Class 2: The cell, the structure, and the community

March 9

What are microbes?

What are some examples of microbes?

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

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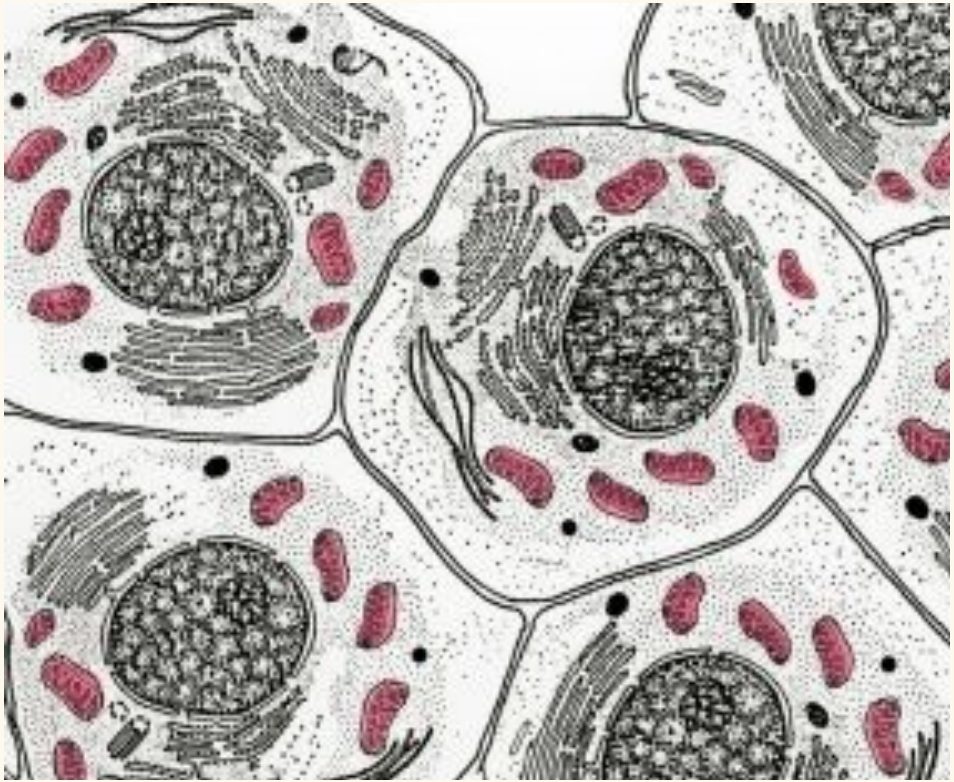
Smaller, with different extracellular features, like a cell wall and flagella

Eukaryote or prokaryote?



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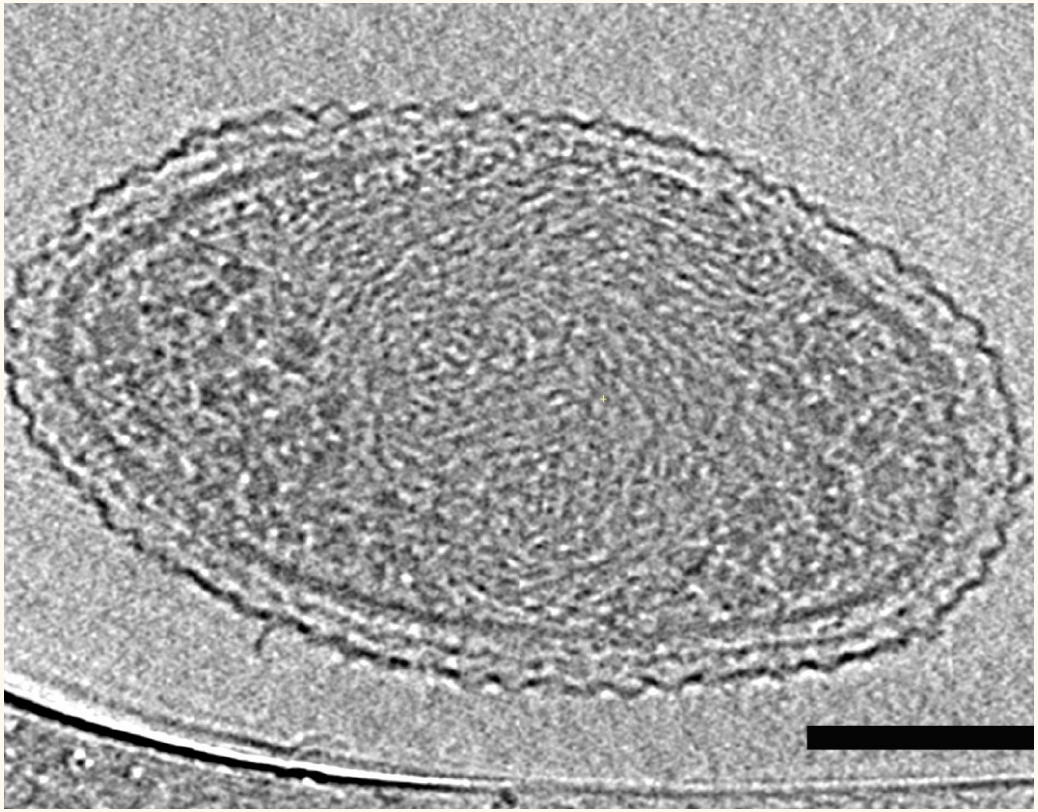

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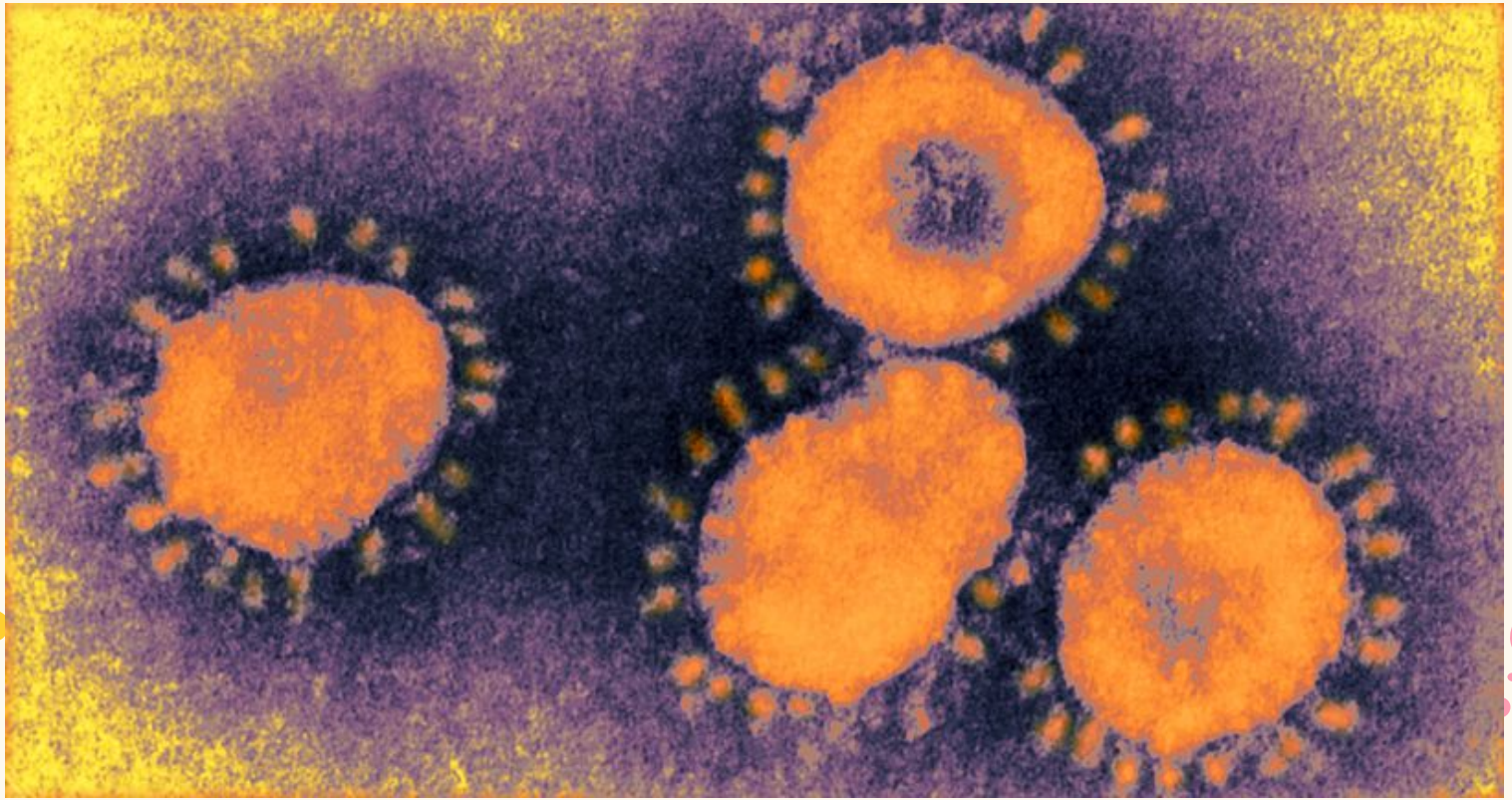

