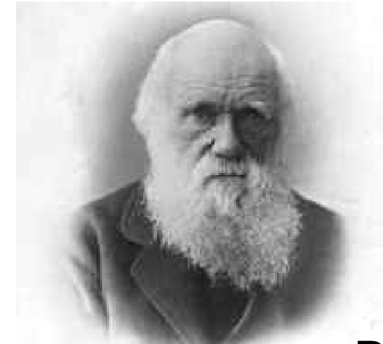
Visualization of redox potential in 3T3 cells



Haeckel

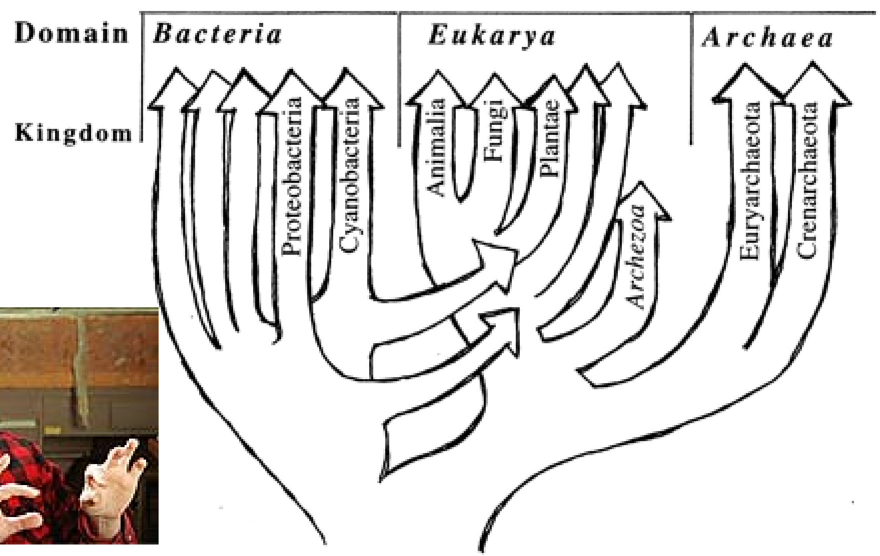




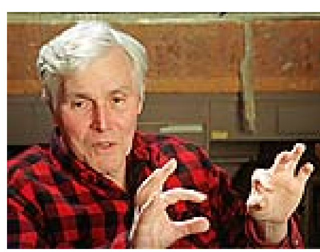


Darwin

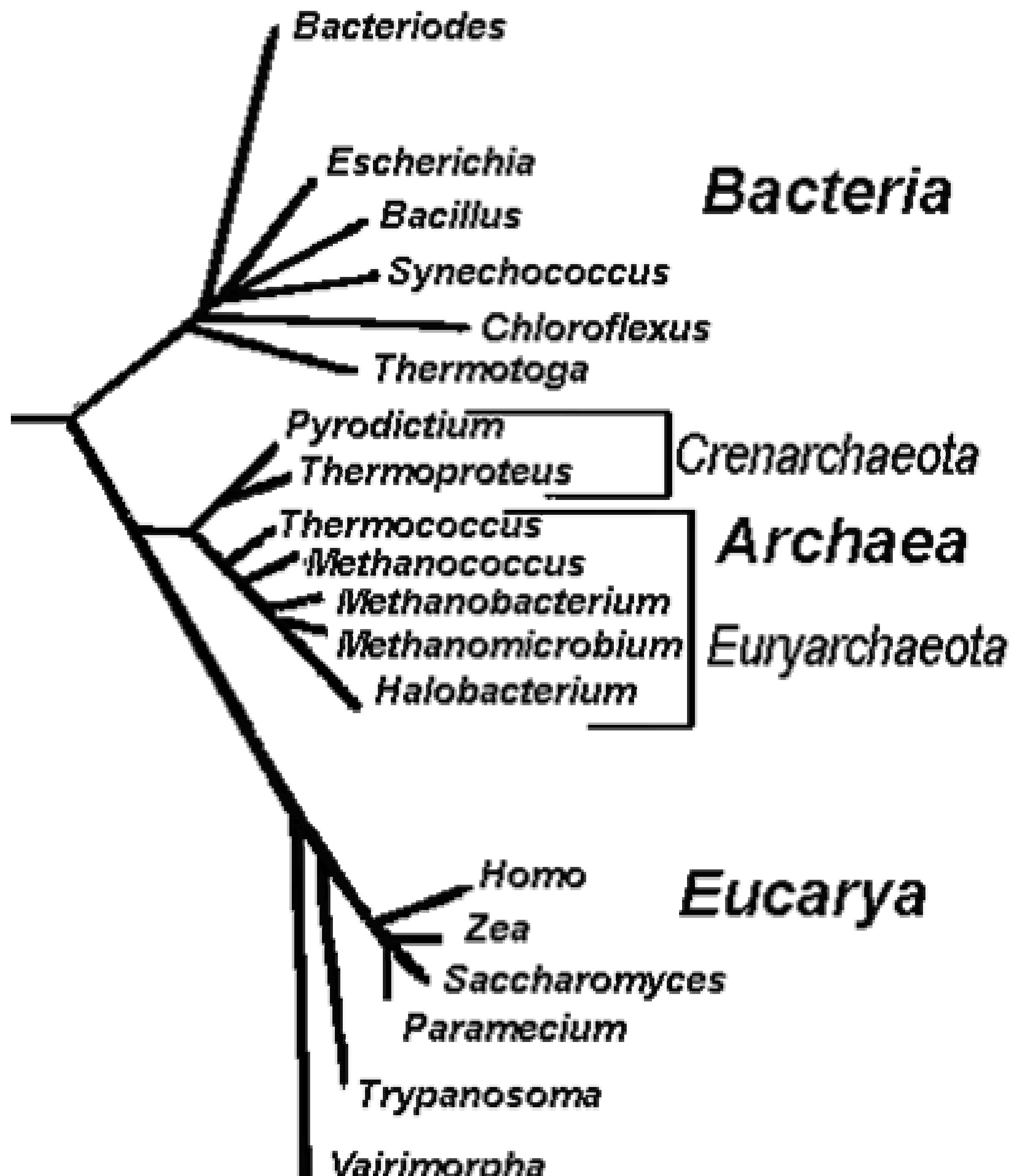
best known for the famous statement "ontogeny recapitulates phylogeny", he also coined many words commonly used by biologists today, such as **phylum**, **phylogeny**, and **ecology**. On the other hand, Haeckel also stated that "politics is applied biology", a quote used by Nazi propagandists.



