



# Chem 452 - Lecture 1

## Introduction to Biochemistry

### Part 1

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**Question for the Day:** Biochemistry is the study of the chemistry of life processes. From the biology courses you have taken, you no doubt have learned that biological systems are quite diverse, from the extremely small, single cell prokaryotes, such as bacteria, to very large multicellular eukaryotes, such as the blue whale. There is no way that we can, in one semester, study the biochemistry of all organisms. Therefore, on day one (today) we will need to discuss which organisms we wish to focus on this semester. Any ideas...?

# What is "Biochemistry"

## Biochemistry

From Wikipedia, the free encyclopedia

*For the journal, see [Biochemistry \(journal\)](#).*

*"[Biological Chemistry](#)" redirects here. For the journal formerly named [Biological Chemistry Hoppe-Seyler](#), see [Biological Chemistry \(journal\)](#).*



This article **needs additional citations for verification**. Please help [improve this article](#) by adding [reliable references](#). Unsourced material may be [challenged](#) and [removed](#). *(June 2011)*

**Biochemistry**, sometimes called **biological chemistry**, is the study of [chemical](#) processes in living [organisms](#), including, but not limited to, living matter. Biochemistry governs all living organisms and living processes. By controlling information flow through biochemical signalling and the flow of chemical energy through [metabolism](#), biochemical processes give rise to the incredible complexity of life. Much of biochemistry deals with the structures and functions of cellular components such as [proteins](#), [carbohydrates](#), [lipids](#), [nucleic acids](#) and other [biomolecules](#) although increasingly processes rather than individual molecules are the main focus. Over the last 40 years biochemistry has become so successful at explaining living processes that now almost all areas of the [life sciences](#) from [botany](#) to [medicine](#) are engaged in biochemical research. Today the main focus of pure biochemistry is in understanding how biological molecules give rise to the processes that occur within living [cells](#) which in turn relates greatly to the study and understanding of whole organisms.

Among the vast number of different biomolecules, many are complex and large molecules (called [biopolymers](#)), which are composed of similar repeating subunits (called [monomers](#)). Each class of polymeric biomolecule has a different set of subunit types.<sup>[1]</sup> For example, a [protein](#) is a polymer whose subunits are selected from a set of 20 or more [amino acids](#). Biochemistry studies the chemical properties of important biological molecules, like proteins, and in particular the chemistry of [enzyme-catalyzed reactions](#).

The biochemistry of [cell metabolism](#) and the [endocrine system](#) has been extensively described. Other areas of biochemistry include the [genetic code](#) ([DNA](#), [RNA](#)), [protein synthesis](#), [cell membrane transport](#), and [signal transduction](#).

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# What is "Biochemistry"

- ✦ If biochemistry is the study of the chemical process in living systems, what are some examples of **living systems**?



# Biology is Varied and Complex



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# What is "Biochemistry"

- ✦ How can we possibly study all of these living systems?



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| <b>BACTERIA</b>    |                   |                 | <b>EUKARYA</b> | <b>ARCHAEA</b>       |            |                      |                      |                      |
|--------------------|-------------------|-----------------|----------------|----------------------|------------|----------------------|----------------------|----------------------|
| <i>Escherichia</i> | <i>Salmonella</i> | <i>Bacillus</i> | <i>Homo</i>    | <i>Saccharomyces</i> | <i>Zea</i> | <i>Methanococcus</i> | <i>Archaeoglobus</i> | <i>Halobacterium</i> |

# What is "Biochemistry"

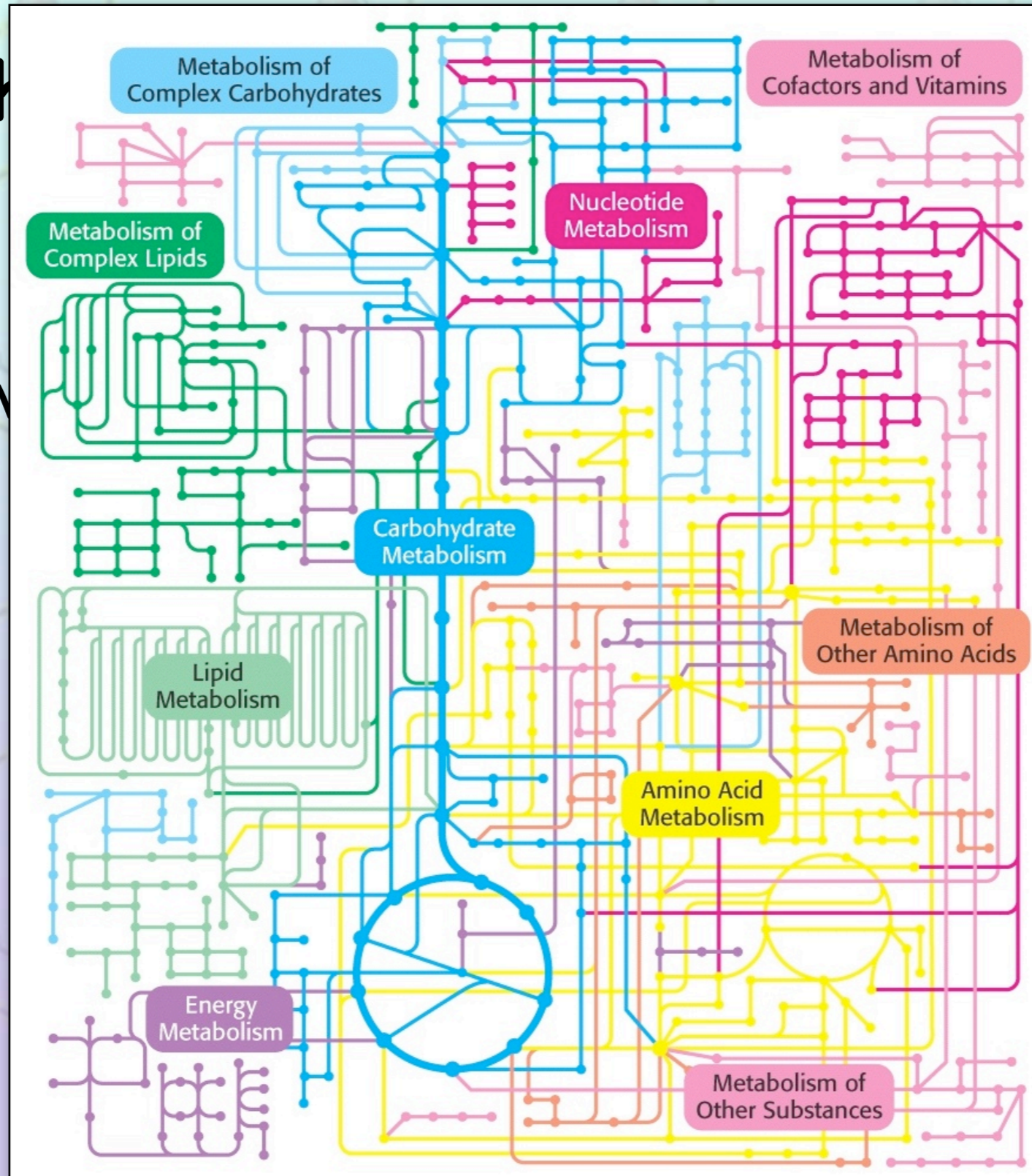
- ✦ How can we possibly study all of these living systems?