Cell wall

Not something found in animal cells

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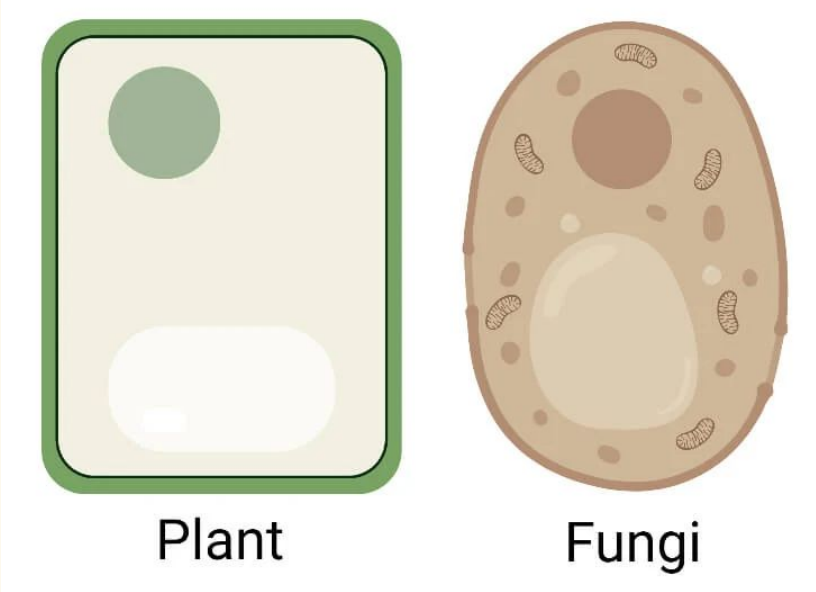

Gram positive vs. Gram negative

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Two main classes of bacteria: Gram positive and Gram negative

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Two main classes of bacteria: Gram positive and Gram negative

Based on differences in their cell wall structures

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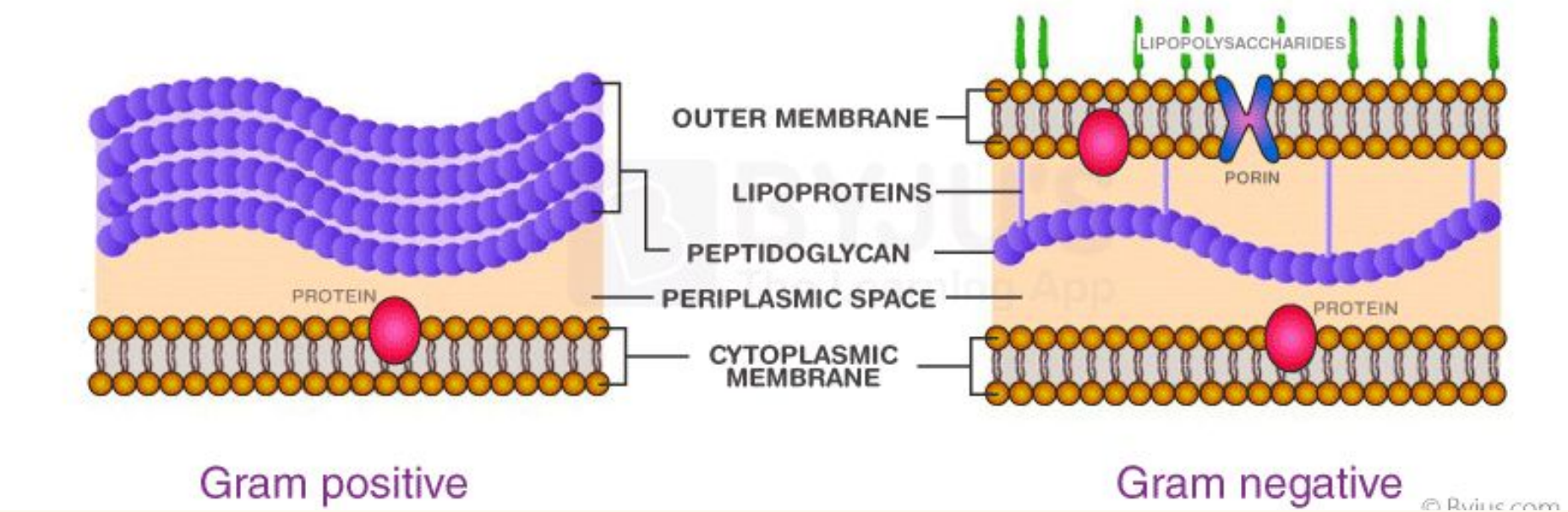
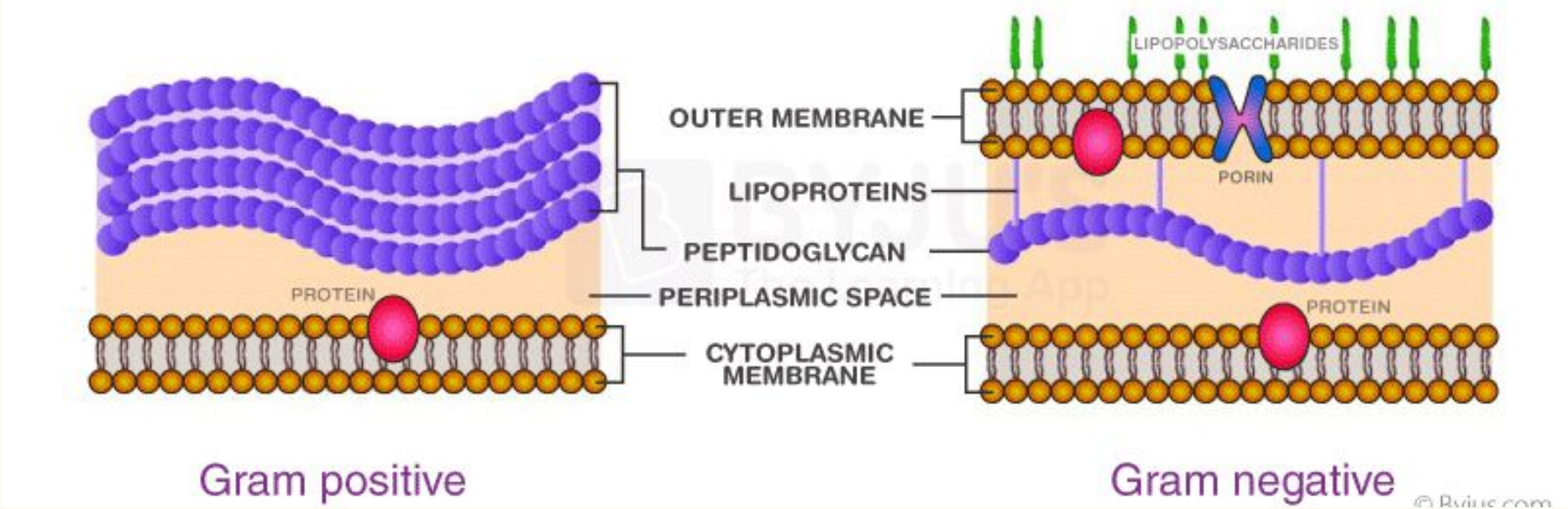
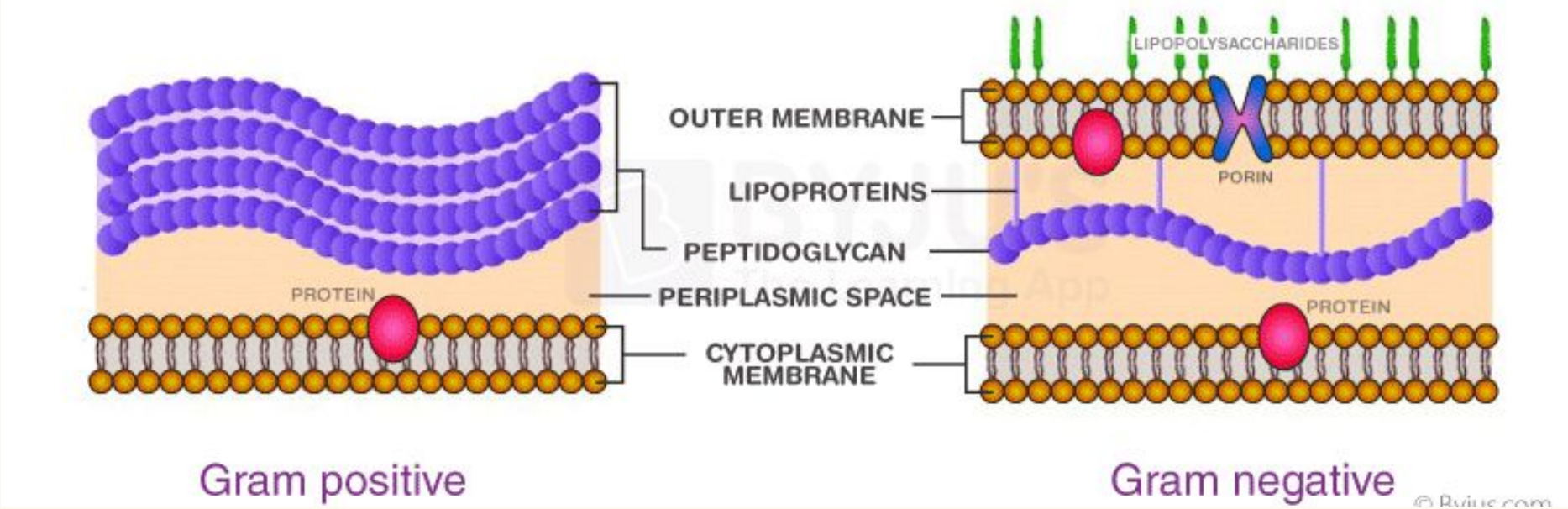