Phylogenetic trees



Woese


Bacteriodes
Escherichia
Bacillus
Synechococcus
Chloroflexus
Thermotoga
Bacteria
Pyrodictium
Thermoproteus
Crenarchaeota
Thermococcus
Methanococcus
Methanobacterium
Methanomicrobium
Halobacterium
Archaea
Euryarchaeota
Homo
Zea
Saccharomyces
Paramecium
Trypanosoma
Vairimorpha
Eucarya

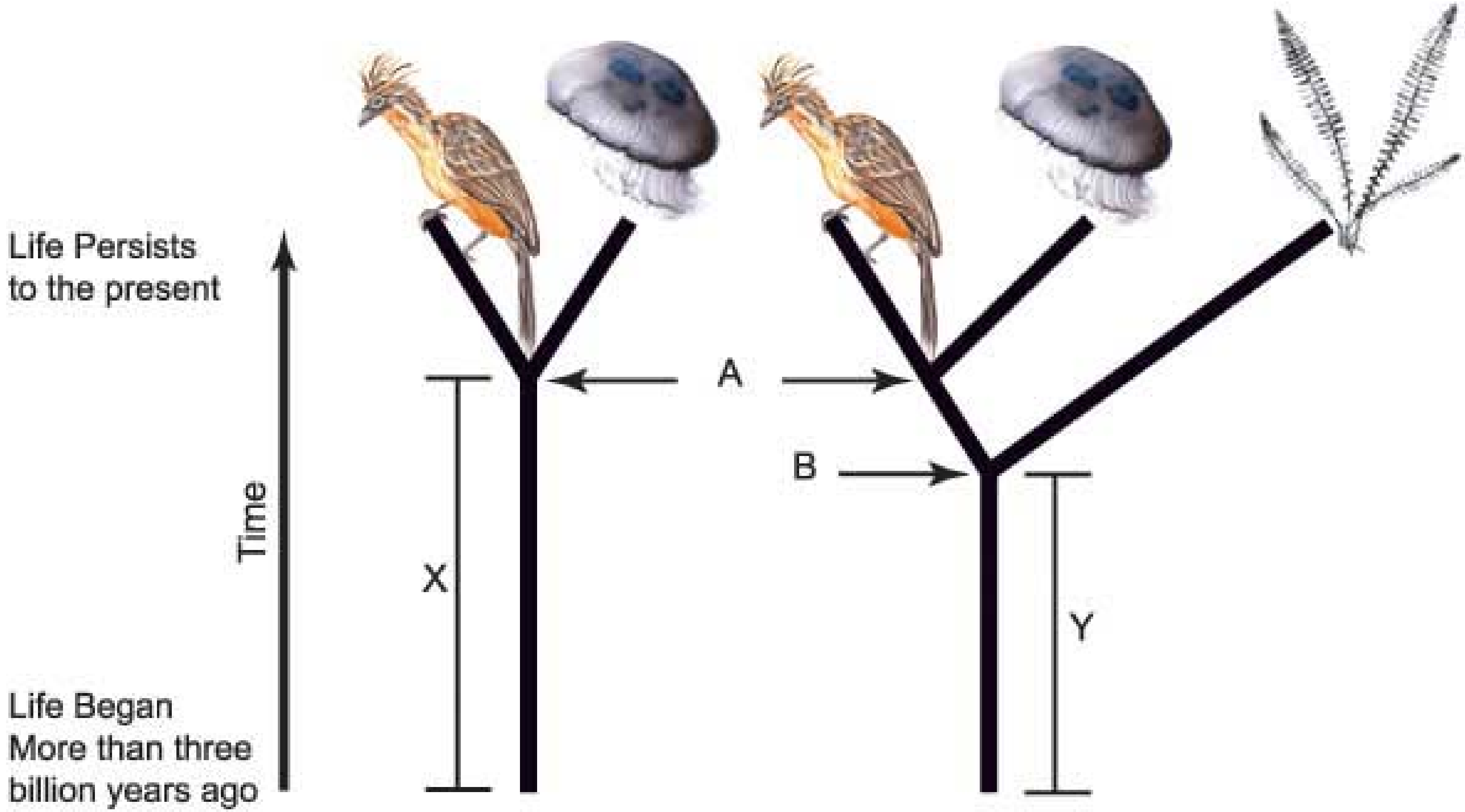


Figure 1. A. The most recent common ancestor of the bird and the jellyfish.
At this point, the two lineages diverged or split.
X. The portion of history that the bird and the jellyfish share.
Their lineages were one during this time.
B. The most recent common ancestor of the bird, jellyfish, and fern.
Y. The portion of history that the bird, jellyfish, and fern share.
The bird and jellyfish share a more recent common ancestor (A) than either does with the fern (B). Therefore, they are more closely related to each other than either is to the fern.

