

Microbiology as a Science and Its impact on Society

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Defining Science

Science

=

Scientia

=

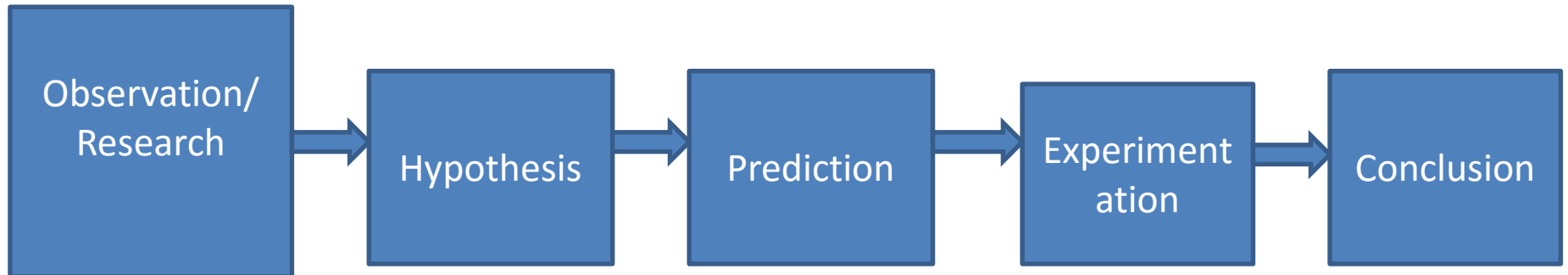
Knowledge

..But also

- Science is a system of acquiring new knowledge
- Involves observation and experimentation to explain natural phenomenon.
- It is the greatest story ever told that keeps unfolding every day with new facts about the Universe
- The story is told by employing “The Scientific method”

The Scientific Method...

- Used by scientists over time to organise their thoughts and design experiments



Defining Orthodoxy

- **or·tho·dox**
- adjective
 - 1. pertaining to, or conforming to the approved form of any doctrine, philosophy, ideology, etc.
 - 2. of, pertaining to, or conforming to beliefs, attitudes, or modes of conduct that are generally approved.
 - 3. customary or conventional, as a means or method; established.

How can Science Change Society?

A trivial question?

Science (knowledge) is the only that has ever
changed society



Microscope
The Germ Theory of Disease
The aeroplane
The Internet
The Antibiotic
The Theory of Evolution
The telephone

Charles Darwin

A Religious student turned Naturalist

Changed the way we view Biology

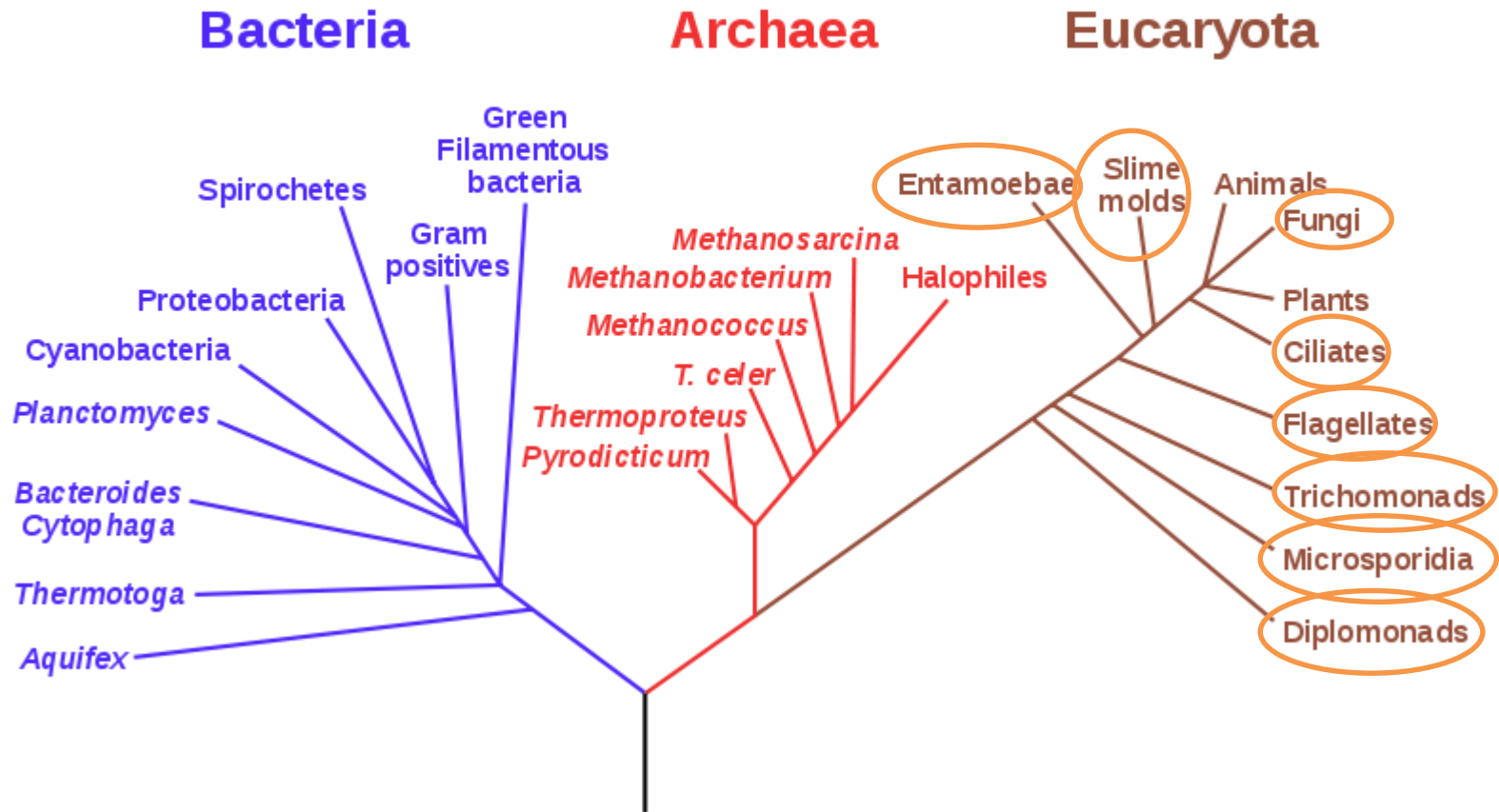
Challenged orthodoxy and shook the foundation of our belief system

Simple observations/experiments

Penned the “Origin of species by means of Natural Selection (1859)” after 30 years of painstaking research.