Gram positive vs. Gram negative



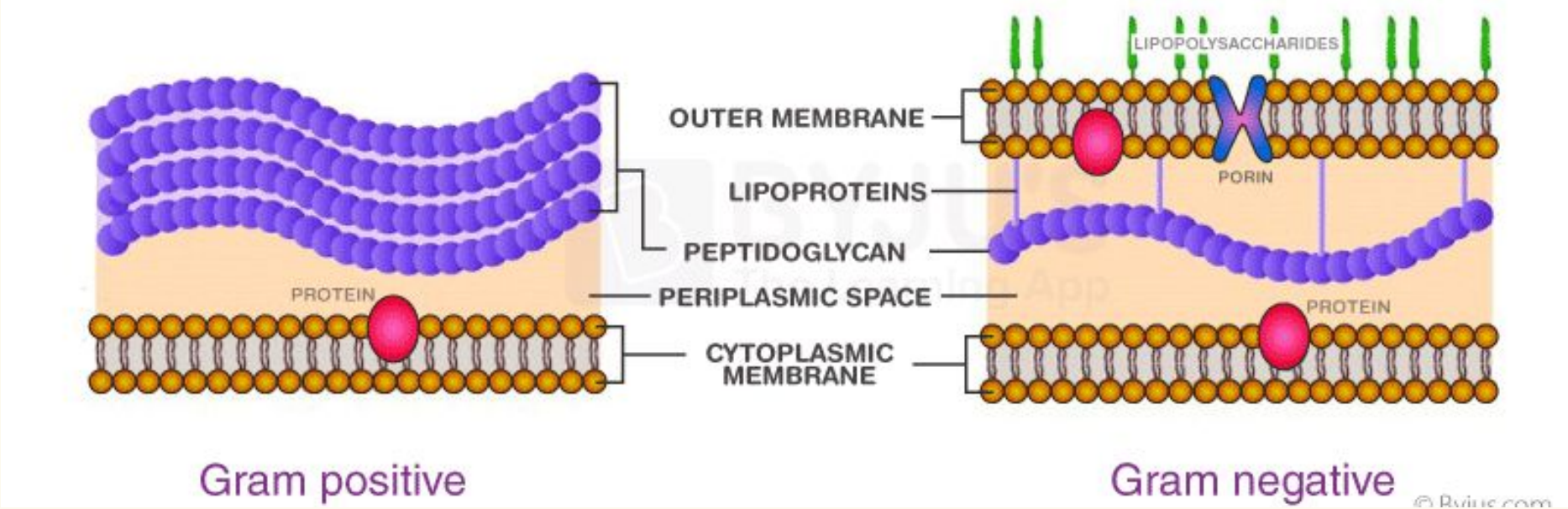
Two outer membranes vs. one cytoplasmic membrane