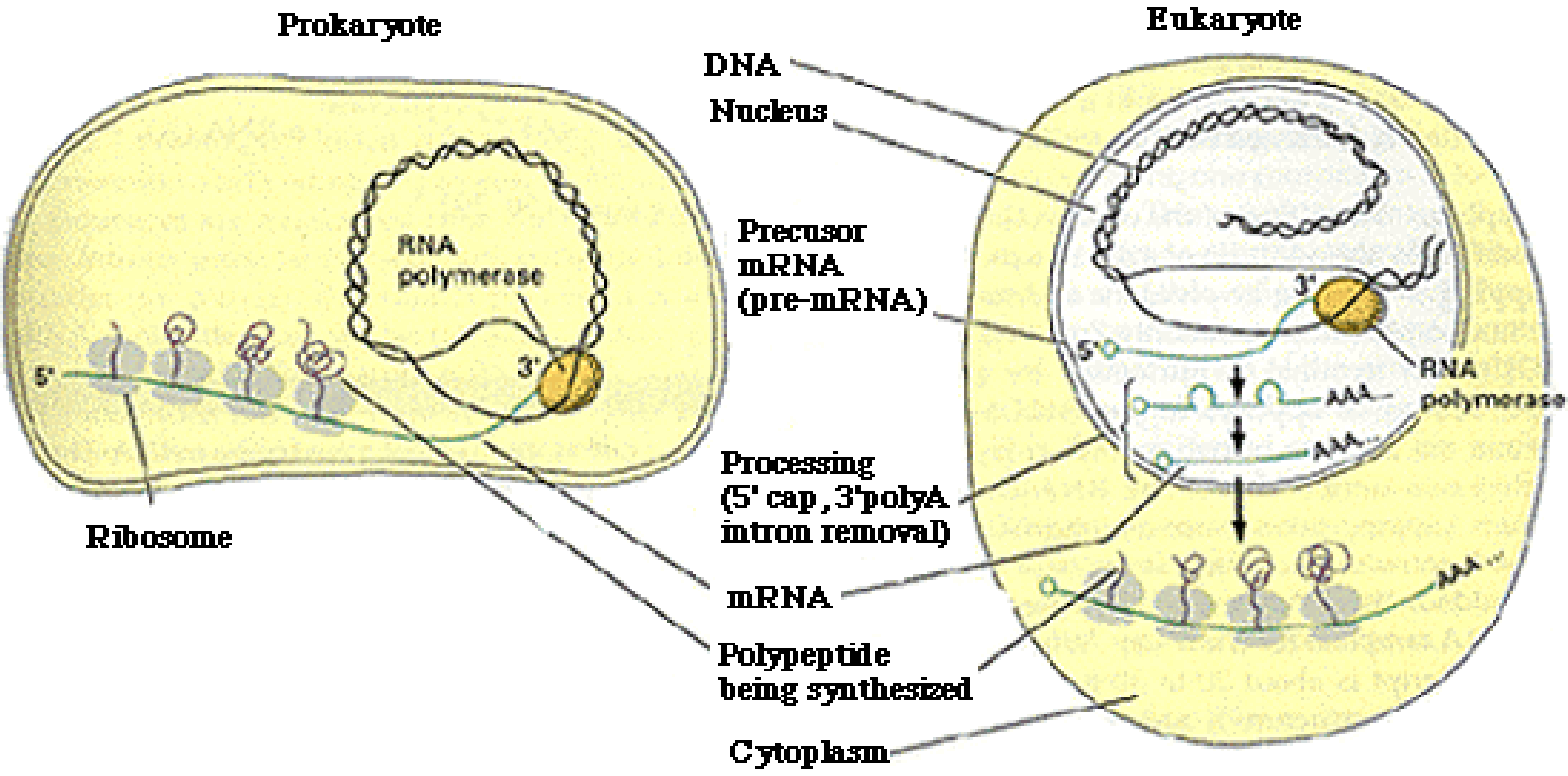
In the case of animals, Linnaean classifications often reflect our intuitive sense of similarity. Thus in the following classifications species 2 and 3 have more levels of classification in common than either has with species 1. This is a reflection of the greater similarity of the fly (*Drosophila melanogaster*) and the mosquito (*Aedes aegypti*), than of fly and lobster (*Homarus americanus*) or mosquito and lobster.