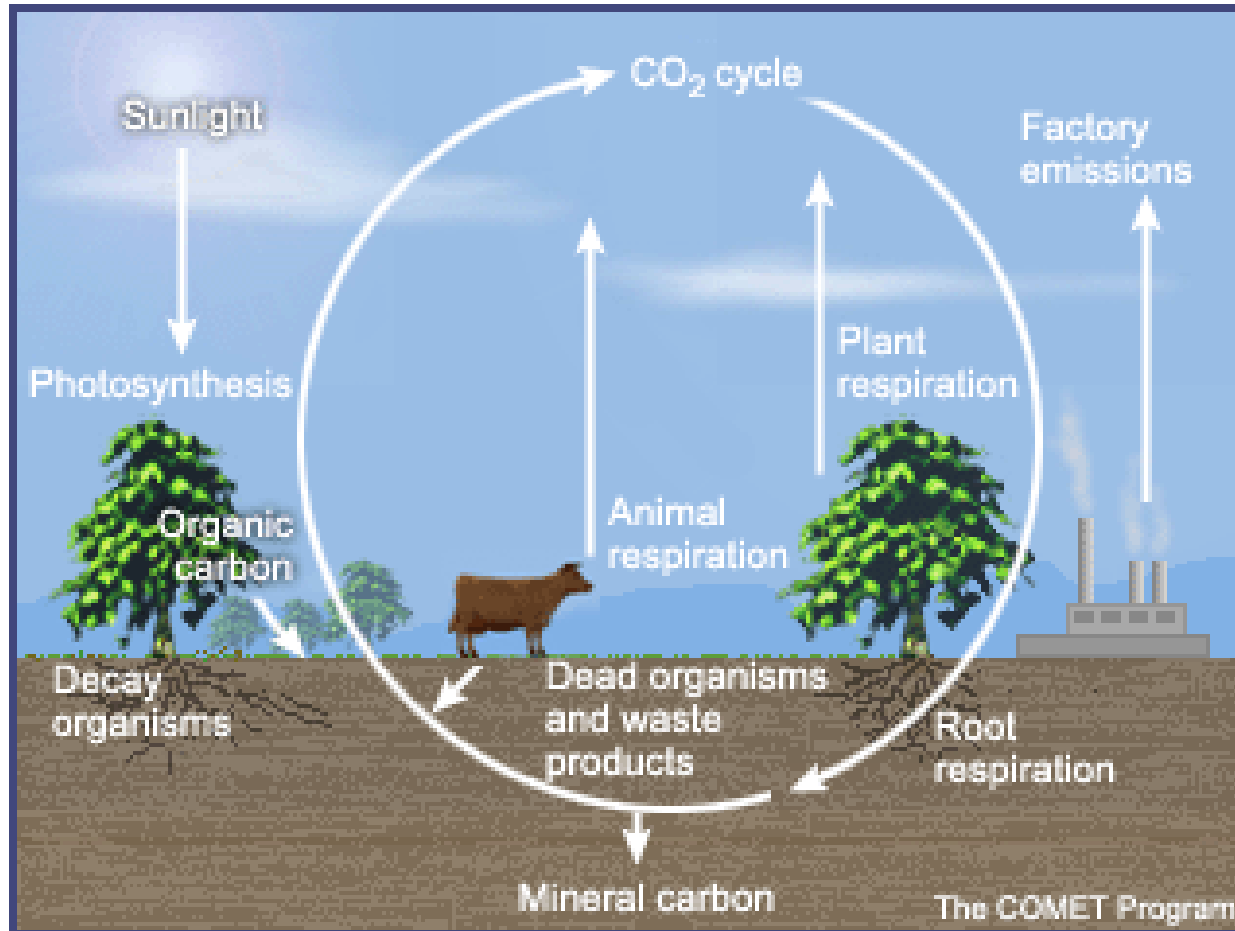
Changed Biology and the way scientists view life.

Phylogenetic Tree of Life



An overview of the Microbial world though molecular tools (16s r RNA genes)

Carbon Cycle



Unity of Biochemistry

- Sugars,
- Amino Acids,
- Proteins,
- Nucleic Acids (RNA and DNA)

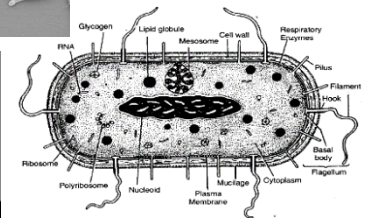
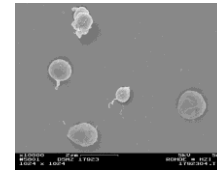
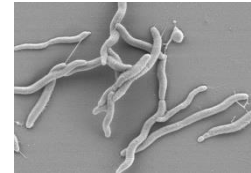
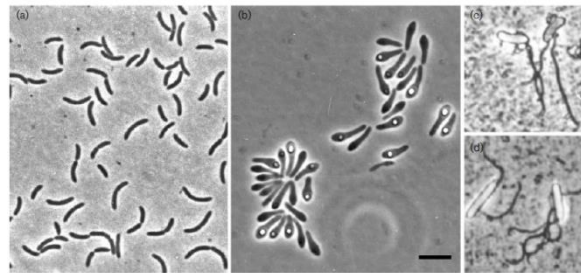
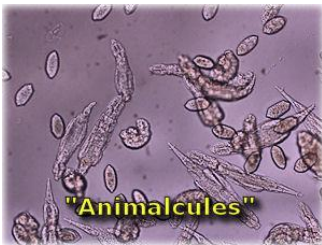
Biology

- Zoology
- Botany
- Microbiology
 - Mycology
 - Bacteriology
 - Virology

Microbial Ecology

- What is Microbiology?
 - Study of Microscopic Organisms mainly bacteria, archaea, fungi and viruses
- **Diversity** of Microorganisms in Ecosystems
- **Activities** of Microorganisms in the Ecosystems
- **Interaction** between microorganisms and other organisms and **their environment** (Immunology, Ecology, Medicine)
- **Microbial Structure + Function** in Ecosystems

Antonie von Leewenhoek (1652)- Seeing the Invincible Life forms



Light

Electron

X 200

X 1250

X1000,000

Magnification

In his own words

“ . . my work, which I've done for a long time, was not pursued in order to gain the praise I now enjoy, but chiefly from a craving after knowledge, which I notice resides in me more than in most other men.”.

