Welcome!!

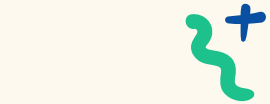
- Find a seat
- Make a nametag with your name and pronouns
- If you have time, decorate with some of your favorite foods

Course Logistics

Introductions!

Introductions!

- Who am I?



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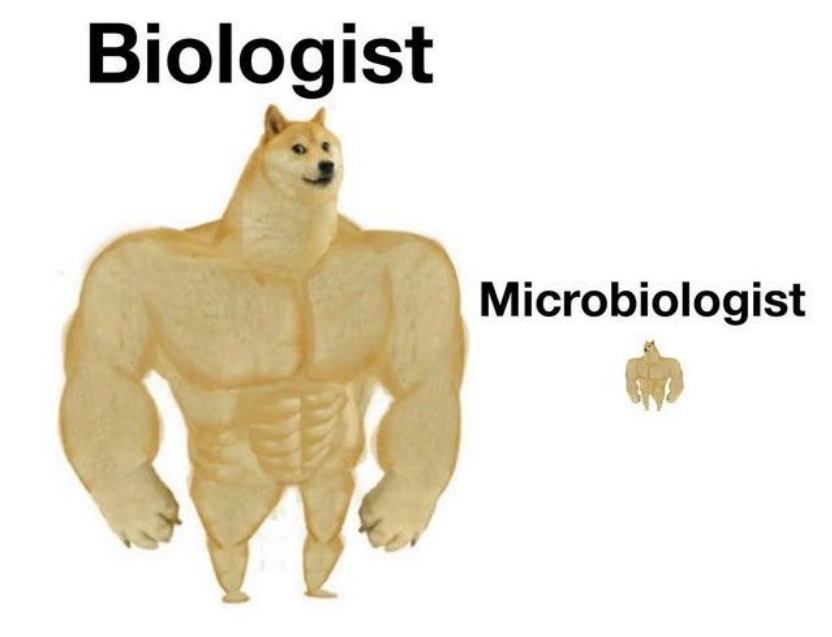

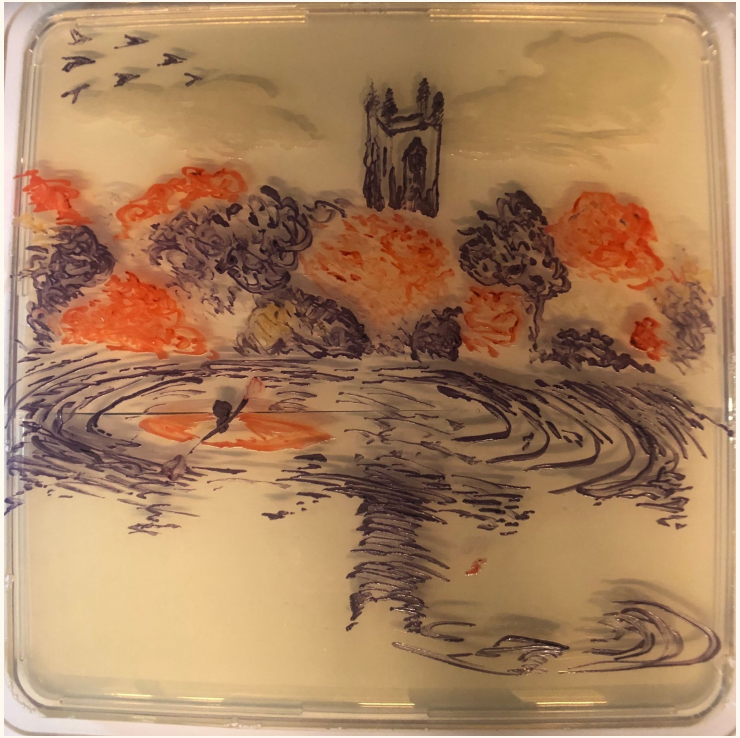

Introductions!

- Who am I?
- Why am I here?

This class prioritizes curiosity and engagement, rather than simply covering content. Asking questions will always be encouraged, no matter how irrelevant they may appear.