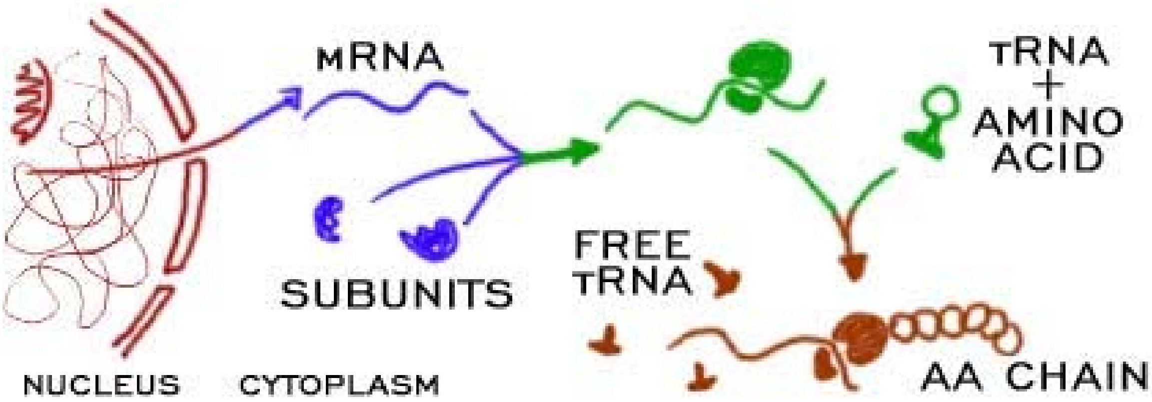
Classifications of Three Species			
Level	Species		
	1	2	3
Domain	Eucarya	Eucarya	Eucarya
Kingdom	Animalia	Animalia	Animalia
Phylum	Arthropoda	Arthropoda	Arthropoda
Class	Crustacea	Insecta	Insecta
Order	Decapoda	Diptera	Diptera
Family	Caridea	Drosophilidae	Nematocera
Genus	*Homarus*	*Drosophila*	*Aedes*
Species	*americanus*	*melanogaster*	*aegypti*

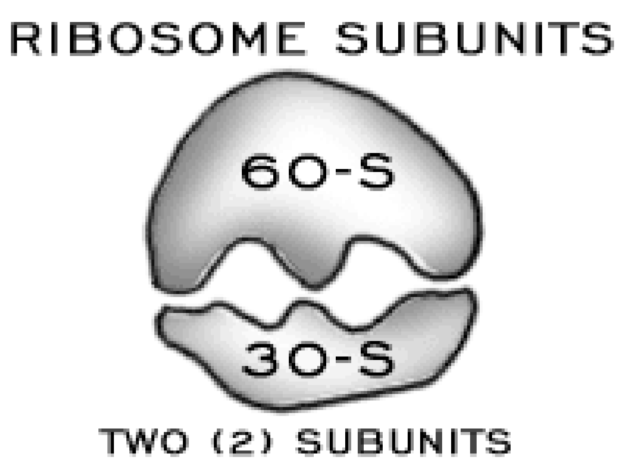
Universe (?)
World (?)
-Continent
-Country
-State/Province
-City
-Street
-Number
-Last Name
-First Name

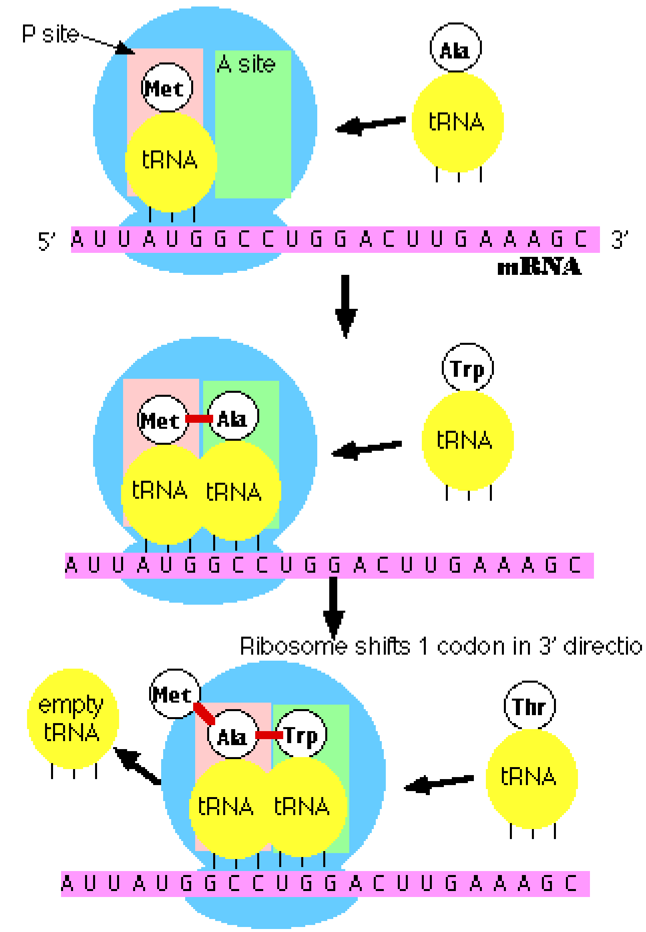
The shared levels of classification can be accentuated by slightly reformatting the data in the table.