Antony van Leeuwenhoek. Letter of June 12, 1716

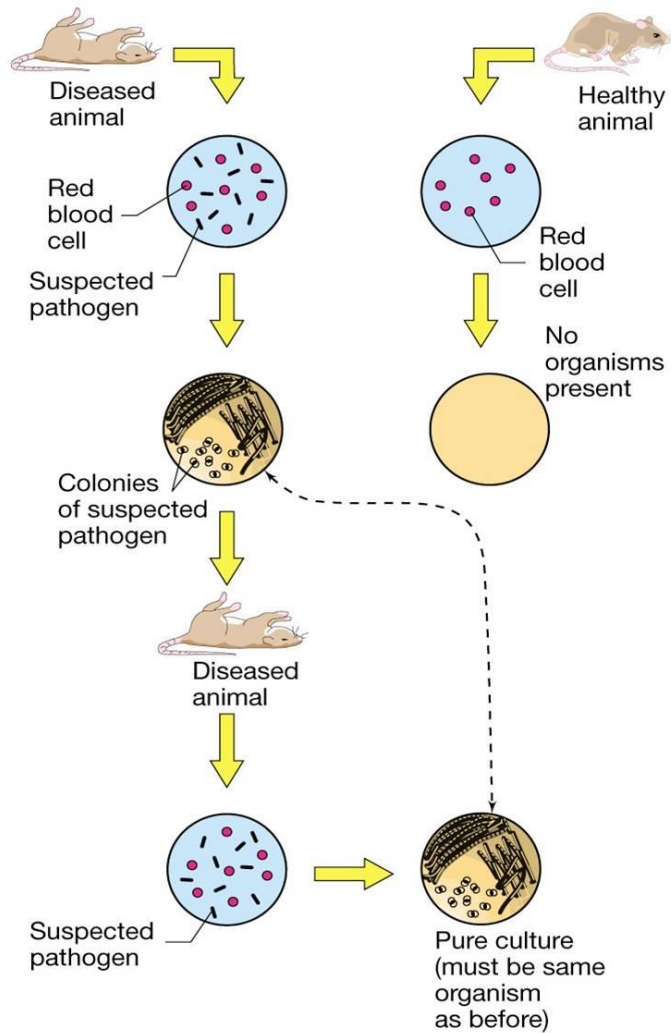
Germ Theory of Disease

-Robert Koch

2. Koch's Postulates

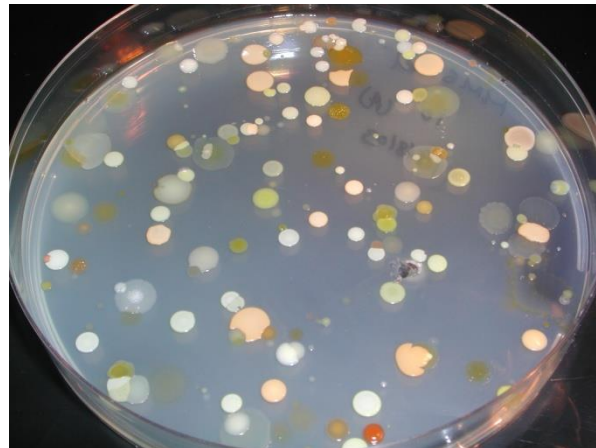
- a. The causative (etiologic) agent is isolated from a sick individual. This agent is absent in healthy individuals.
- b. The agent is cultured, grown outside the host.
- c. When the cultured etiologic agent is introduced into a healthy individual, it becomes sick.
- d. The etiologic agent is cultured from the experimental sick organism.

Robert Koch's experiment



Growing Bacteria

- Slices of Potato ==> Bacterial Media (Agar)



Playing Around with Conditions

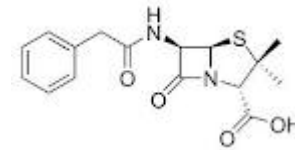
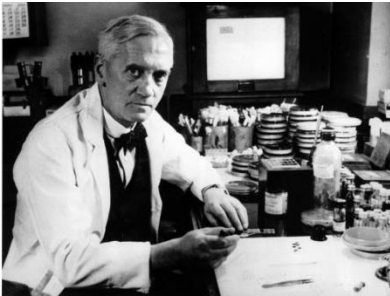
Temperature

Aerobic (air) /Anaerobic (no Air)

Effect of various chemicals on grown

Discovery and Innovation

Alexander Fleming: Bugs that kill bugs

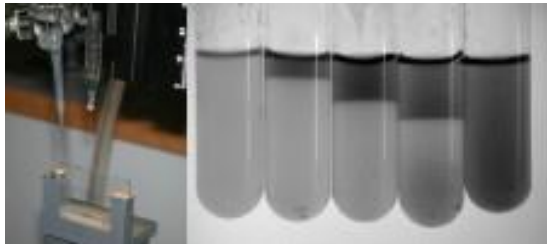
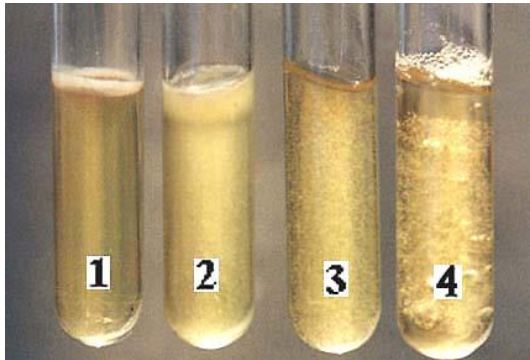


Penicillin

Biology

Chemistry

Bacterial Cancer Therapy



Tumors

- Abnormal growth/swelling of tissue
- No air.
- Lack a good supply of blood
- Maybe Benign or Malignant (cancerous)
- Conventional cancer drugs unable to reach the central parts of the tumor

Treatment

Surgery, Chemotherapy, radiotherapy

Clostridium novyi

- Anaerobic, forms spores, non-pathogenic
- Close relatives are: *Clostridium botulinum* and *Clostridium perfringens* which produce some of the most potent toxins on earth
- Used in Tumor therapy
- Consume (dissolve the interior anoxigenated part of the tumor) then killed by oxygen.
- Conventional drugs then kill the rest of the tumor (cells in the oxygenated part)

Bacterial Communication?

- Recognition-Through signalling
- Bacteria engage in Sexual Interaction
- Bacteria share innovations and Technology
 - The spread of antibiotic Resistance
- Bacteria engage in “quorum sensing”
 - i.e. Do we have a quorum?
 - Through chemical communication?

The Kenya Microbiome Project

- Study of **Microorganisms** in various **biotopes**
- Emphasis on **Soda Lakes, Magadi, Elmenteita, Nakuru, Bogoria**
- Some studies on Soils focusing on **Legume nodulating bacteria (LNB)** and **Mycorrhizal fungi**
- Studies on Microbial diversity of **termites**
- Isolation of **Entomopathogenic** fungi and bacteria