# Biology is Varied and Complex

- ✦ At the molecular level, living systems look remarkably similar.
- ✦ This similarity is a reflection of how life evolved on earth

# Biology is Varied and Complex

- ◆ At the molecular level
- ◆ This evolves over time

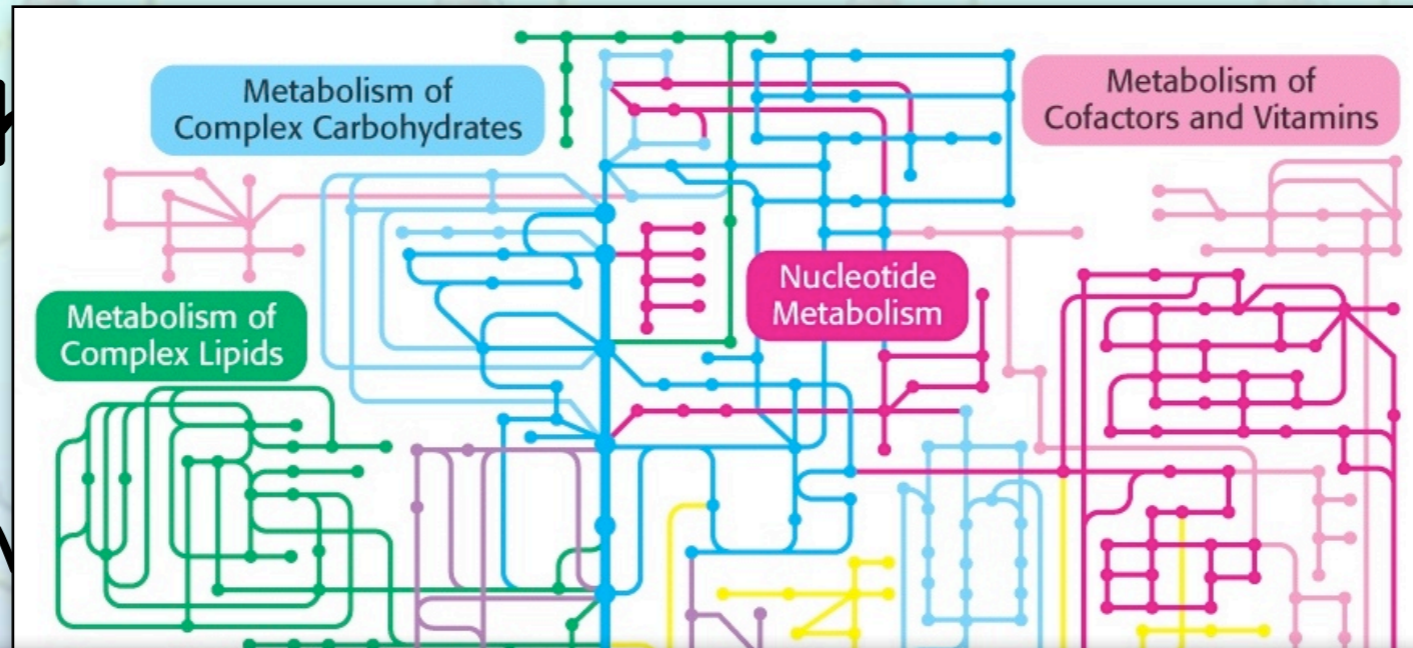


systems

life

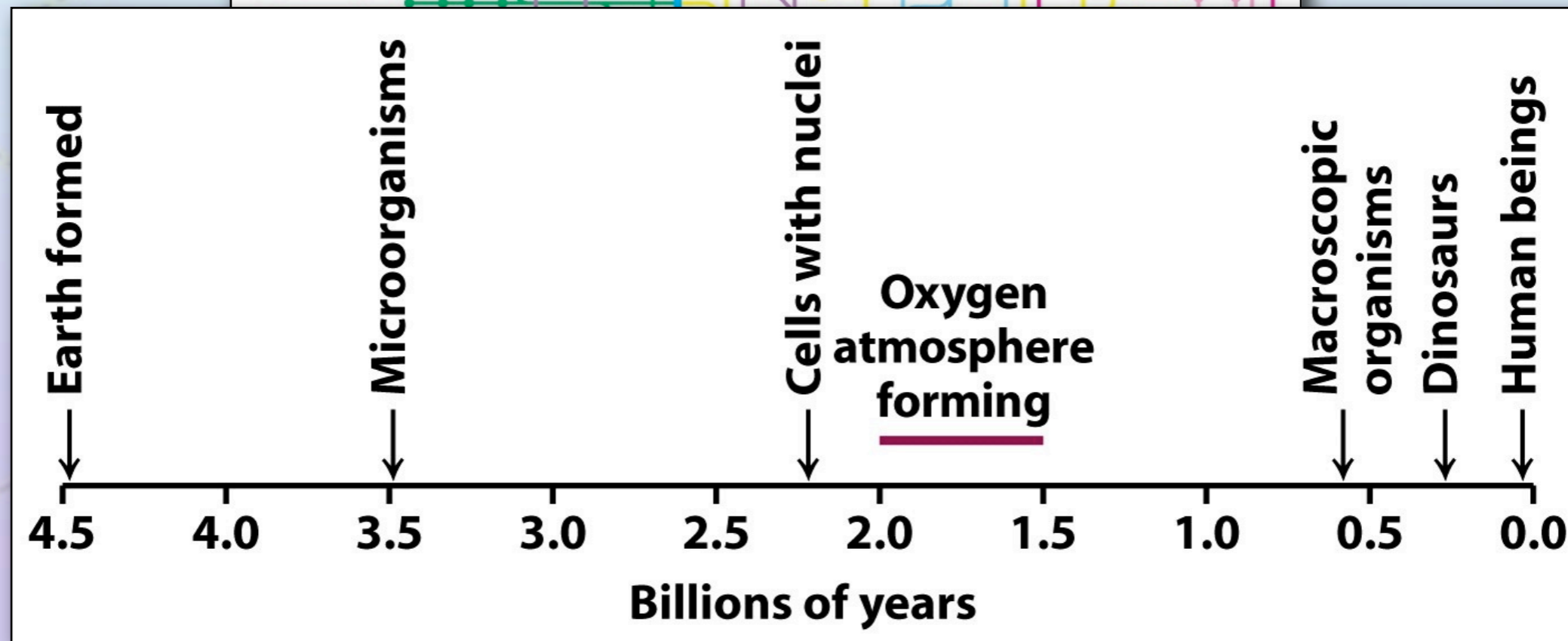
# Biology is Varied and Complex

- ◆ At the
- look
- ◆ This
- evolv



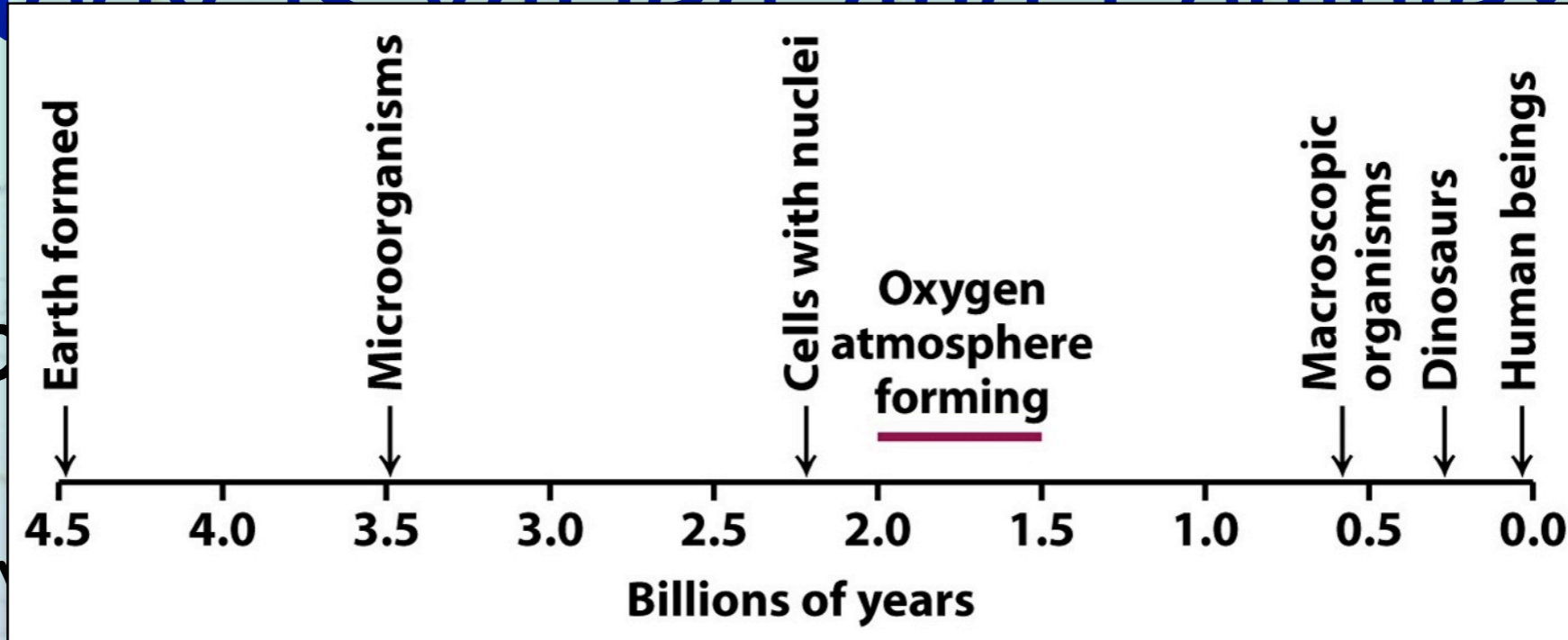
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