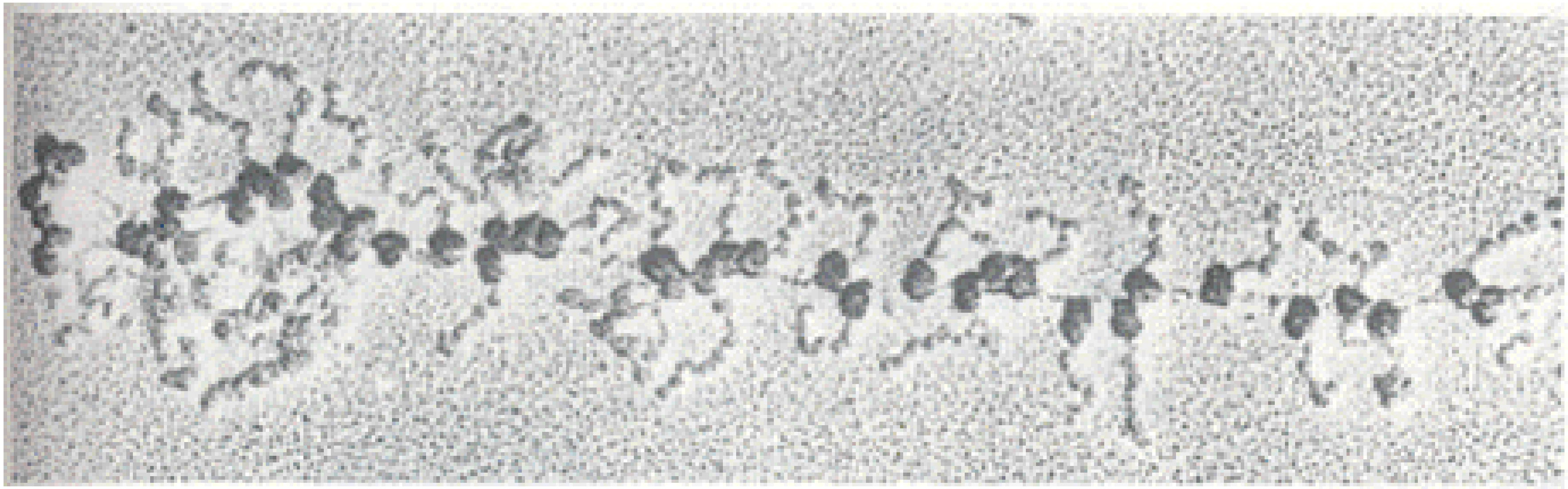
<table>
<tr><th colspan="4">Classifications of Three Species</th></tr>
<tr><th rowspan="2">Level</th><th colspan="3">Species</th></tr>
<tr><th>1</th><th>2</th><th>3</th></tr>
<tr><td rowspan="3">Domain
Kingdom
Phylum
Class
Order
Family
Genus
Species</td><td colspan="3">Eucarya
Animalia
Arthropoda</td></tr>
<tr><td rowspan="2">Crustacea
Decapoda
Caridea
Homarus
americanus</td><td colspan="2">Insecta
Diptera</td></tr>
<tr><td>Drosophilidae
Drosophila
melanogaster</td><td>Nematocera
Aedes
aegypti</td></tr>
</table>

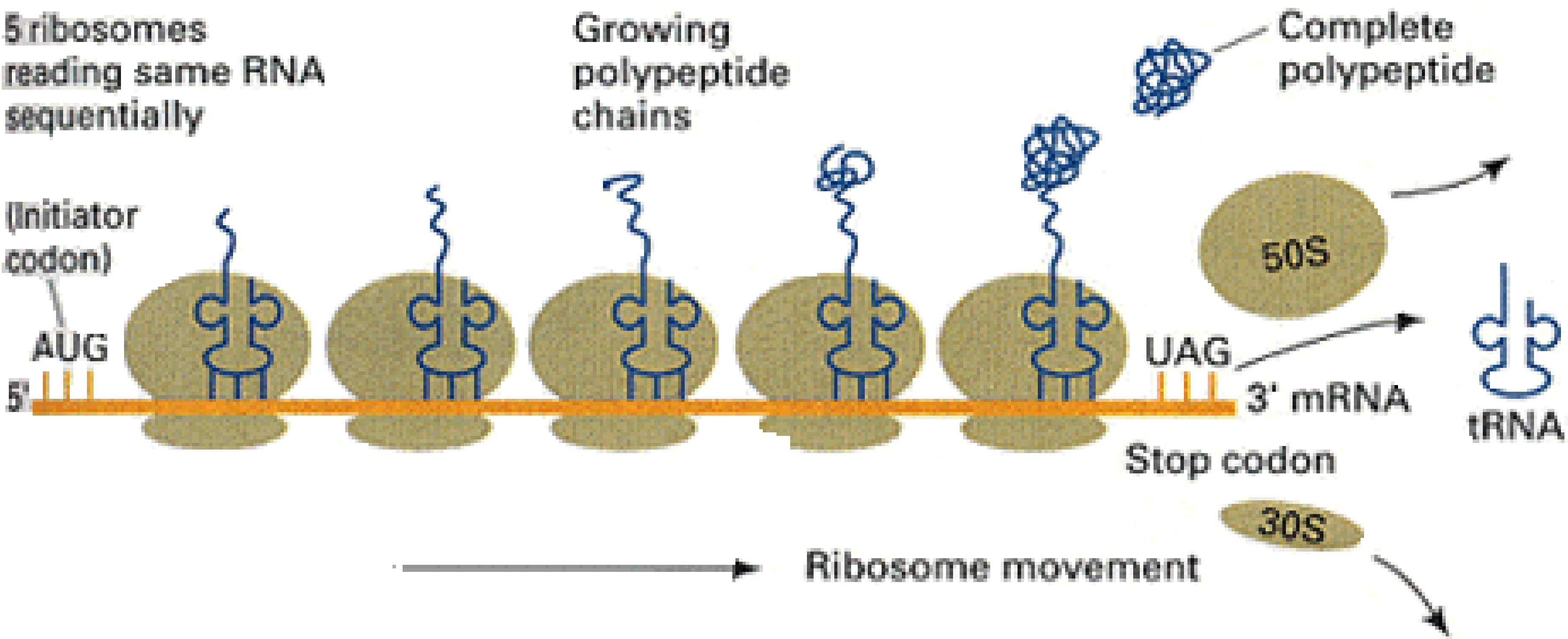

Prokaryote
Eukaryote
DNA
Nucleus
RNA polymerase
3'
5'
Precusor mRNA (pre-mRNA)
RNA polymerase
AAA
Processing (5' cap , 3'polyA intron removal)
Ribosome
mRNA
Polypeptide being synthesized
Cytoplasm