Diverse Ecosystems in Kenya

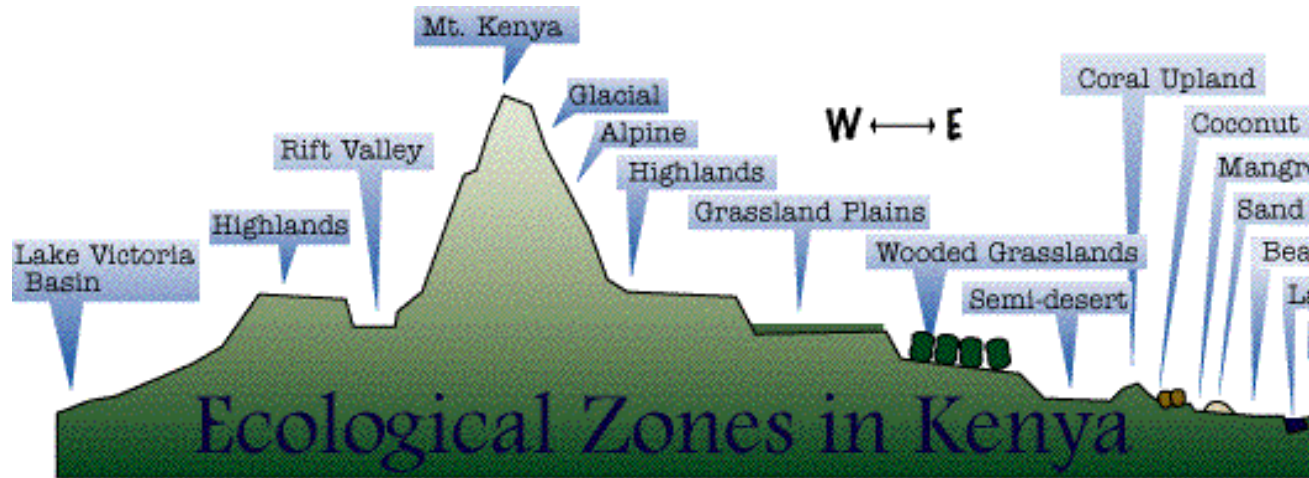
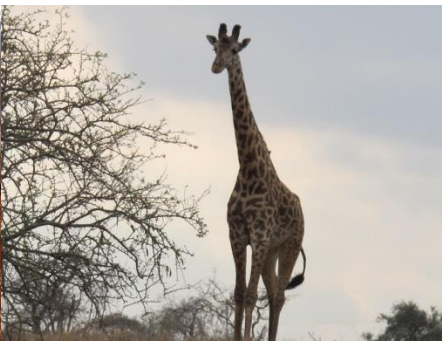


Figure 1: Sectional representation of ecological zones in Kenya (Source: <http://www.geointeractive.co.uk>)



The Initial Soda Lakes Work

INTERNATIONAL JOURNAL OF SYSTEMATIC BACTERIOLOGY, July 1993, p. 401–404
0020-7713/93/030401-04\$02.00/0
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Natronobacterium vacuolata sp. nov., a Haloalkaliphilic Archaeon Isolated from Lake Magadi, Kenya

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A novel haloalkaliphilic archaeon was isolated from Lake Magadi, a Kenyan alkaline soda lake. Cells of the organism contain large gas vacuoles in the stationary phase of growth, and colonies produced by these archaea are bright pink in appearance. The major polar lipids of these organisms are C₂₀C₂₀ and C₂₀C₂₅ derivatives of phosphatidylglycerol phosphate and phosphatidylglycerol, and the organisms contain an unidentified phospholipid as a minor component. The G+C content of the DNA is 62.7 mol%. The name *Natronobacterium vacuolata* sp. nov. is proposed. The type strain is designated NCIMB 13189.

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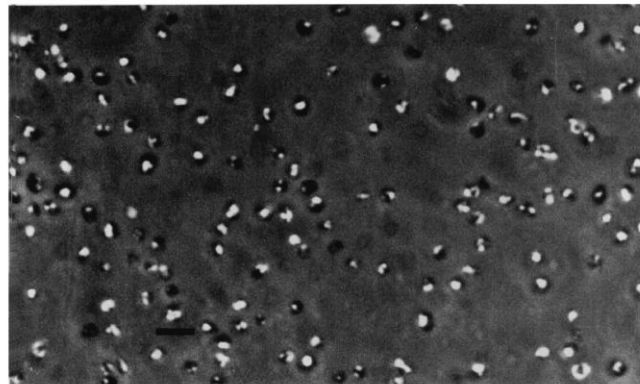
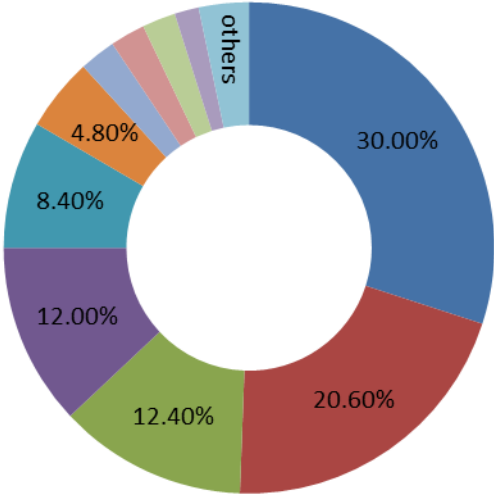
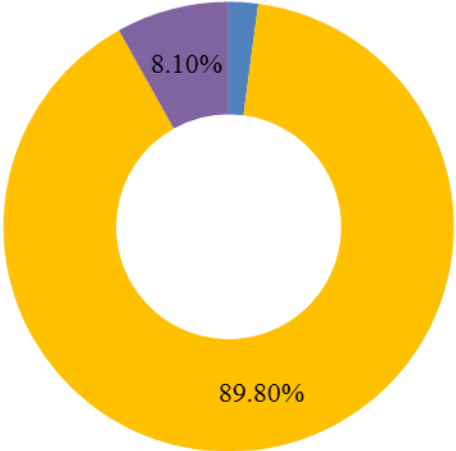


FIG. 1. Cells of strain M24 after 7 days at 37°C in the medium of Tindall et al. (14). This image was obtained with phase-contrast optics. Bar, 10 µm.

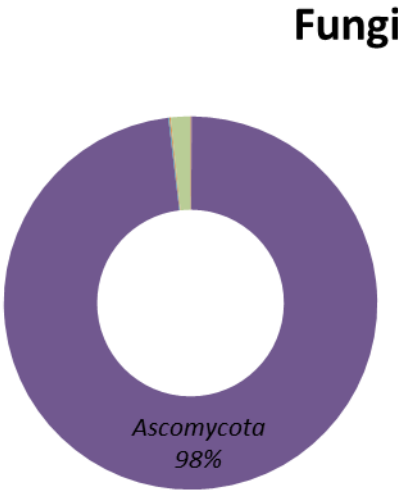
Microbial Diversity of Soda Lakes



- Bacteria**
- Proteobacteria
 - Cyanobacteria
 - Firmicutes
 - Bacteroidetes
 - Actinobacteria
 - Gemmatimonadetes
 - Chlorobi
 - Acidobacteria
 - Chloroflexi
 - Deinococcus-Thermus
 - others