Introductions!

- Who am I?
- Why am I here?
- Who are you? Why are you here?

Introductions!

- Who am I?
- Why am I here?
- Who are you? Why are you here?
- Share with someone next to you:
  - Name
  - Pronouns
  - Grade
  - Why you're here
  - Favorite organism
  - Your dream job from elementary school

Class 1: What is microbiology?

March 2

The study of:

The study of: microbes

What are some examples of microbes?

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- Amoebas
- Paramecia
- Germs
- Algae
- Prions
- Lichens
- Slime mold

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- Paramecia
- Germs
- Algae
- Prions
- Lichens
- Slime mold
- Bacteria
- Viruses
- Archaea
- Protista
- Fungi
- Eukarya
- Protozoa

What do these organisms have in common?

Formal definition:

A life form that is too small to be seen with the naked eye

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So what can we use to study microbes?

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So what can we use to study microbes?

Is there any issue with this definition?

(Is there anything that we just named that isn't usually considered living?)

Viruses

- Typical requirements of life:
  - Composed of one or more cells
  - Exchanges energy with the environment
  - Able to reproduce using replication machinery
- Viruses:
  - Not made up of cells
  - Can’t produce their own energy
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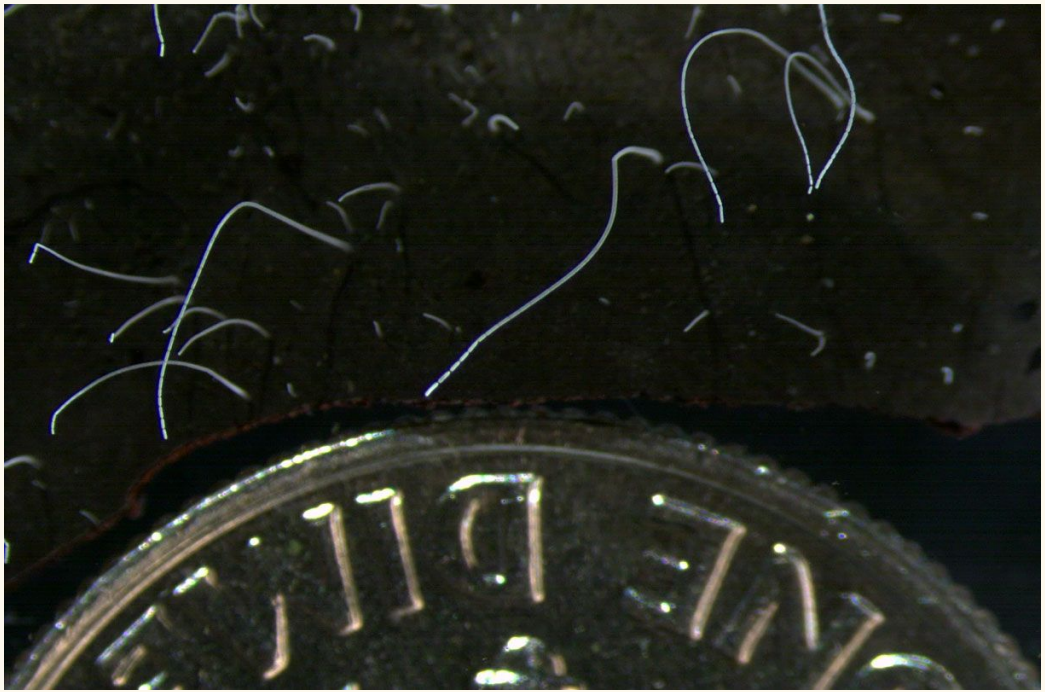
Any other reasons to exclude viruses?

Other exceptions

- *Thiomargarita magnifica*: more than a centimeter in length



How do we study microbes?

DNA-based approaches:

DNA-based approaches:

Who is there?
What can they do?

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Genomics and metagenomics

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Transcriptomics and metatranscriptomics

Protein-based approaches:

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Metabolomics

What are some advantages and disadvantages to using one of these methods over another?

Genomics

Transcriptomics

Proteomics

Metabolomics

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When might it be useful to use multiple in combination?