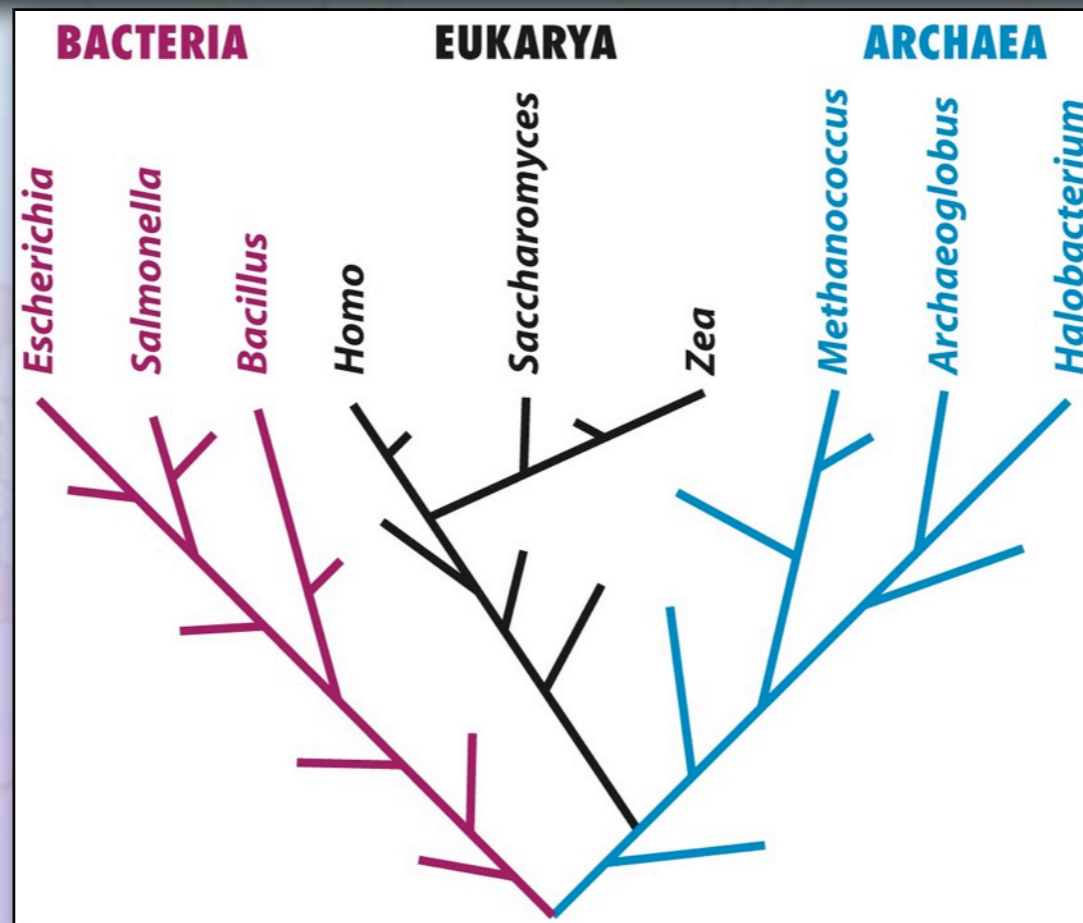
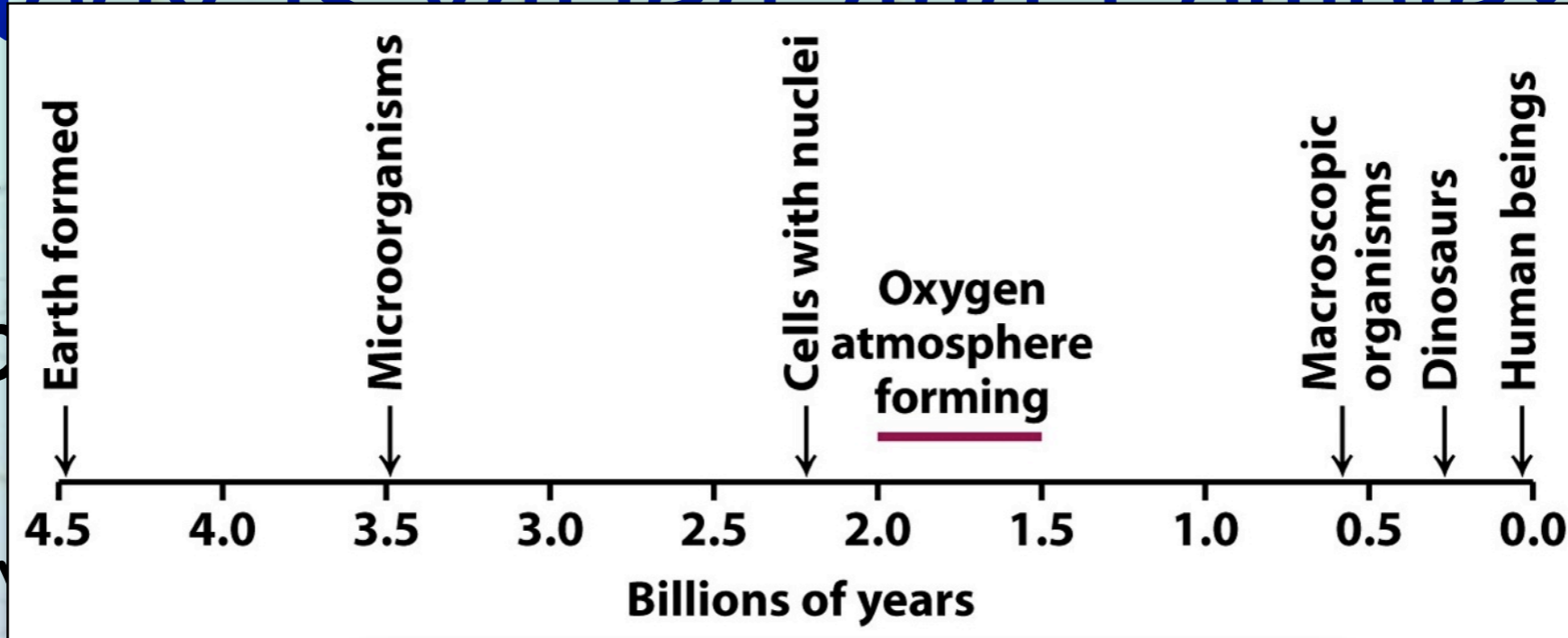
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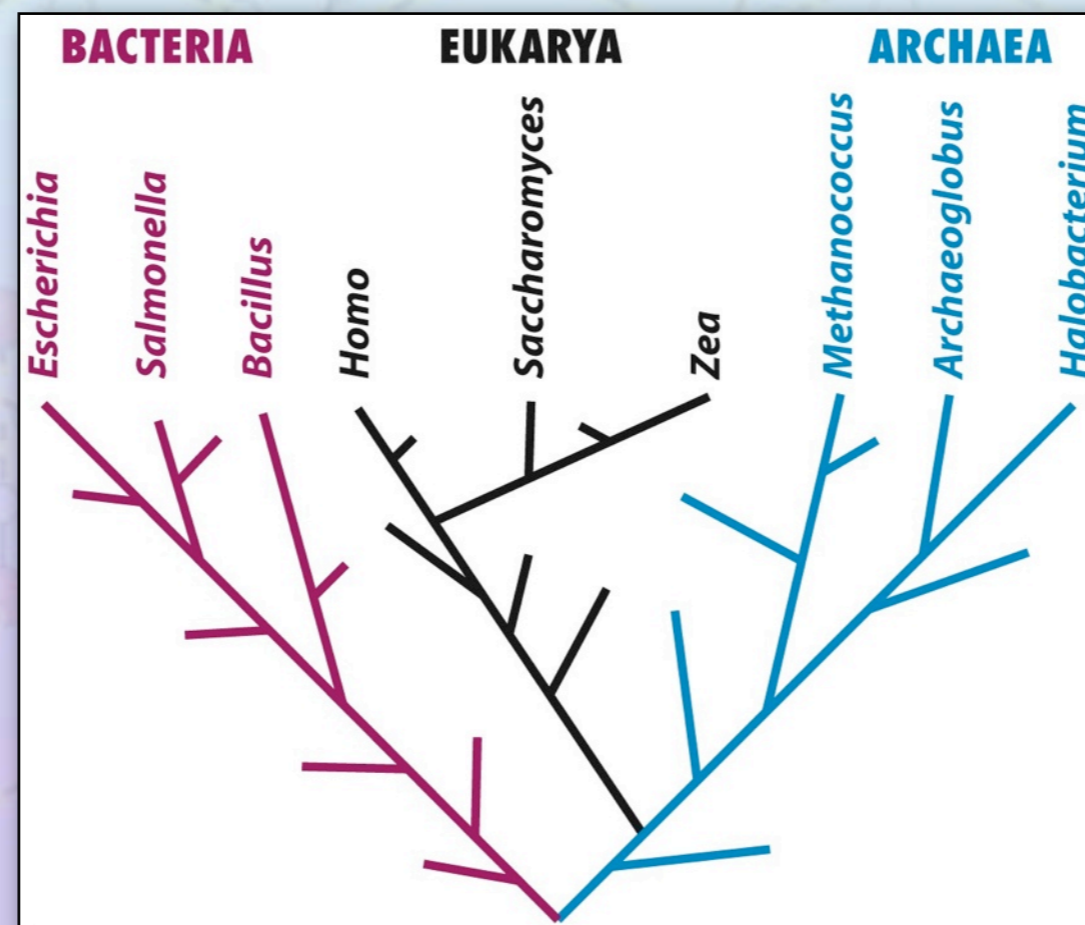
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- ◆ At local
- ◆ Time