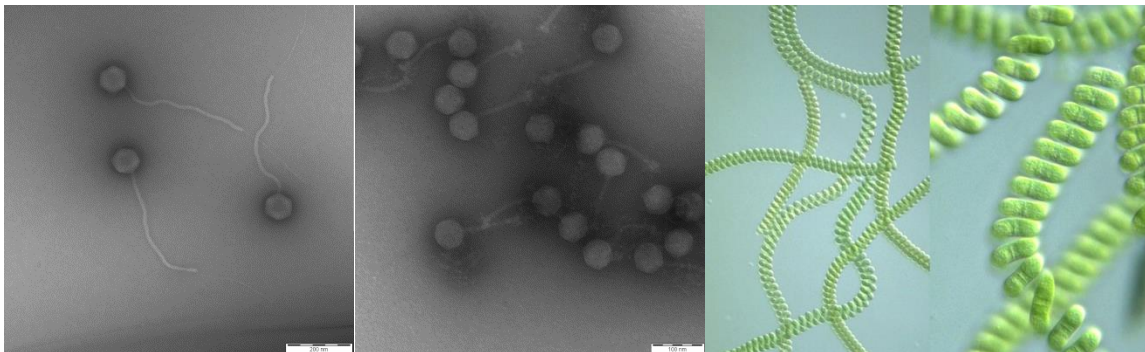
- Archaea**
- Crenarchaeota
 - Euryarchaeota
 - Korarchaeota
 - Thaumarchaeota



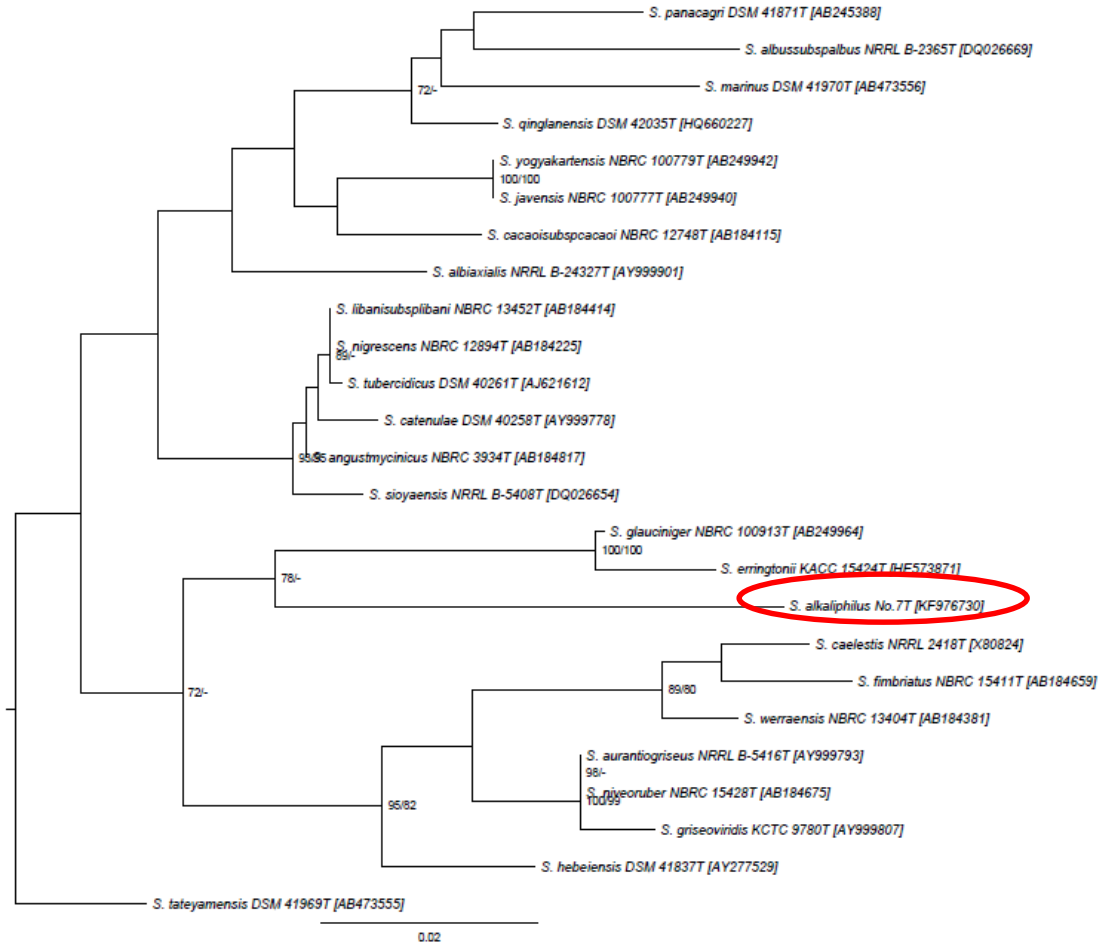
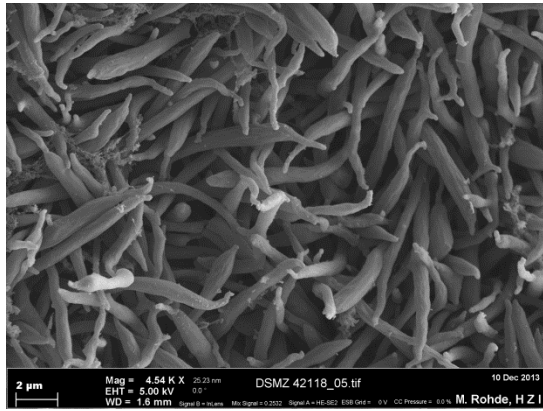
- Fungi**
- Blastocladiomycetes
 - Chytridiomycetes
 - environmental samples
 - Ascomycota
 - Basidiomycota
 - environmental samples
 - Fungi incertae sedis
 - Glomeromycetes
 - environmental samples

Other organisms

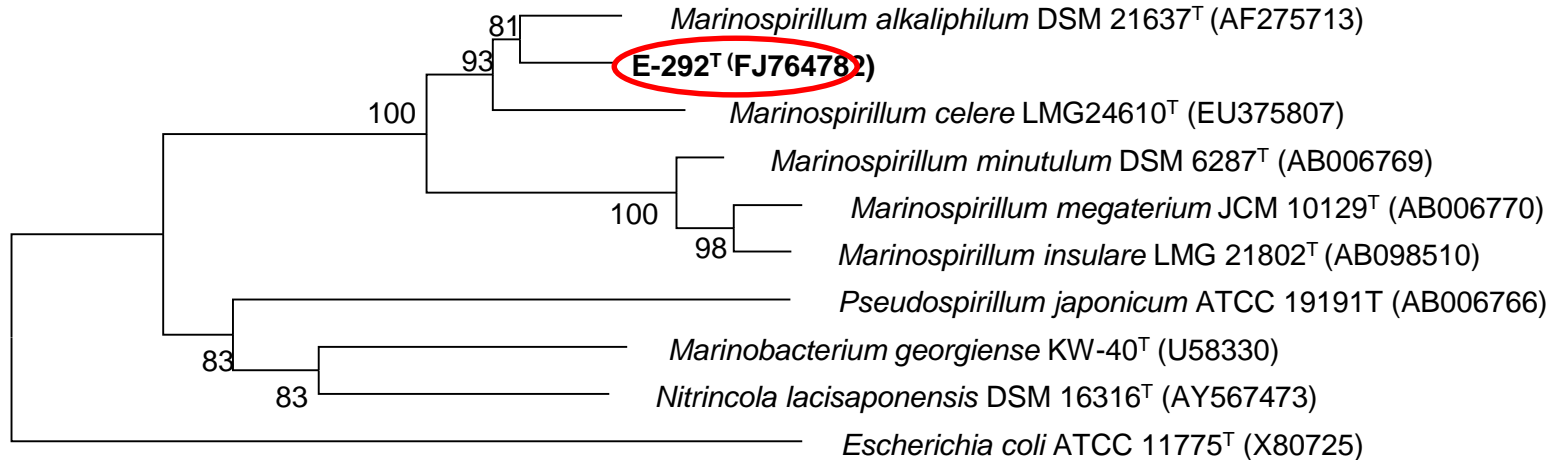
- Bacteriophages/Viruses
- Protists
- Algae
- Macrofauna
 - Birds (Flamingos etc)