MRNA
TRNA + AMINO ACID
SUBUNITS
FREE TRNA
AA CHAIN
NUCLEUS
CYTOPLASM


RIBOSOME SUBUNITS
60-S
30-S
TWO (2) SUBUNITS


P site
A site
Met
Ala
tRNA
5′ A U U A U G G C C U G G A C U U G A A A G C 3′
mRNA
Trp
Ribosome shifts 1 codon in 3′ direction
empty tRNA
Thr




5 ribosomes reading same RNA sequentially
Growing polypeptide chains
Complete polypeptide
(Initiator codon)
AUG
5'
UAG
3' mRNA
Stop codon
50S
30S
tRNA
Ribosome movement

Ribosomal RNA Genes and Their Sequences

To infer relationships that span the diversity of known life, it is necessary to look at genes conserved through the billions of years of evolutionary divergence. An example of genes in this category are those that define the ribosomal RNAs (rRNAs). Most prokaryotes have three rRNAs, called the 5S, 16S and 23S rRNA.

Ribosomal RNAs in Prokaryotes

Name[a]	Size (nucleotides)	Location
5S	120	Large subunit of ribosome
16S	1500	Small subunit of ribosome
23S	2900	Large subunit of ribosome

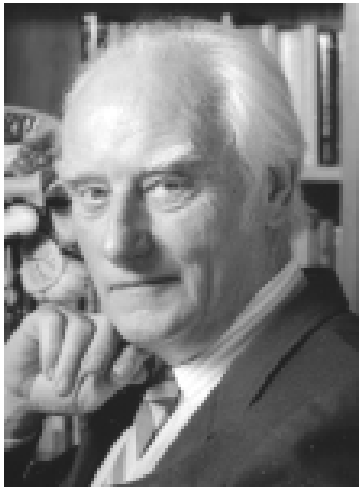
[a] The name is based on the rate that the molecule sediments (sinks) in water. Bigger molecules sediment faster than small ones.

The 5S has been extensively studied, but it is usually too small for reliable phylogenetic inference. The 16S and 23S rRNAs are sufficiently large to be quite useful.[18]

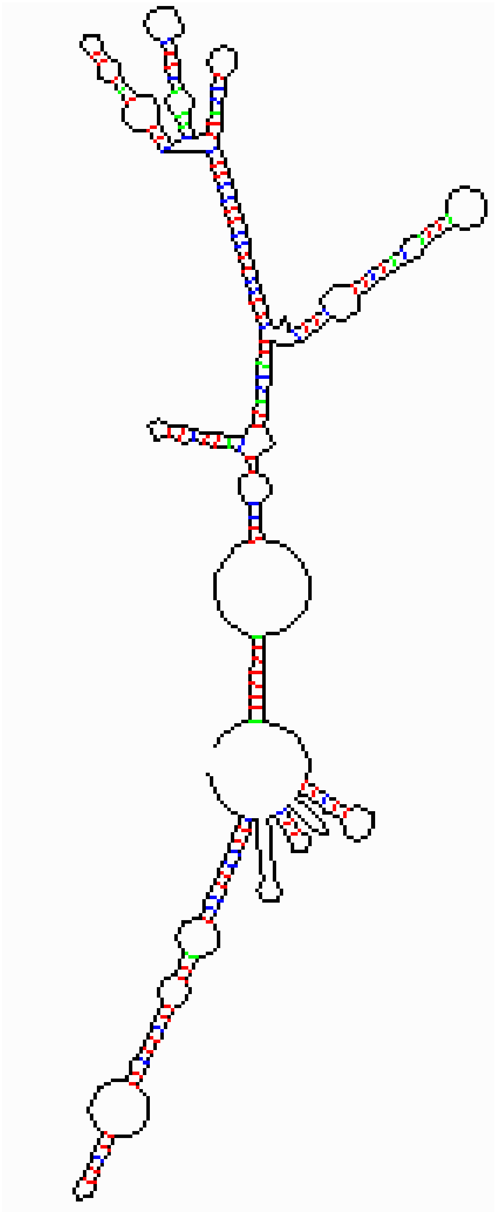
The extraordinary conservation of rRNA genes can be seen in these fragments of the small subunit rRNA gene sequences from organisms spanning the known diversity of life:

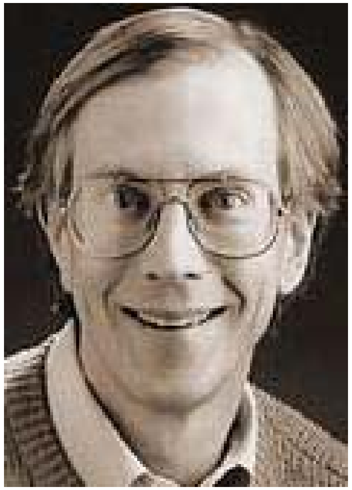
human	...GTGCCAGCAGCCGCGGTAATTCCAGCTCCAATAGCGTATATTAAAGTTGCTGCAGTTAAAAAG...
yeast	...GTGCCAGCAGCCGCGGTAATTCCAGCTCCAATAGCGTATATTAAAGTTGTTGCAGTTAAAAAG...
corn	...GTGCCAGCAGCCGCGGTAATTCCAGCTCCAATAGCGTATATTTAAGTTGTTGCAGTTAAAAAG...
Escherichia coli	...GTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCG...
Anacystis nidulans	...GTGCCAGCAGCCGCGGTAATACGGGAGAGGCAAGCGTTATCCGGAATTATTGGGCGTAAAGCG...
Thermotoga maratima	...GTGCCAGCAGCCGCGGTAATACGTAGGGGGCAAGCGTTACCCGGATTTACTGGGCGTAAAGGG...
Methanococcus vannielii	...GTGCCAGCAGCCGCGGTAATACCGACGGCCCGAGTGGTAGCCACTCTTATTGGGCCTAAAGCG...
Thermococcus celer	...GTGGCAGCCGCCGCGGTAATACCGGCGGCCCGAGTGGTGGCCGCTATTATTGGGCCTAAAGCG...
Sulfolobus sulfotaricus	...GTGTCAGCCGCCGCGGTAATACCAGCTCCGCGAGTGGTCGGGGTGATTACTGGGCCTAAAGCG...