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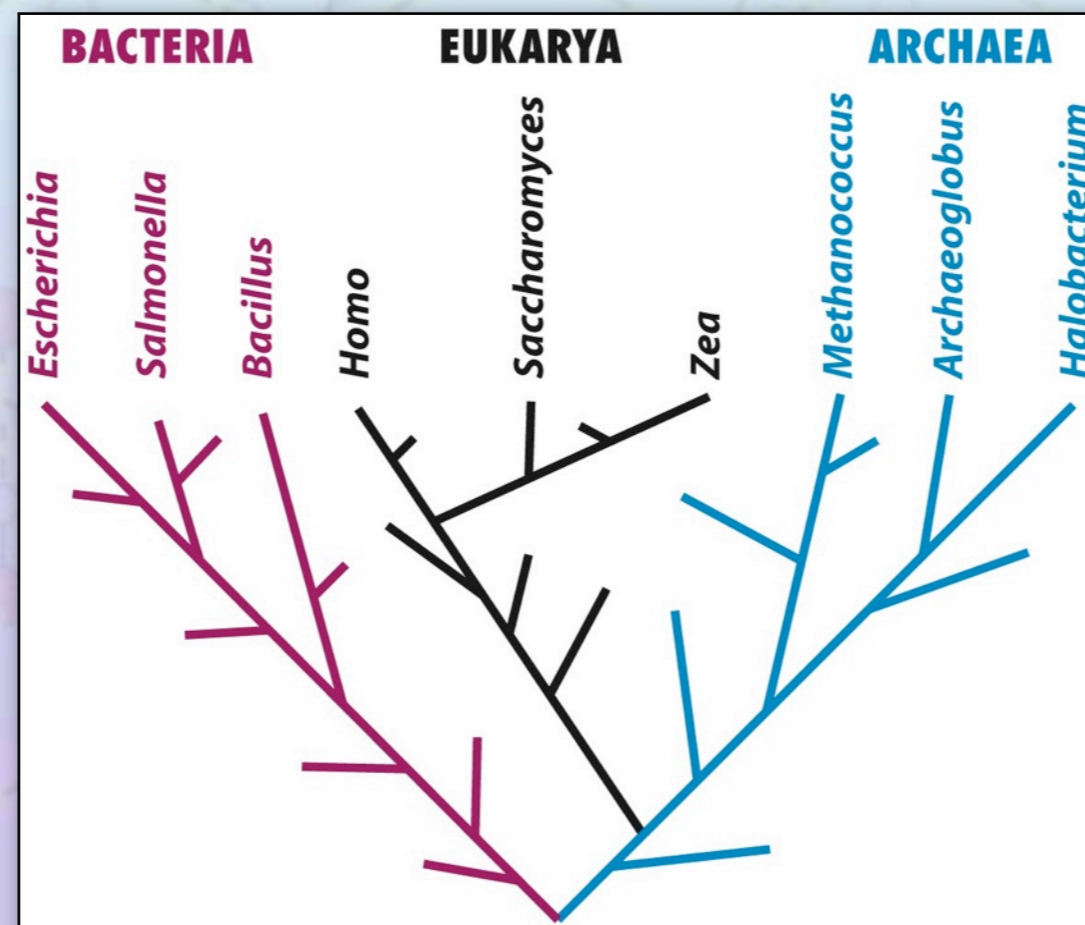
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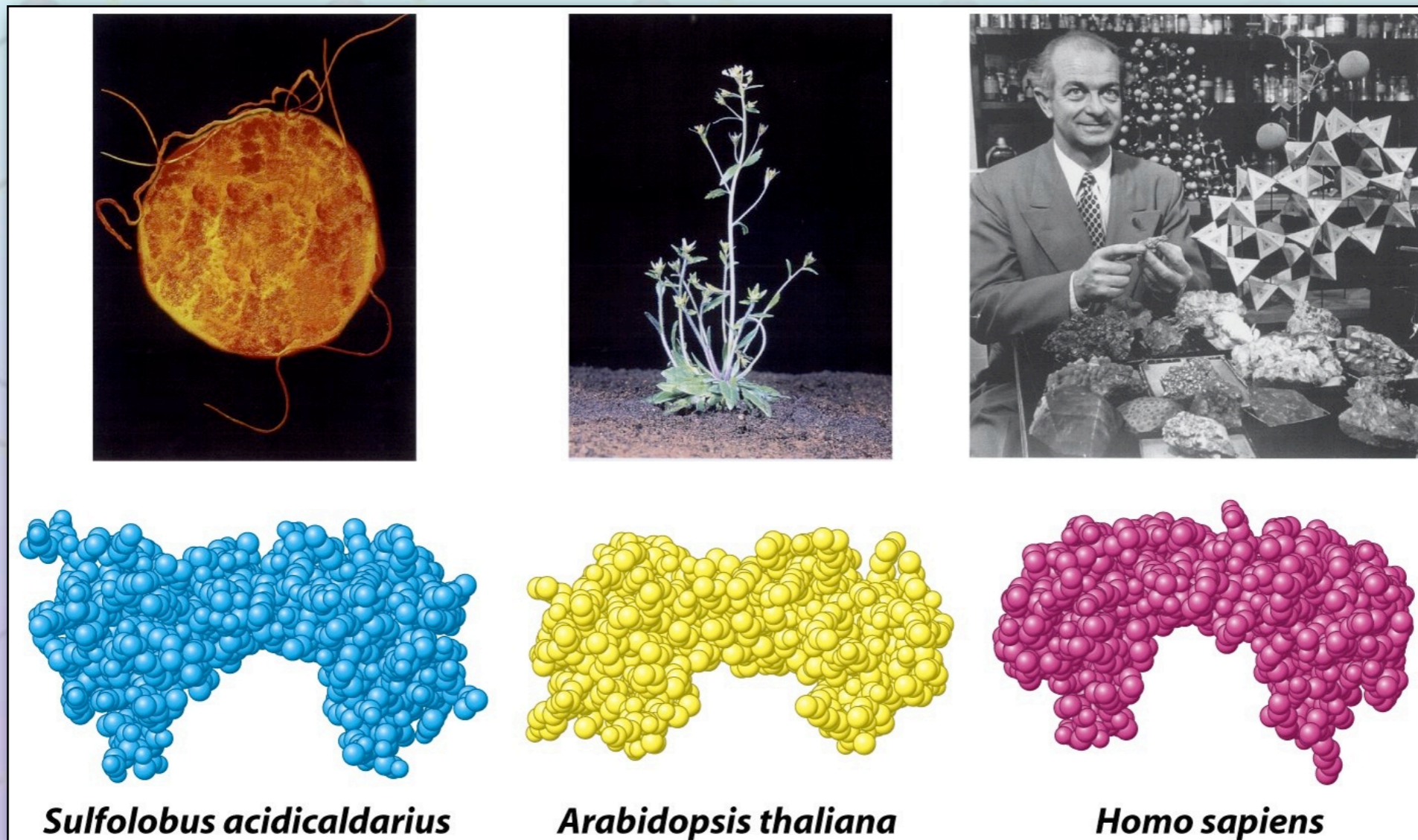
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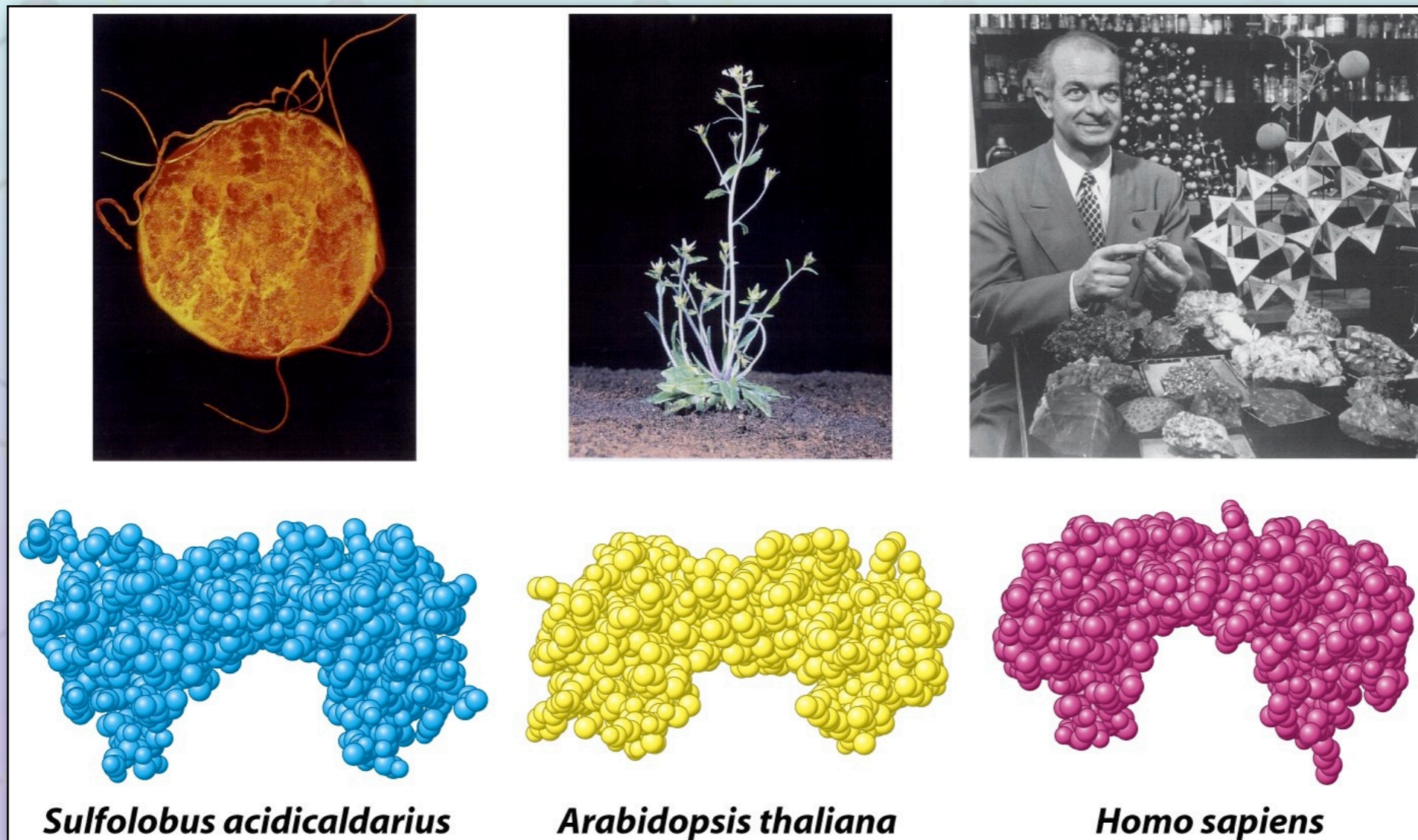
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- ◆ Biochemistry unifies biology
  - ◆ Macromolecules and metabolites