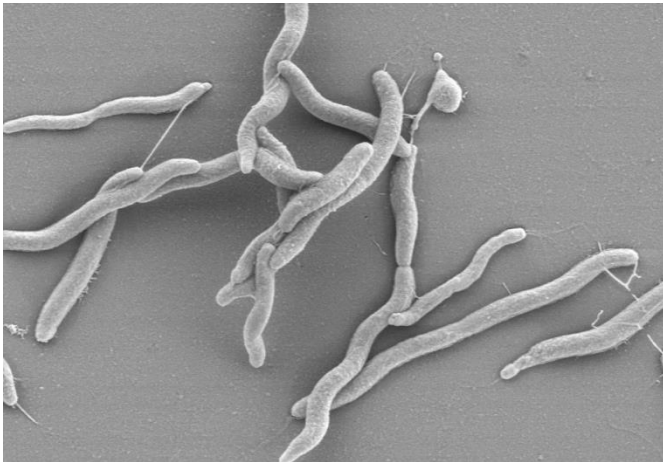
Novel Organisms



Marinospirillum related species



0.02



Marinospirillum alkaliphilum is the closest relative as per BLAST analysis at 97% similarity.

Relevance

- Understanding the function of the unique but unstable ecosystem which support biodiversity
- The **Flamingo's** cyclical lifestyle (here today-gone tomorrow)-the role of *Arthrospira platensis*
- *Application of Microbes in Industry (detergents, extremozymes etc)*

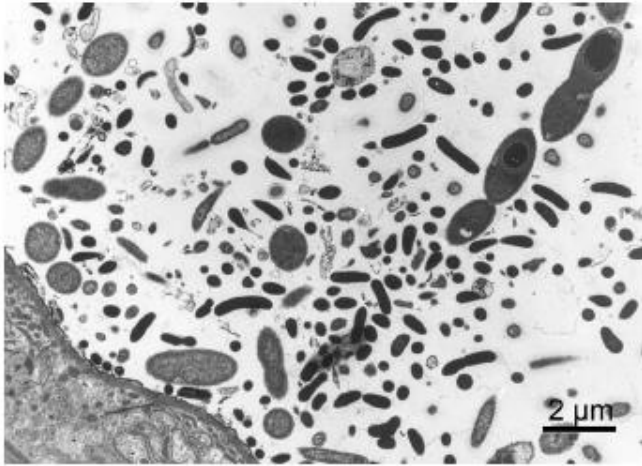
Termites



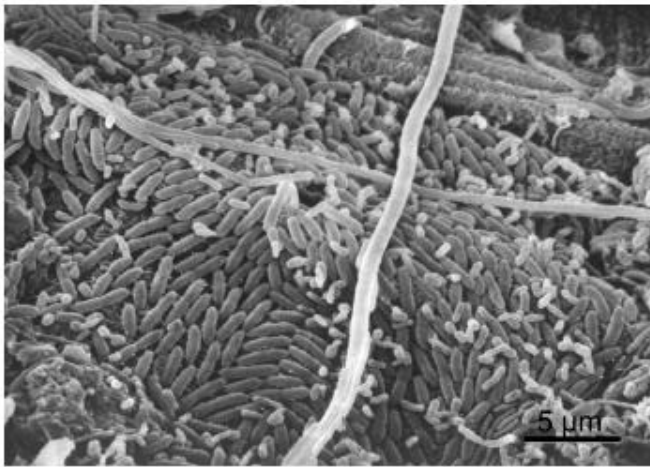
1. Queen
 2. King
 3. Soldiers Major
 Minor
- Workers: Major
 Minor



Termite gut microorganisms



(a) Transversal section through the peripheral hindgut, showing the diverse bacterial microbiota associated with the thin cuticle of the hindgut wall (bottom left). Transmission electron micrograph provided by J.A. Breznak.



(b) Preparation of the hindgut wall, showing the dense colonization of the cuticle by numerous rod-shaped and filamentous bacterial morphotypes. Scanning electron micrograph provided by J.A. Breznak.

Classification of Termites

Order Isoptera: 7 families

Lower Termites (Pearce, 1997

Family Mastotermitidae
Family Kalotermitidae
Family Hodotermitidae
Family Rhinotermitidae
Family Termosidae
Family Serritermitidae