Gram positive vs. Gram negative



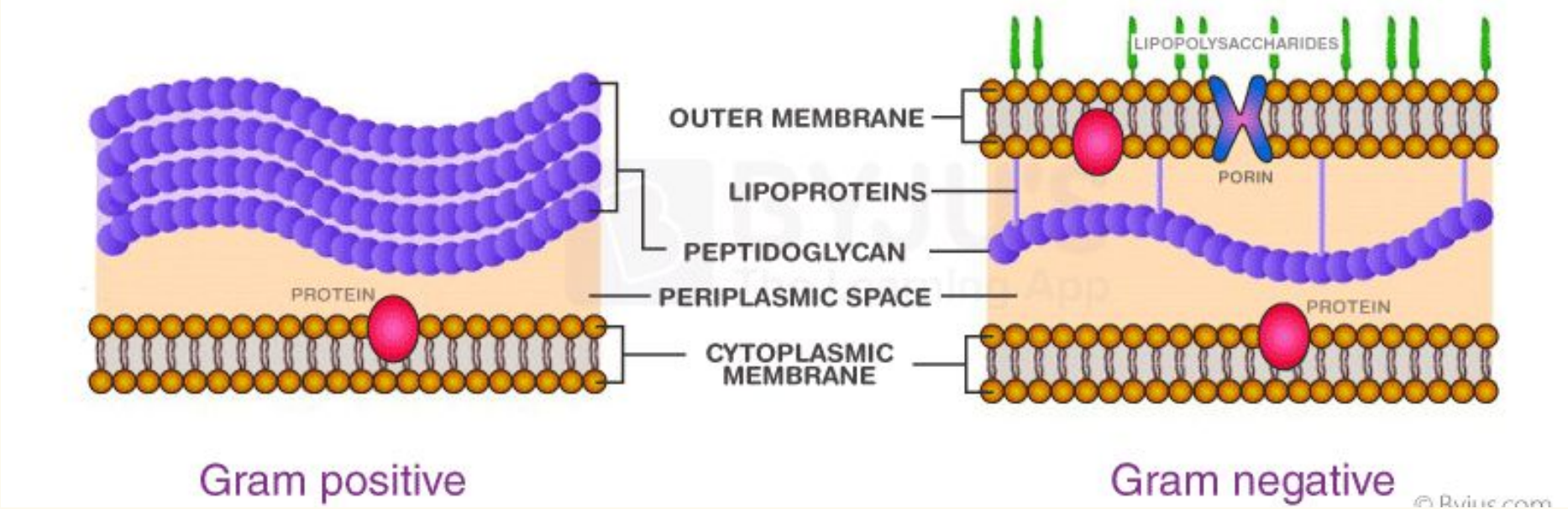
Lipoproteins

Gram positive vs. Gram negative



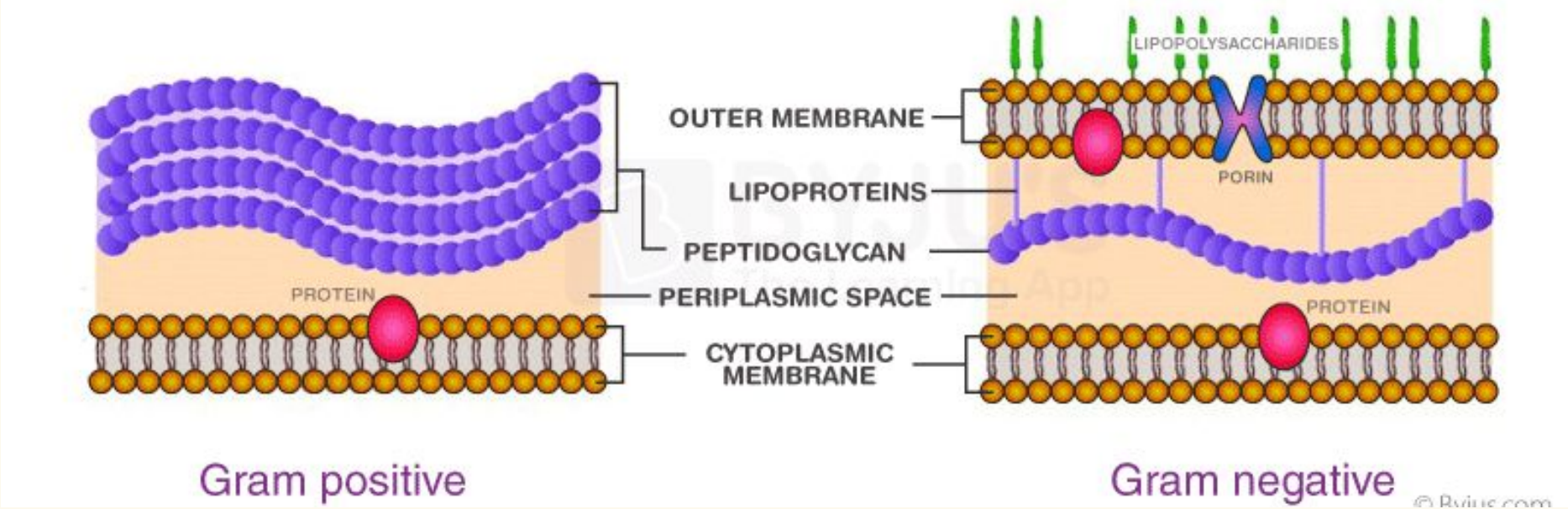
Thick vs. thin peptidoglycan layer

Gram positive vs. Gram negative



From what layer inward are these cells identical?

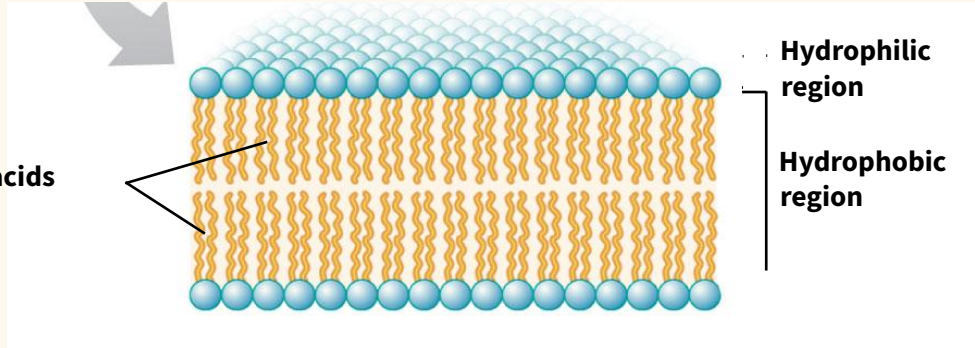
Gram positive vs. Gram negative



Which of these is going to be easier to kill?

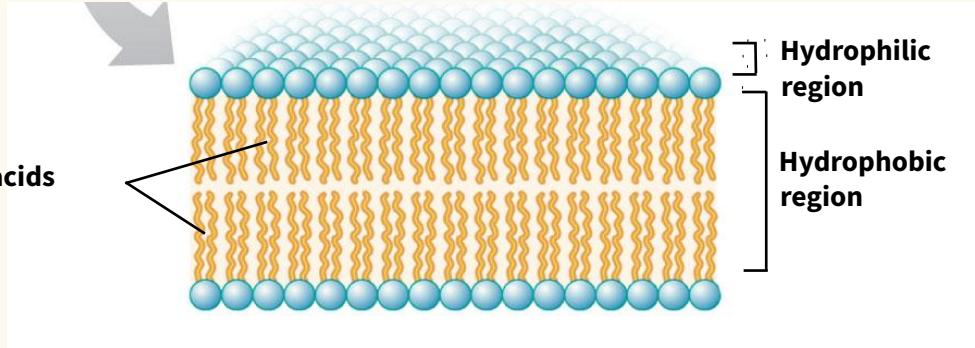
Gram staining

Plasma membrane



Plasma membrane

Composed of phospholipids: hydrophilic head and hydrophobic tail



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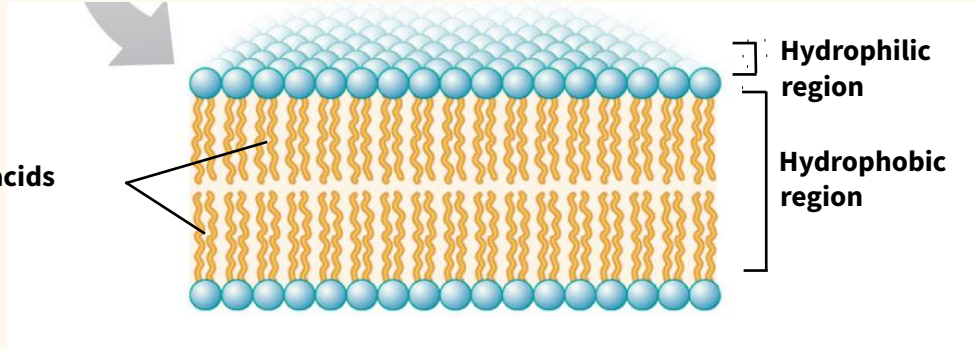
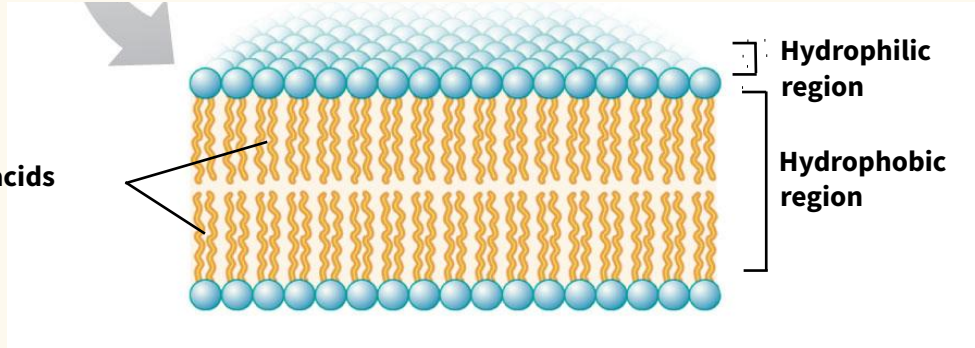
Composed of phospholipids: **hydrophilic** head and **hydrophobic** tail