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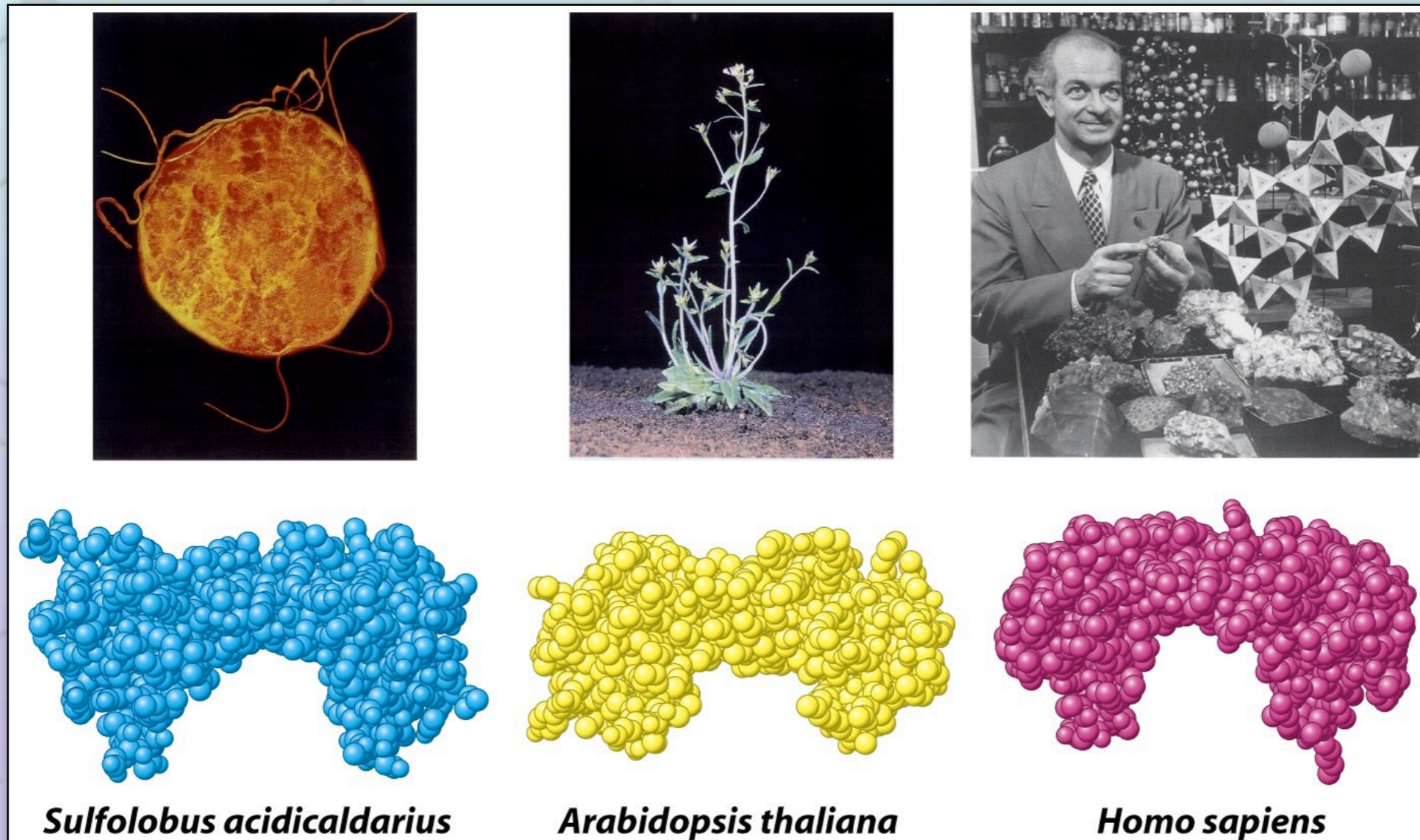
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Archaea