Think, pair, share

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You just discovered a new microbe! Congratulations! Now, it’s time to characterize it. What techniques are you going to use first?
Feel free to draw or write your answer, or just talk about it.

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You just discovered a new microbe! Congratulations! Now, it's time to characterize it. What techniques are you going to use first?
Feel free to draw or write your answer, or just talk about it.

(There's no wrong answer–if you have a question or curiosity, let's talk about it!)

The study of microbes

But where did they come from?

What did early Earth look like?

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- Extremely hot
  - No ozone layer
- No accessible liquid water

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How would this limit the development of life as we know it?

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Evidence in favor of any of these hypotheses?

Early Cellular Life and LUCA

- Early life was *unicellular* - biological molecules enclosed in a membrane compartment
- High rates of *horizontal gene transfer*: movement of genetic material between cells
- Most likely lived in deep hydrothermal vents - what are some advantages of this environment?

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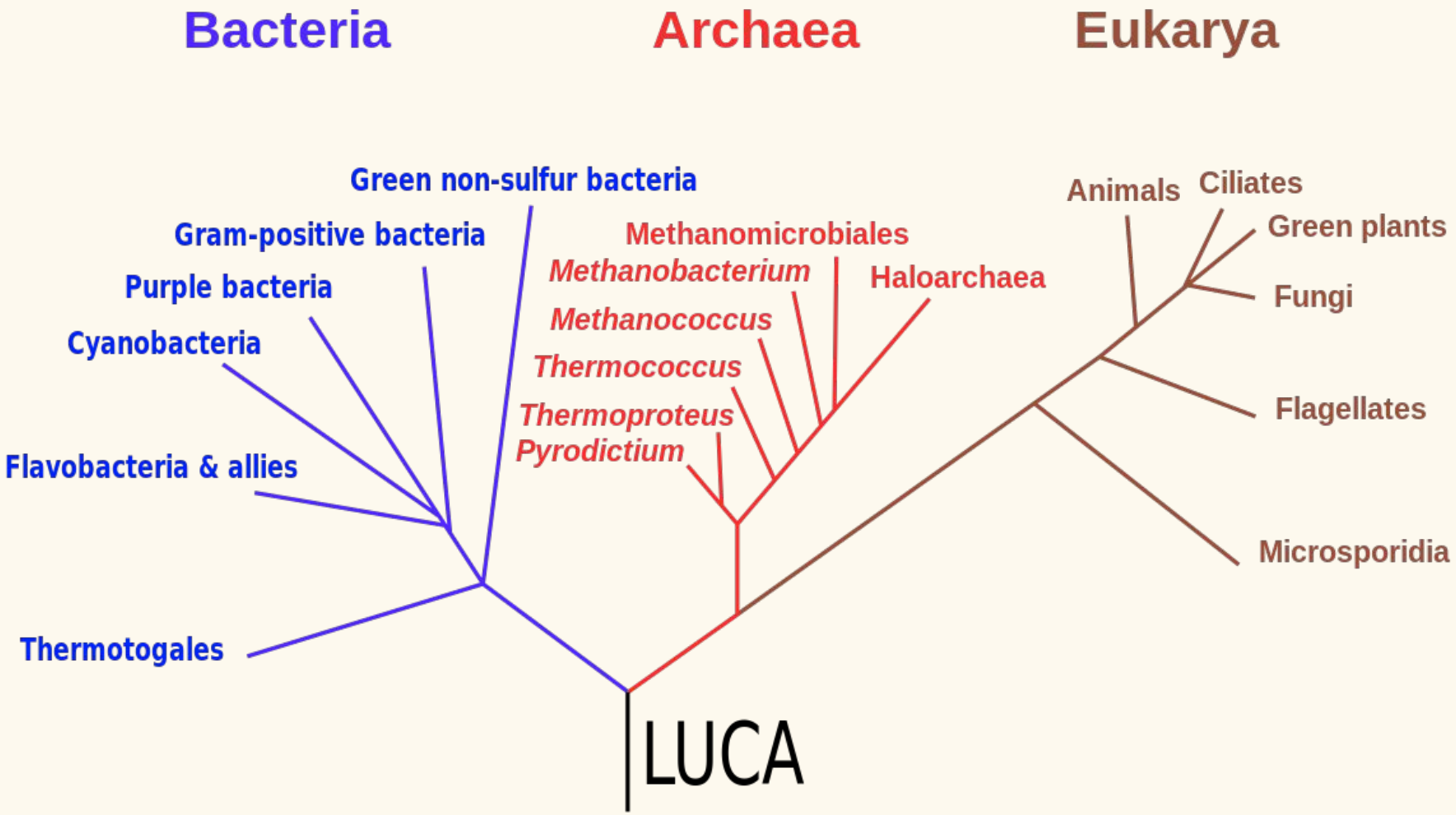
- Most likely lived in deep hydrothermal vents - what are some advantages of this environment?
    - An abundance of metals to get energy from
    - Consistent temperature and composition