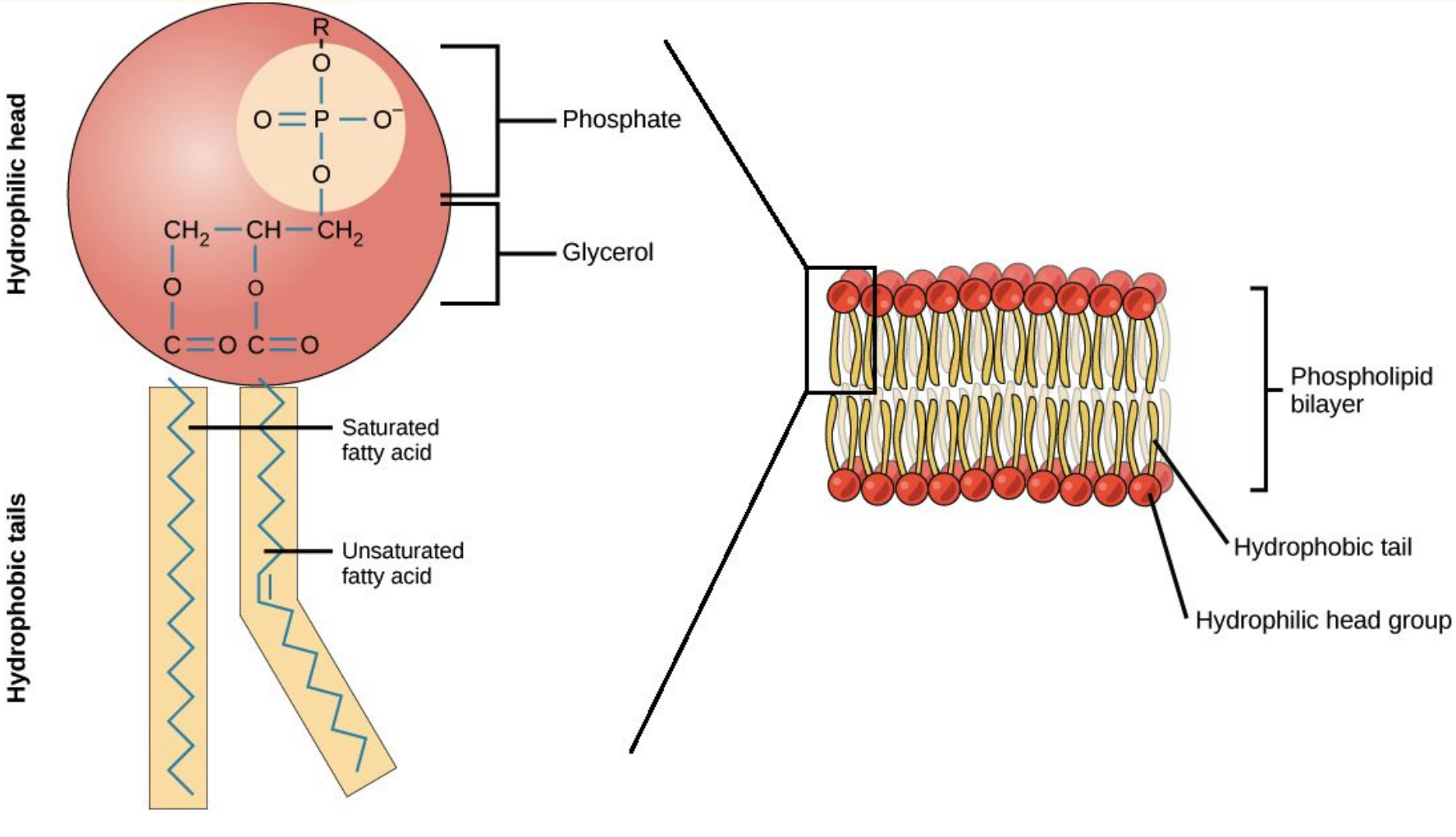


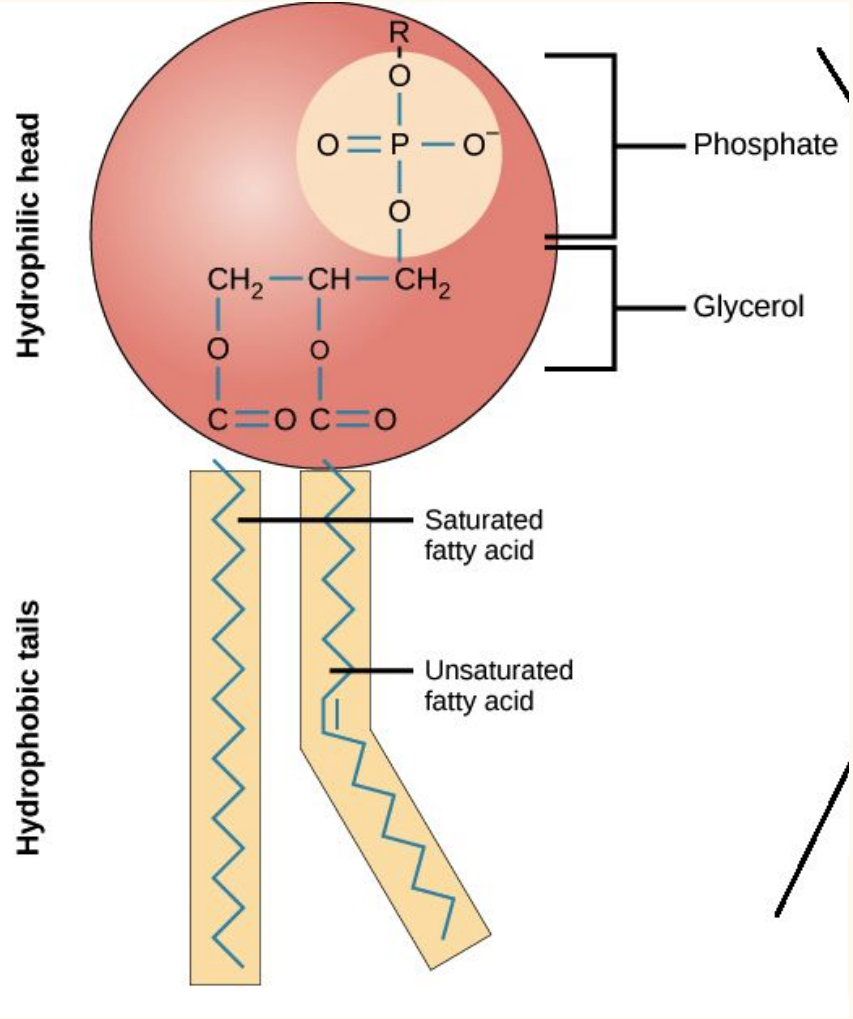
Plasma membrane

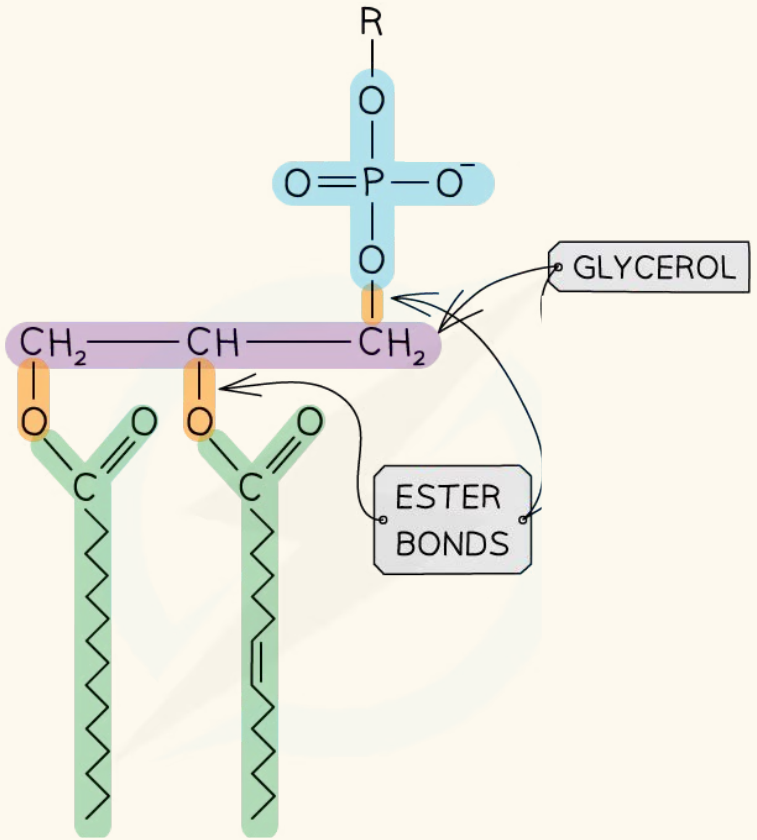
Composed of phospholipids: **hydrophilic** head and **hydrophobic** tail