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*Sulfolobus acidicaldarius*

Archaea

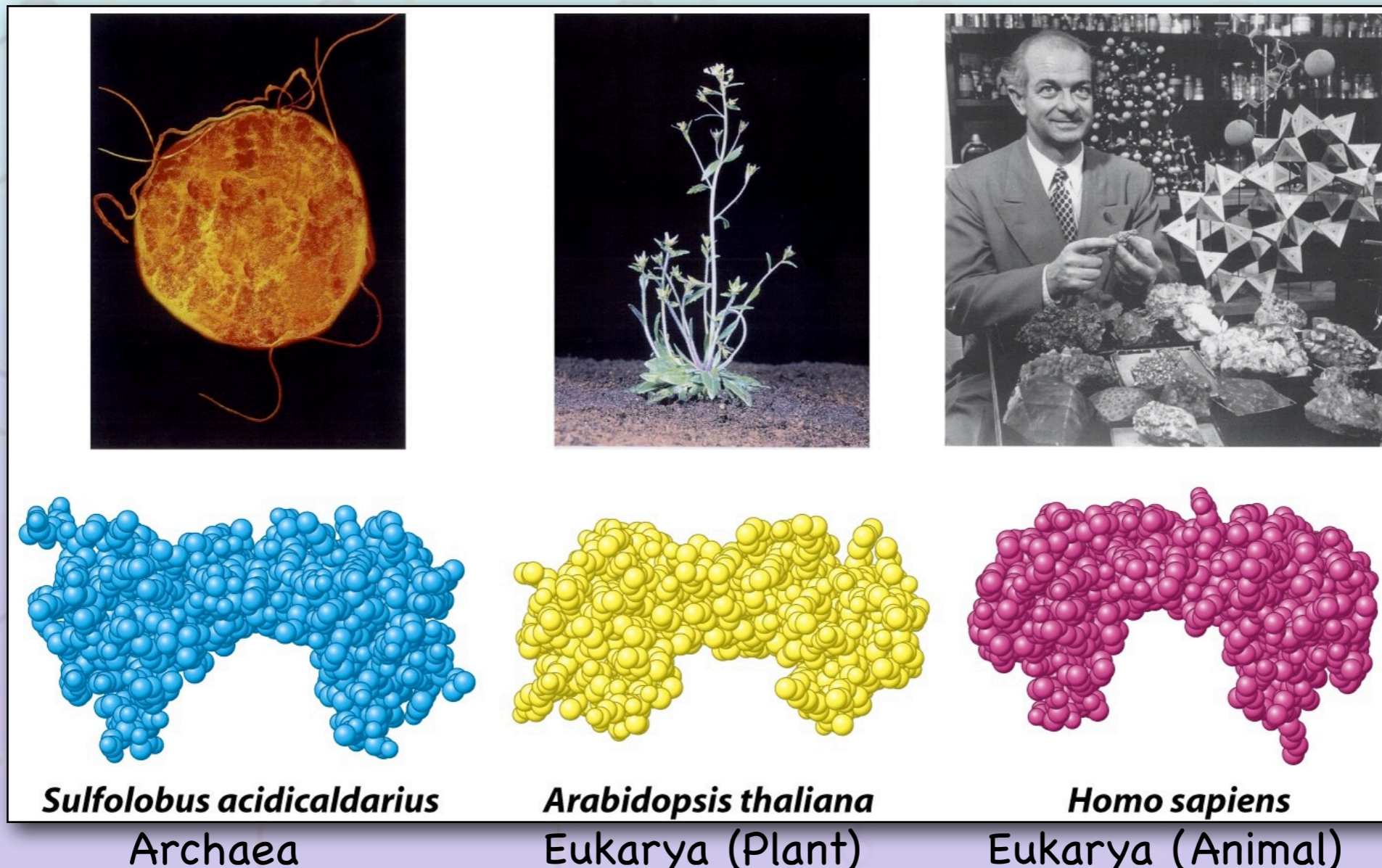
*Arabidopsis thaliana*

Eukarya (Plant)

*Homo sapiens*

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Archaea

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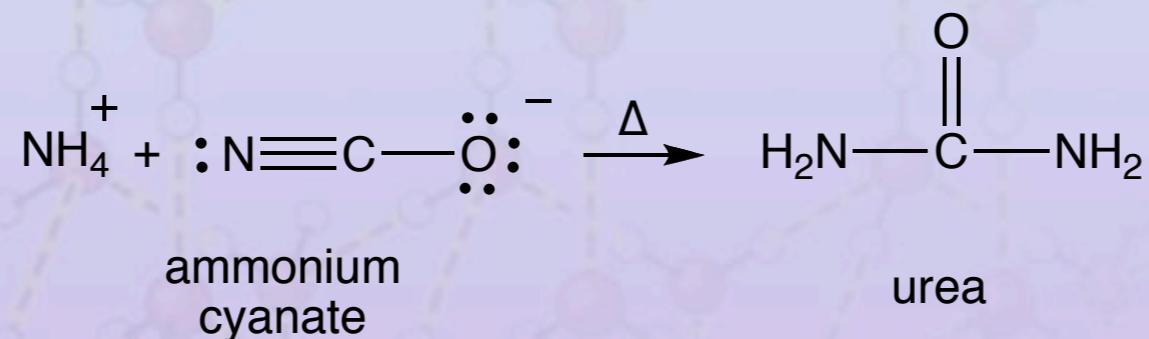
Eukarya (Animal)



# A brief history of Biochemistry

## ♦ Friedrich Wöhler (1800-1882)

- ♦ Demonstrated in 1828 that **urea**, a compound that had only been associated with living cells, could be synthesized from an inorganic compound outside of the cell.





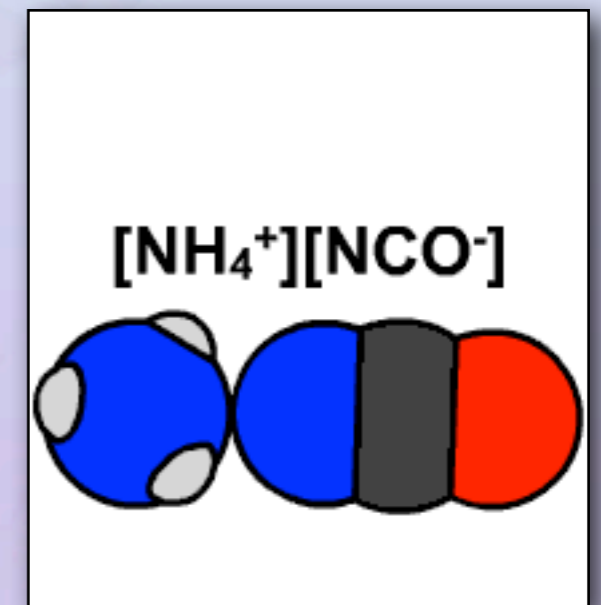
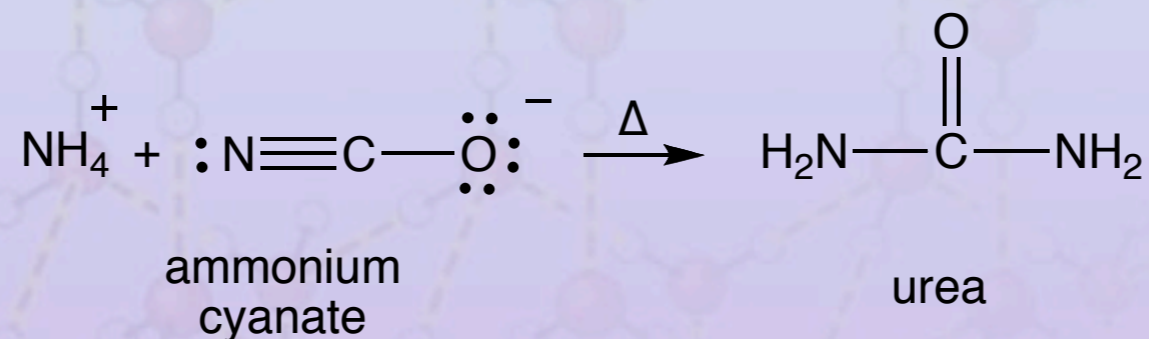
# A brief history of Biochemistry

- ✦ Outcomes for this semester include:
  - ✦ Apply your knowledge of general and organic chemistry to predicting the structures and interactions of biological molecules from their elemental compositions and structures.
  - ✦ Develop an understanding of how the chemical structures and physical properties of biological molecules relate to their function.
  - ✦ Develop an understanding of how biological molecules interact with one another to produce complex, self-regulating systems, and how chemical energy is utilized to drive and sustain these processes.