} wood feeders

Higher Termites

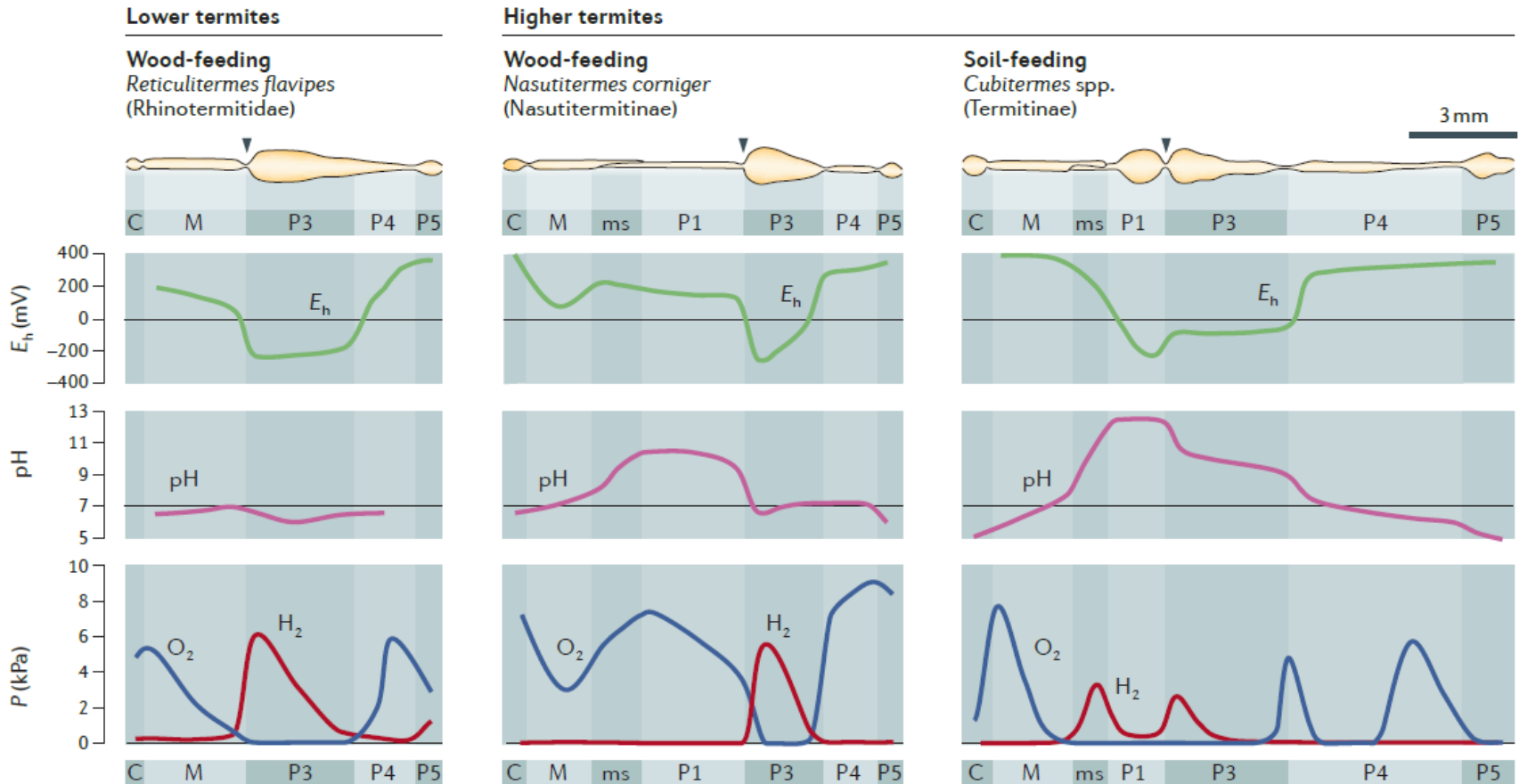
Family Termitidae

Subfamily Termitinae
Subfamily Apicotermitinae
Subfamily Nasutitermitinae

} Soil and wood feeders

Subfamily Macrotermitinae (Fungus-growing termites)

Of Termites ...and food

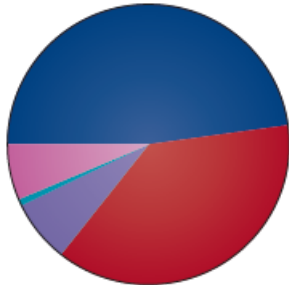


Brune A. 2014

Food determines...gut diversity

a Cockroaches

Shelfordella lateralis



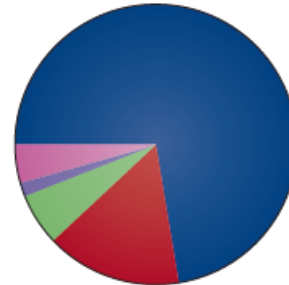
Omnivorous

b Lower termites

Reticulitermes speratus



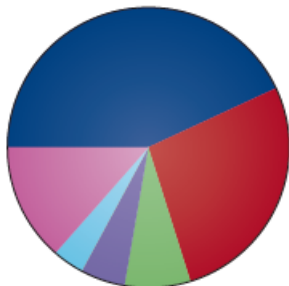
Coptotermes formosanus



Wood-feeding

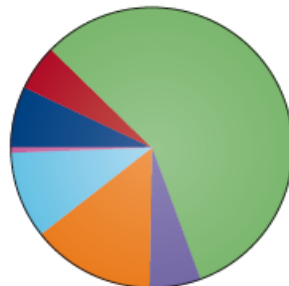
c Higher termites

Macrotermes gilvus



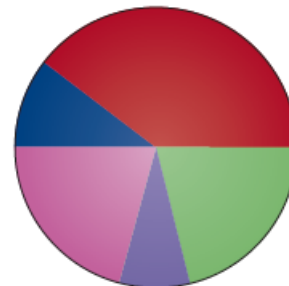
Fungus-feeding

Nasutitermes takasagoensis



Wood-feeding

Termes comis



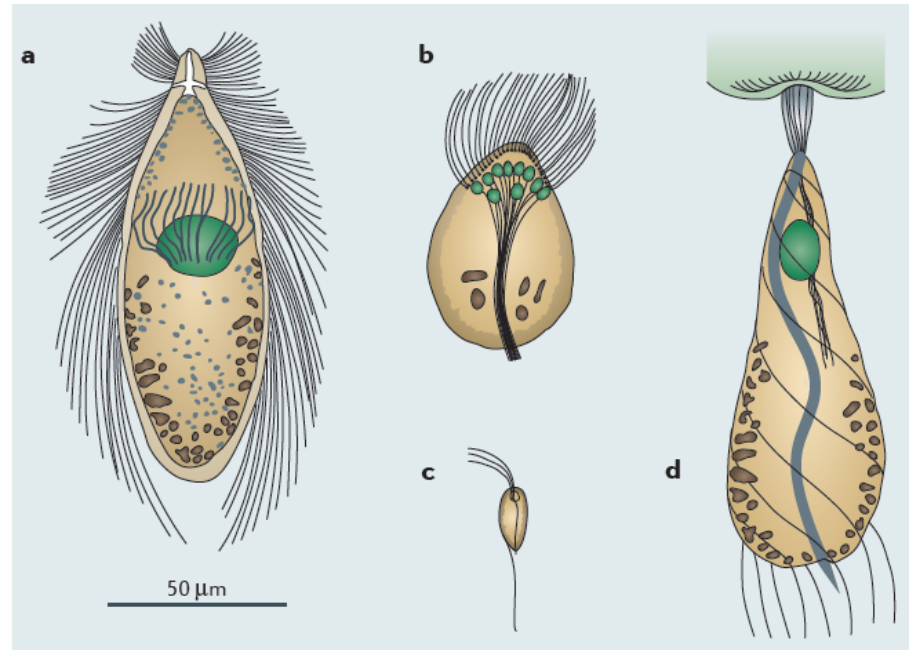
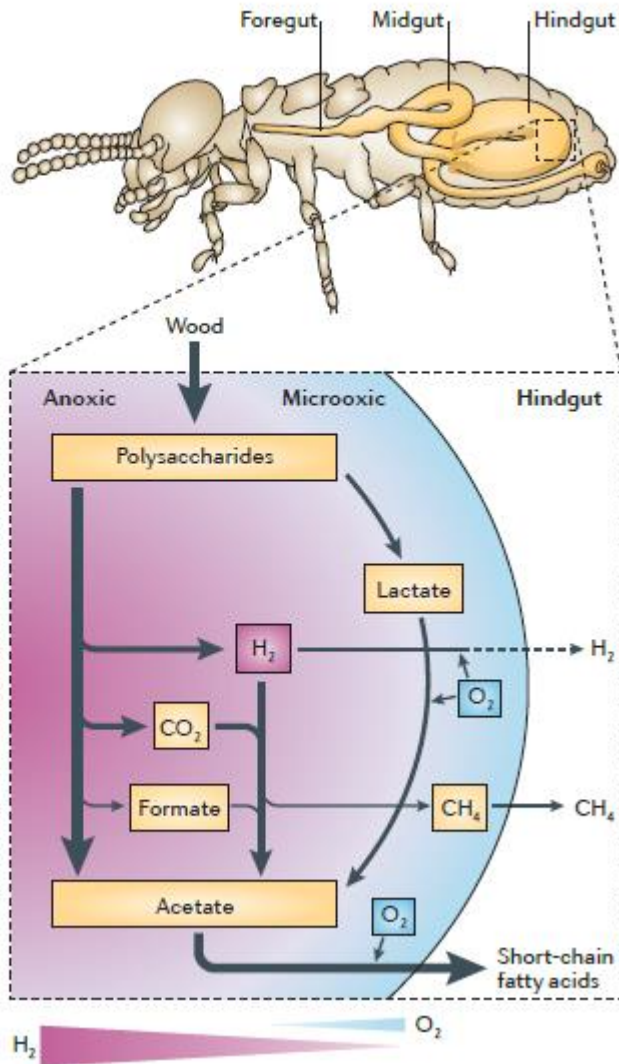
Humus-feeding