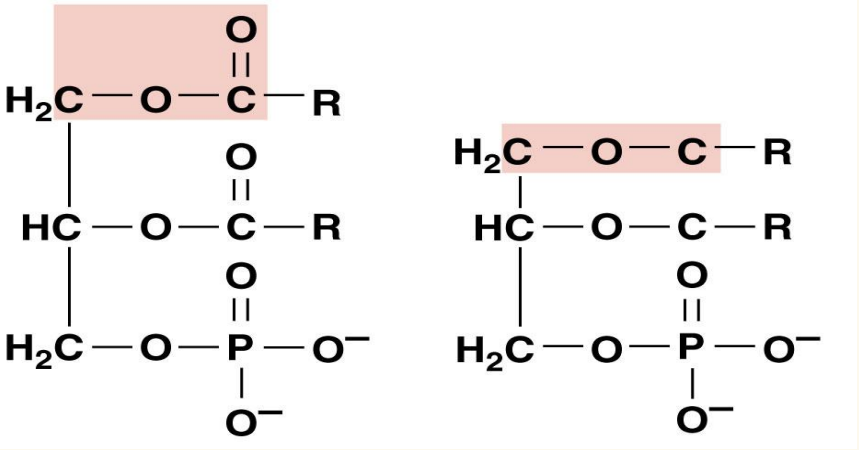
These components (head and tail) are connected by different linkages... let's do some chemistry!

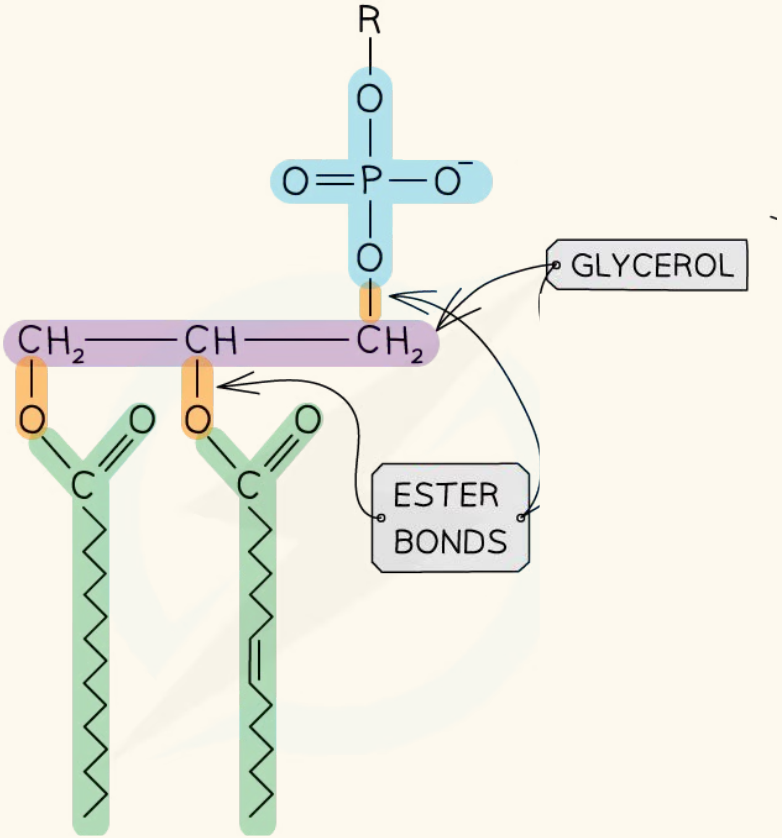


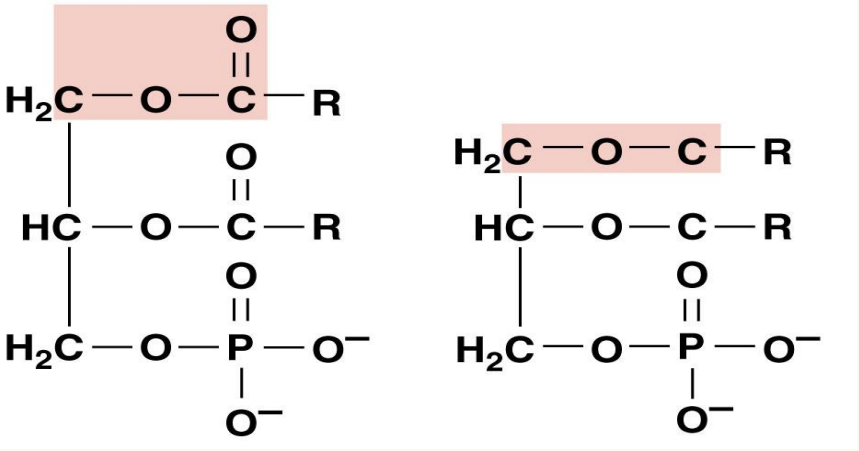

Hydrophilic head
Hydrophobic tails
R
O
O = P — O⁻
O
CH2 — CH — CH2
O O
C = O C = O
Phosphate
Glycerol
Saturated fatty acid
Unsaturated fatty acid
Phospholipid bilayer
Hydrophobic tail
Hydrophilic head group