# A brief history of Biochemistry

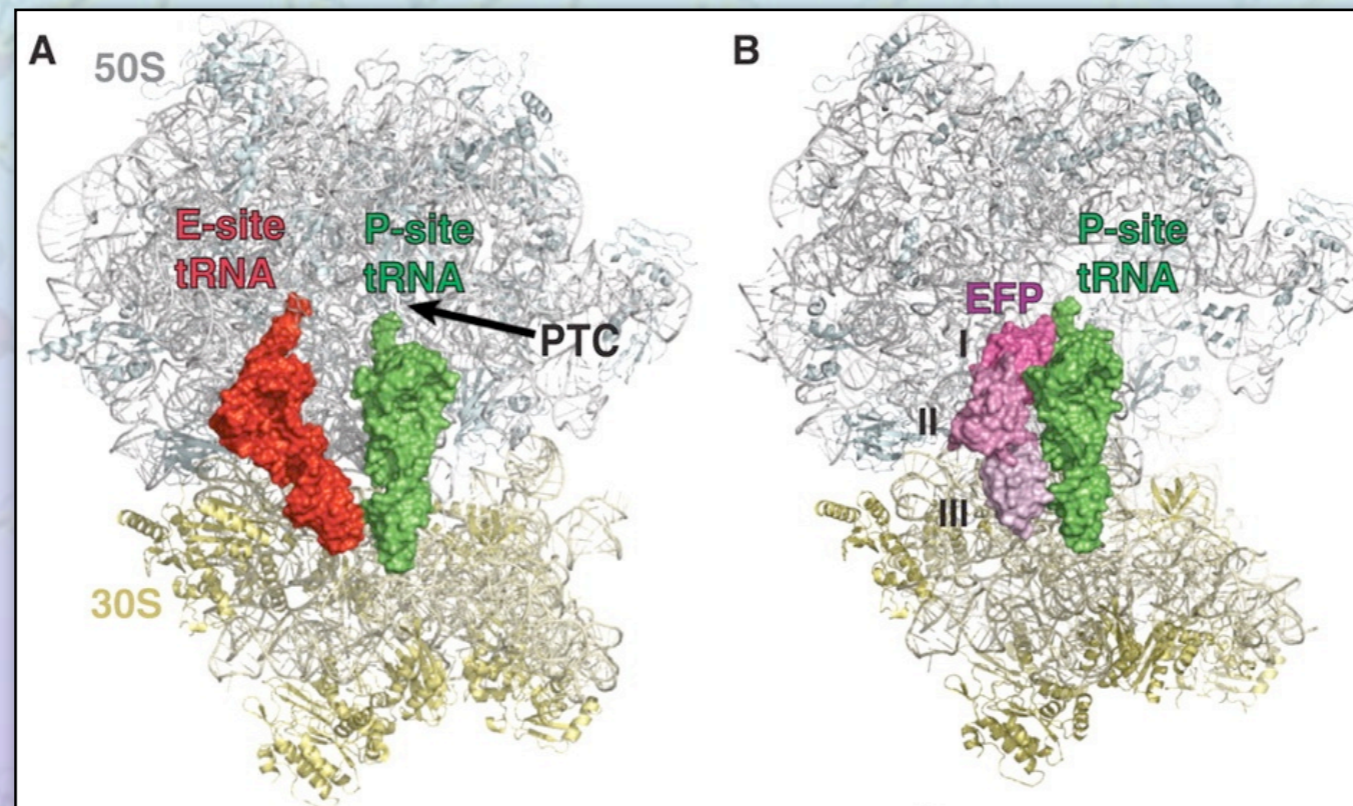
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# A brief history of Biochemistry

- ✦ Roll forward to 2009 (181 years later)
- ✦ We can now view the steps of protein synthesis by ribosomes at the atomic level



Blaha *et al.*, "Formation of the First Peptide Bond: The Structure of EF-P Bound to the 70S Ribosome" *Science* **2009**, 325, 966-970.

# A brief history of Biochemistry

## ♦ Nobel Prize in Chemistry, 2009



Photo: U. Montan

**Venkatraman  
Ramakrishnan**



Photo: U. Montan

**Thomas A. Steitz**



Photo: U. Montan

**Ada E. Yonath**

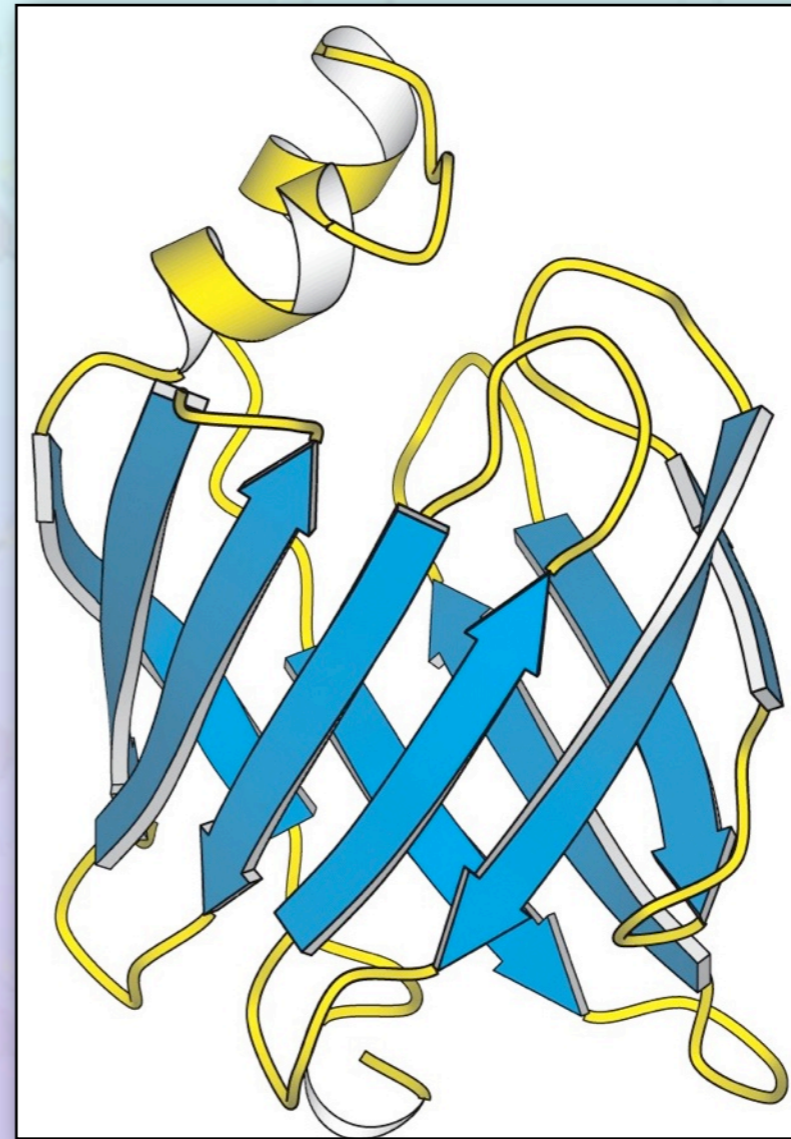
The Nobel Prize in Chemistry 2009 was awarded jointly to Venkatraman Ramakrishnan, Thomas A. Steitz and Ada E. Yonath *"for studies of the structure and function of the ribosome"*.

Nobel Prize Committees News Release

# Using Jmol to view structures

- ♦ Styer's companion website (6th Ed.)  
and "Living Figures"

Figure 2.40 A protein rich in  $\beta$  sheets. The structure of a fatty acid b-binding proteins [Drawn from 1FTP.pdb]



# Looking ahead to Friday, 7. Sept

- ✦ Review DNA structure and function
- ✦ Review non-covalent interactions.
- ✦ Review the properties of water and the hydrophobic effect
- ✦ Review Thermodynamics



# Looking ahead to Friday, 7. Sept

- ♦ Problem Assignment for Chapter 1
- ♦ **Question of the Day:** Watson and Crick made the following observation in their landmark article, which was published in 1953 in the journal Nature,
  - ♦ “It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.”
  - ♦ What are they talking about?