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2014

Termite guts as Bioreactors

Brune 2014



Flagellates from wood-feeding Termites

Potential Sources of Energy from Termites

- Conversion of Cellulose/Lignin into
 - Formate
 - Acetate
 - Methane
 - Hydrogen
 - Ethanol

Complexity of Termite Gut Ecosystems

- Diversity of Termites
- Diversity of Food Sources
- Diversity of Microbes and Microbial Enzymes and Processes
- Cooperation between organisms
- Oxygen/Redox Potential dynamics
- Can the Microbes function outside their ecosystem?

Good Science

- Driven by

curiosity..

Ideas,

Funds

and

a good supply of young enthusiastic minds who have no idea what is not possible? So they keep trying.

Ideas are the source of science's power—not discoveries.”

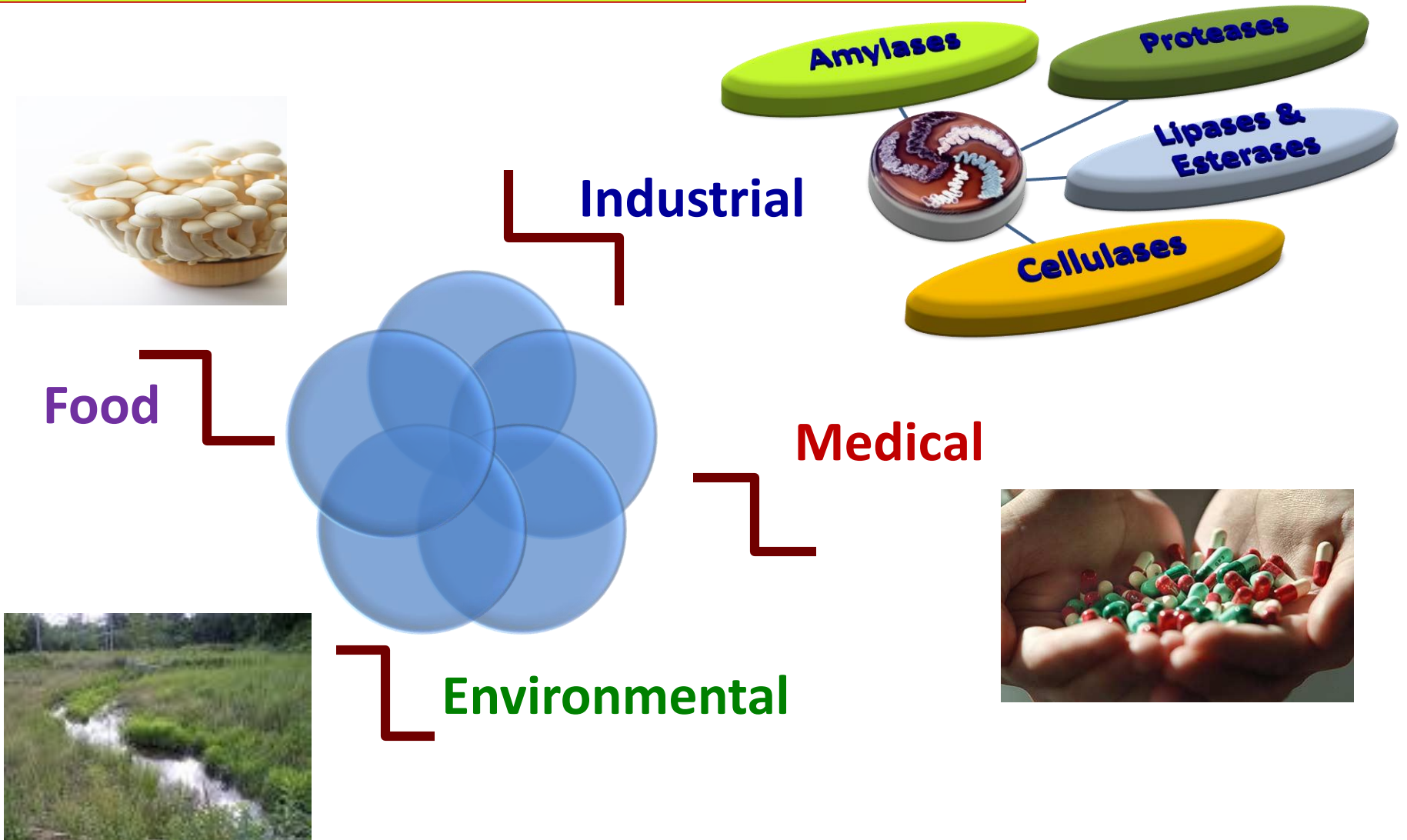
“The idea of science itself is an idea that had to be invented.”

Prof. Steven L. Goldman

Conclusion

- Africa is a **Biodiversity Hotspot**
- Great opportunity for research in Biodiversity
- Do not forget the Microbes...earth cannot sustain itself without them
- Novel organisms reveal novel pathways and processes.
- There exists many opportunities for exploitation of microbes in industry
- Great opportunity in Africa to study Microbiomes

Commercial value of Microbes



The Ball is in your court

Do not be afraid to think outside the Box

Play your part in telling this story

Work smart-The scientific method.

Let the story continue to be told..by generation
after generation of Scientists.