Bacteria
Archaea
Eukarya
Green non-sulfur bacteria
Gram-positive bacteria
Purple bacteria
Cyanobacteria
Flavobacteria & allies
Thermotogales
Methanomicrobiales
Methanobacterium
Haloarchaea
Methanococcus
Thermococcus
Thermoproteus
Pyrodictium
Animals
Ciliates
Green plants
Fungi
Flagellates
Microsporidia
LUCA

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- Microfossils: date back as early as two billion years ago
- Biomarkers: lipid molecule derivatives
- BUT comparison with modern species is often subjective
- BUT even the most stable molecules found aren’t older than 2.5 billion years

How do we track evolution in macroscopic organisms?

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- Morphological features
  - Homologous structures
  - Analogous structures
  - Vestigial structures
- Fossils

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Do these measurements work for microscopic organisms?

Solution: 16S rRNA DNA

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16S: a specific segment of the ribosome
rRNA: a structural component of the ribosome
16S rRNA DNA: the specific GENE to make this part of the ribosome

Ribosome: a structure in the cell responsible for making proteins

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- Found in all domains of life
- Functionally constant
- Mutates slowly
- Long enough for most experiments
- Not transferred horizontally

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- Any disadvantages to using this gene?
- How do we use this gene?

How do we use this gene?

Culture-dependent

Culture-independent

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- Isolate and grow different species
- Characterize them in various conditions
  - Ex. test their growth in microaerophilic environment
- Sequence 16S rRNA DNA to identify the species and their ancestry

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What would each of these types of molecules tell us about?

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Which technique is better?

The Great Plate Anomaly

An environmental sample leads to 100x more cells visible in a microscope than colonies growing in culture

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Why?

What results do we get from sequencing a community?

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3. The **pangenome**

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Information about the community's genome
But really, this genome can be classified into three different genomes:

1. The **core genome**: includes the genes that ALL species present in the community share
2. The **accessory genome**: includes the genes that some, but not all species present have
3. The **pangenome**: includes ALL the genes present in the community, core and accessory

Extended metaphor: iPhone apps

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- Core genome:
- Accessory genome:
- Pangenome:

Extended metaphor: iPhone apps

- Core genome: the apps on everyone's phone, like Camera, Photos, Settings, and Phone
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Extended metaphor: iPhone apps

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- Accessory genome: the apps on some phones, like Instagram, Duolingo, Twitter, and Uber
- Pangenome: all the possible apps that can be on an iPhone - everything on the App Store

Assessment and activity!

Assessment

Tells me what I taught well and what could have been taught better – your only job is to have fun and be creative!

Assessment

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You can work with other students, work alone, work online, or work on a notebook - your choice!

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PLEASE ask questions! I love even the most irrelevant questions!

Assessment

Prompt: Your boss tells you that there's an important microbe hiding in the human gut microbiome. All we know is that it is the only microbe capable of turning glucose (sugar) directly into a protein associated with fame and fortune. How are you going to find this microbe and learn about it?

Tools: 16S rRNA DNA, genomics, transcriptomics, proteomics, metabolomics, culture-dependent and culture-independent methods.