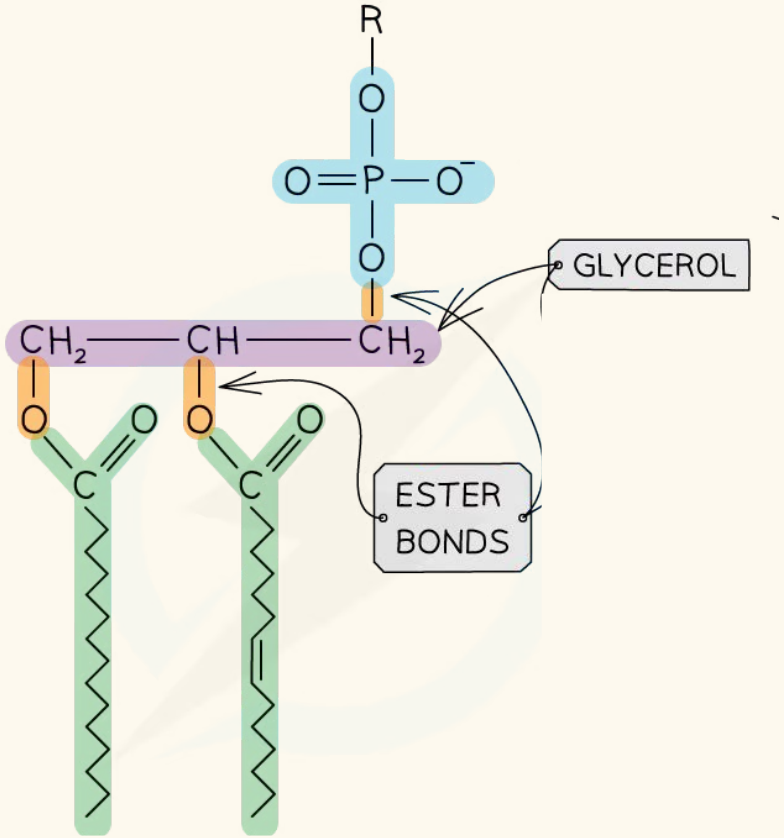


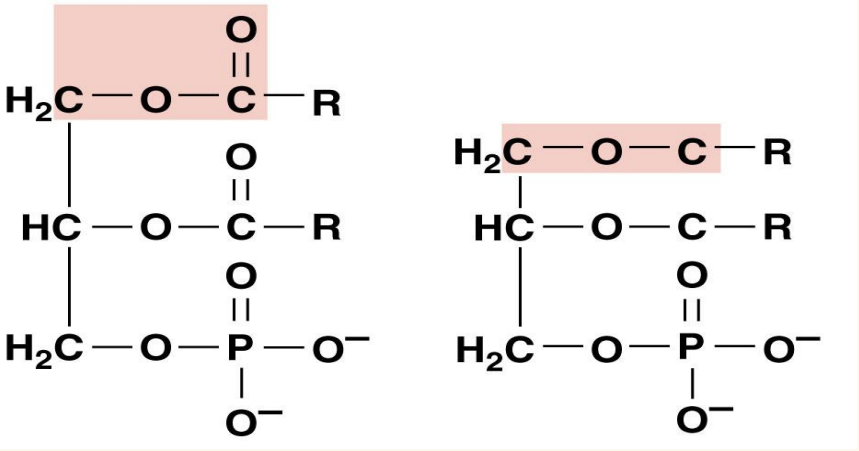




Ester bond

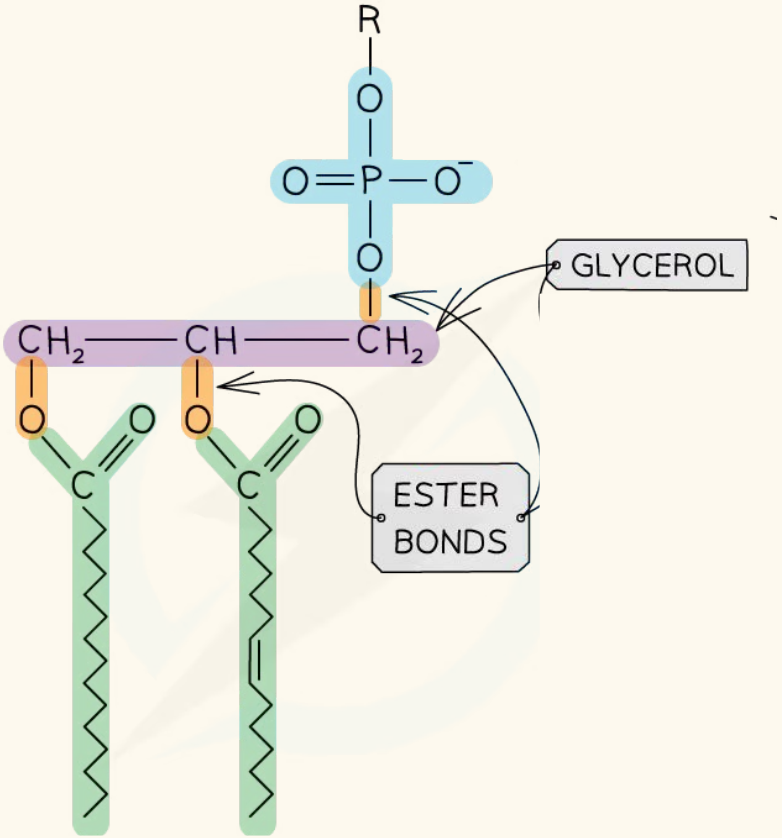
Ether bond





Ester bond

Ether bond
More chemically resistant



Archaea vs. Bacteria

Archaea:

Found in extreme temperatures, and very basic or acidic environments

Bacteria:

Mainly found on/in living organisms or in soil or hot springs

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Which one has to be more resistant to chemical reactions or extreme temperatures?

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Which one has to be more resistant to chemical reactions or extreme temperatures?
Which one do you think has *ether* linkages, and which has *ester* linkages?

Think, pair, share

Within each of the following pairs, which would be easiest to design an antibiotic against? Why?

Gram-negative vs. gram positive bacteria

Archaea cell vs. bacterial cell

Growth

- How do we define growth in a human?

Growth

- How do we define growth in a human?
- How do we define growth in a *population* of humans?

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- Which definition do you think is more like the one we use for microbes? Why?

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Definition: an increase in the number of bacterial cells in a given system, NOT an increase in cell size

What does a bacterial cell need to grow?

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- Food and nutrients (media)

What does a bacterial cell need to grow?

- Food and nutrients (media)
- Space

What does a bacterial cell need to grow?

- Food and nutrients (media)
- Space
- Waste removal

What does a bacterial cell need to grow?

- Food and nutrients (media)
- Space
- Waste removal
- Anything else?

Batch culture

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- The simplest way to grow a population of bacteria

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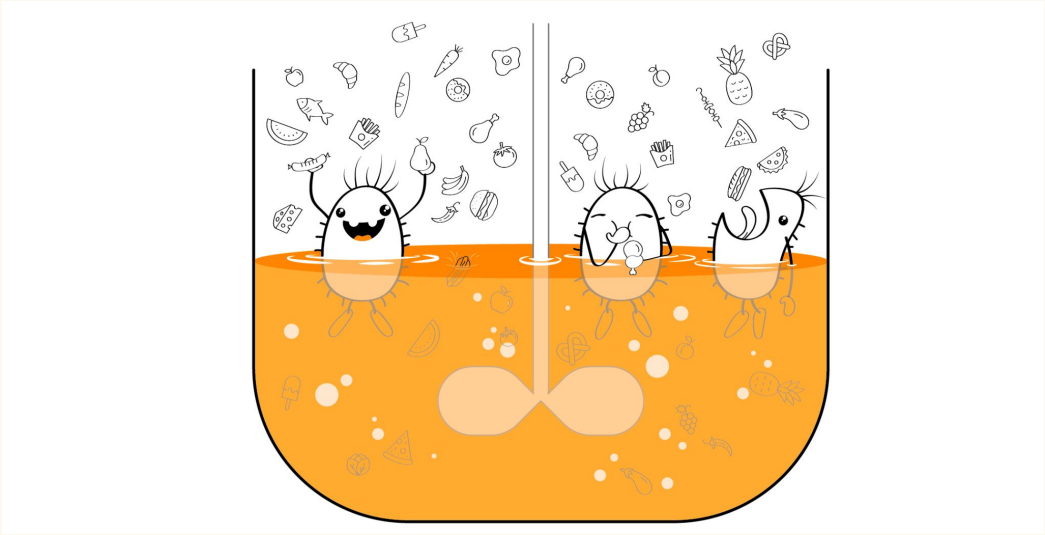
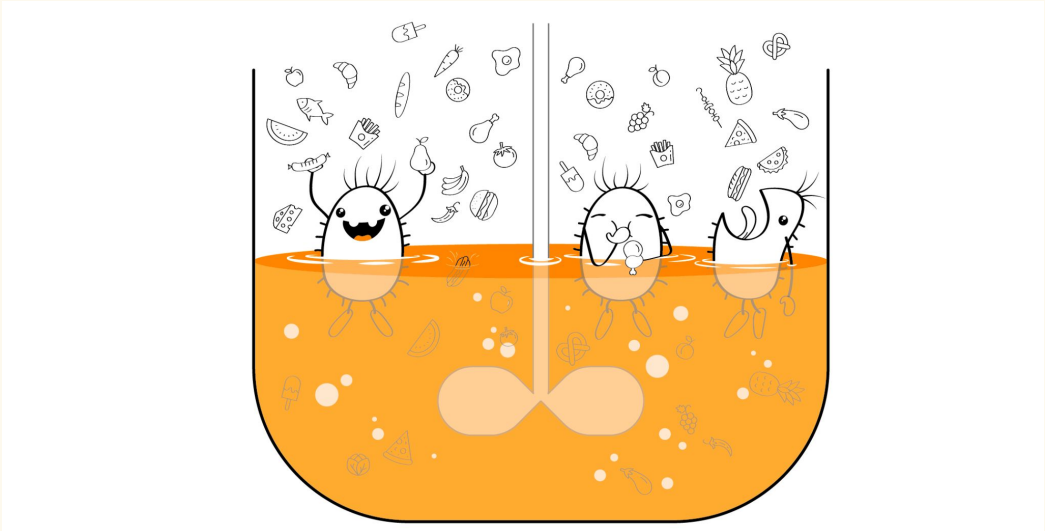


Batch culture

- The simplest way to grow a population of bacteria
- A liquid medium within a closed system
- Any predictions?