The RNA World

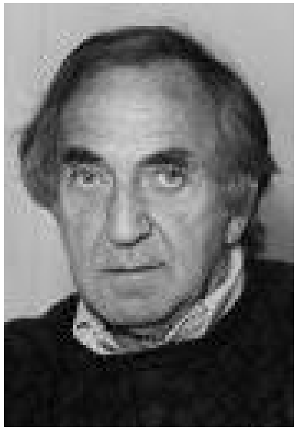


Francis Crick

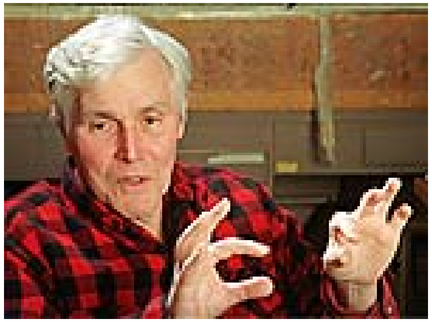




Thomas Cech

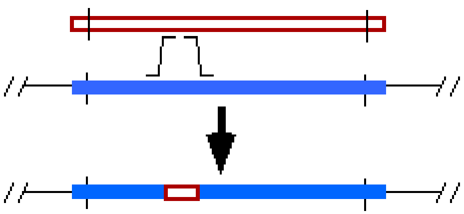


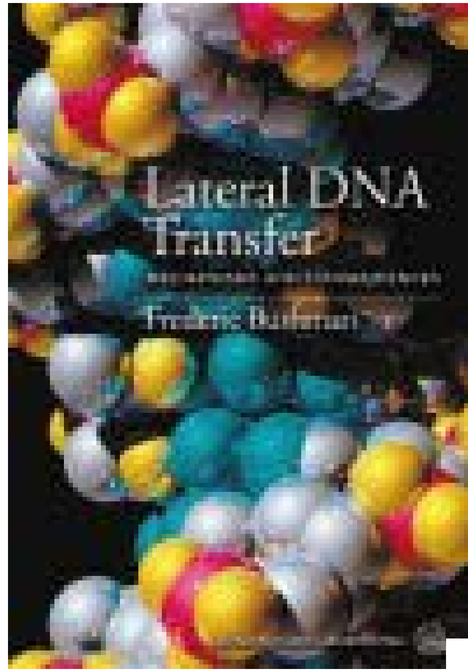
Leslie Orgel



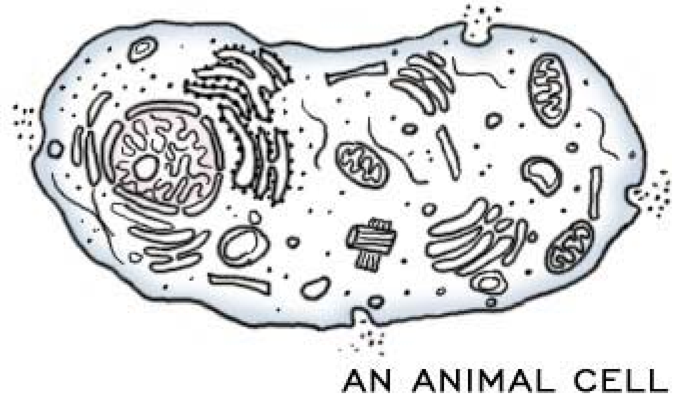
Carl Woese

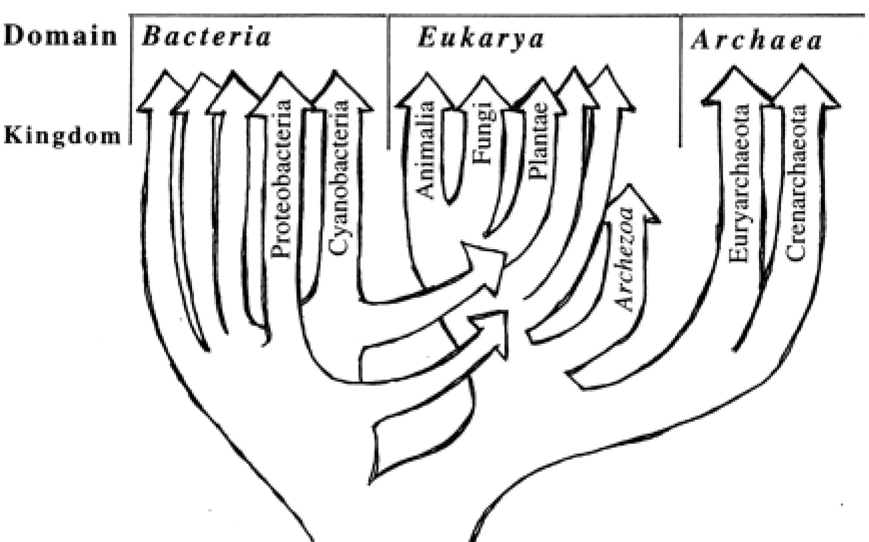
Horizontal Gene Transfer

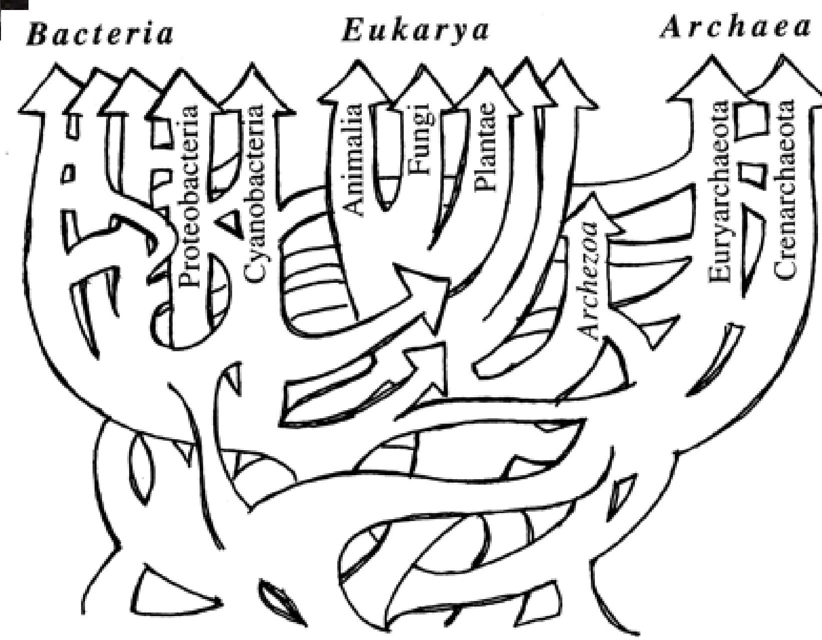




When did the cell arrive?







Horizontal Gene Transfer

Transformation - the uptake of naked DNA is a common mode of horizontal gene transfer that can mediate the exchange of any part of a chromosome; this process is most common in bacteria that are naturally transformable; typically only short DNA fragments are exchanged.

Conjugation - the transfer of DNA mediated by conjugal plasmids or conjugal transposons; requires cell to cell contact but can occur between distantly related bacteria or even bacteria and eukaryotic cells; can transfer long fragments of DNA.

Transduction - the transfer of DNA by phage requires that the donor and recipient share cell surface receptors for phage binding and thus is usually limited to closely related bacteria; the length of DNA transferred is limited by the size of the phage head

Examples of Gene Transfer by Bacterial Transformation in the Environment

Bacterial Host	Environmental situation	Genetic Marker	Reference
Pseudomonas stutzeri	Marine Water microcosm	Chromosomal *rif*	Stewert & Simigalliano, 1991
Pseudomonas sp.	Marine water and sediment	Plasmid multimers	Paul et al., 1991,1992
Acinetobacter calcoceticus	Ground water and soil extract	Chromosomal *trp*	Lorenz et al. 1991,1992
E.coli	River and spring water	Plasmid	Bauer et al., 1996

Examples of Gene Transfer by Bacterial Conjugation in the Environment

Donor	Recipient	Environment	Genetic Marker	Reference
E. coli	*Shigella flexneri*	Urinary tract?	Amp plasmid	Tauxe et al, 1989
Pseudomonas syringae	*P. syringae*	Pear leaves	Amp plasmid	Nijsten et al., 1995
Pseudomonas flourescens	*P. flourescens*	Wheat rhizosphere	Chromosomal genes	Troxler et al.,1997

The RNA World
http://www.panspermia.org/rnaworld.htm

The Ribosome Structure & Funftion
http://ntri.tamuk.edu/cell/ribosomes.html

Endoplasmic Reticulum: Structure & Function
http://www.cytochemistry.net/Cell-biology/rer1.htm

Gene Translation: RNA to Protein
http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/T/Translation.html#2._Elongation

Biology for Kids (not bad – a quick look at the cell)
http://www.biology4kids.com/files/cell_ribos.html

National Center for Biotechnology Information
http://www.ncbi.nlm.nih.gov/About/sitemap.html

Glossary for Phelogenetic Systematics
http://www.bechly.de/glossary.htm

Evolution - Systematics and Phylogeny
http://www.nearctica.com/evolve/taxonomy.htm

Classification and Phylogeny
http://www.bact.wisc.edu/Bact303/Phylogeny

Bacteriology
http://www.bact.wisc.edu/Bact303/Bact303mainpage

Phylogeny Programs
http://evolution.genetics.washington.edu/phylip/software.html#Alignment

Phylogeny of Life
http://www.ucmp.berkeley.edu/exhibit/phylogeny.html