Stage 1: Lag

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Bacteria are preparing for growth

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Bacteria are preparing for growth
May be adjusting to a new environment or learning how to get energy from a new medium

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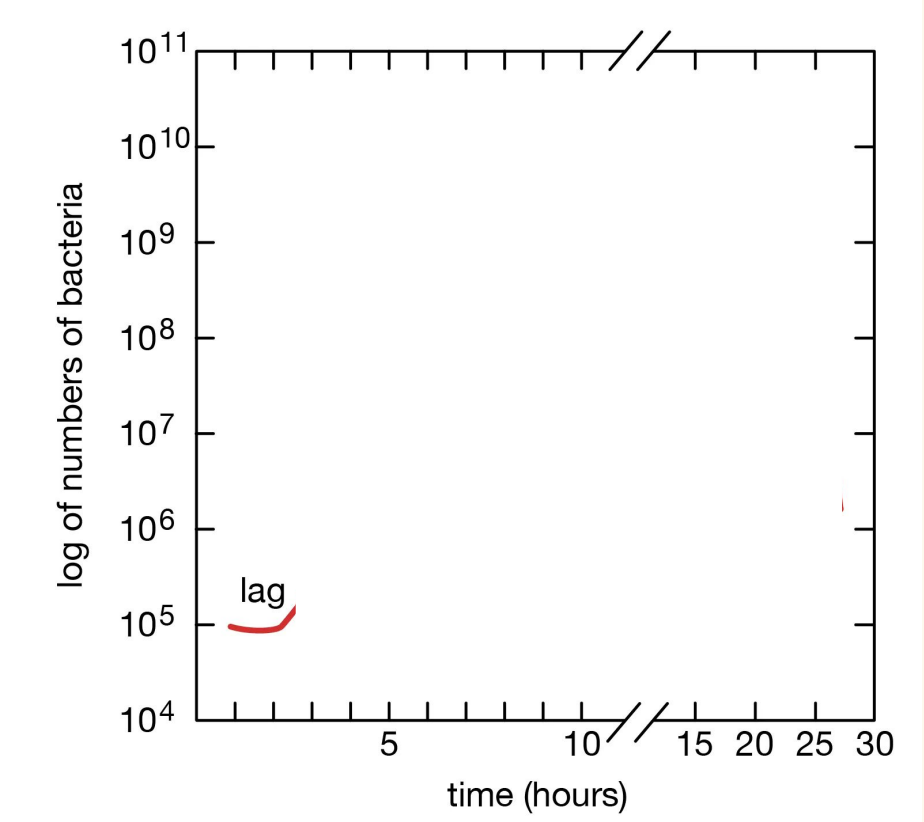

Stage 2: Log

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Bacteria are using their environments at maximum efficiency

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Maximum amount of nutrients with minimal amount of waste

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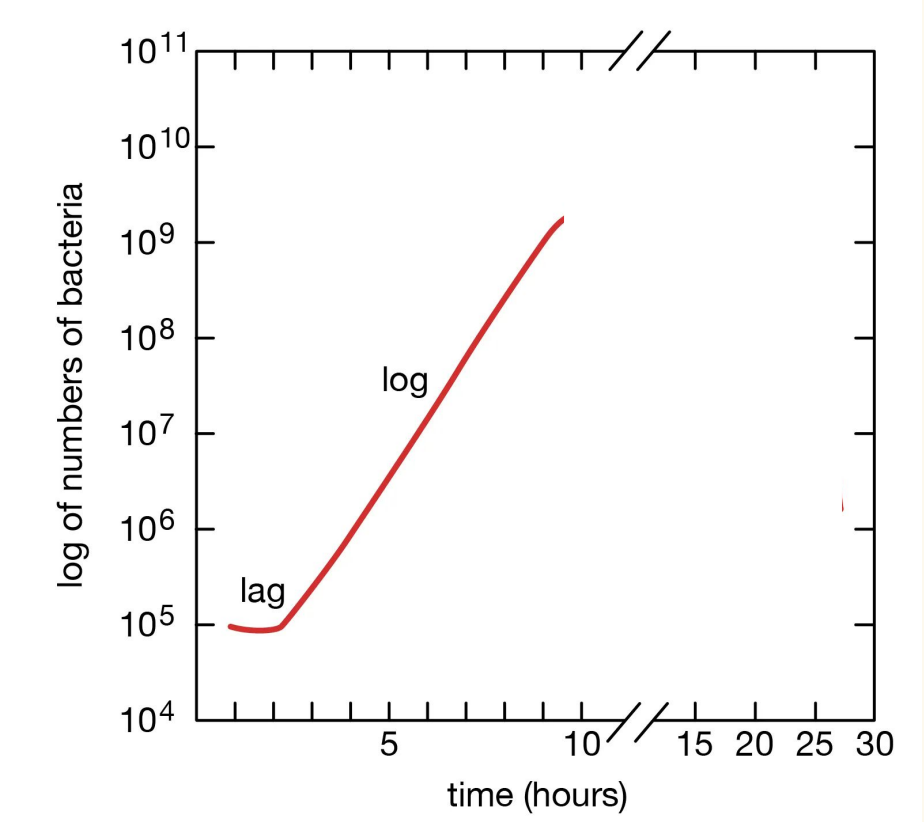

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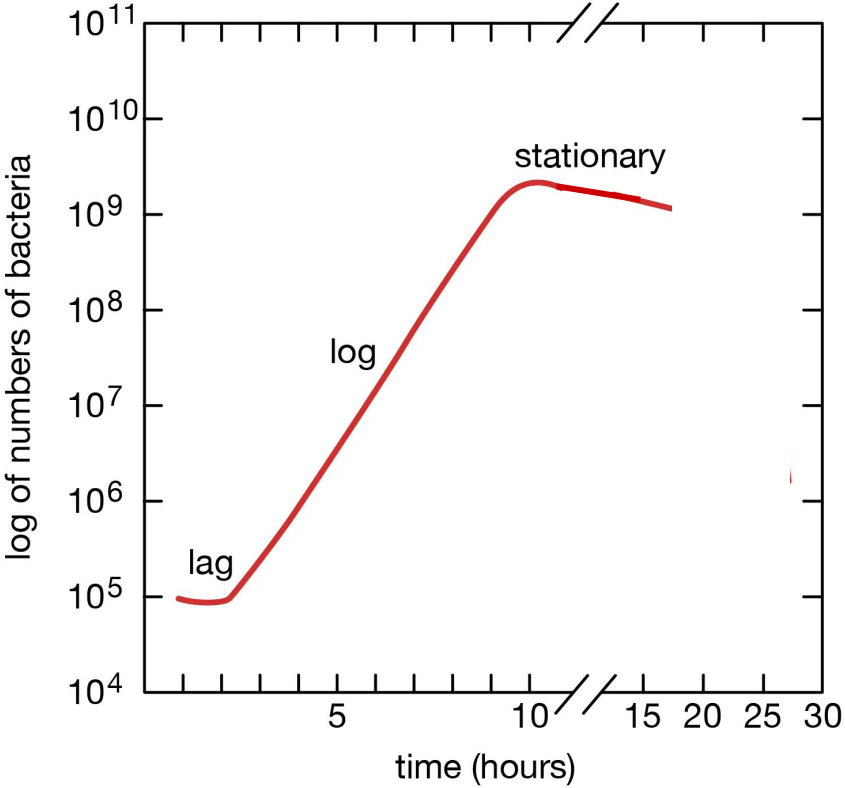

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Stage 4: Death

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Bacteria run out of materials and space

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Bacteria run out of materials and space
Cells begin dying

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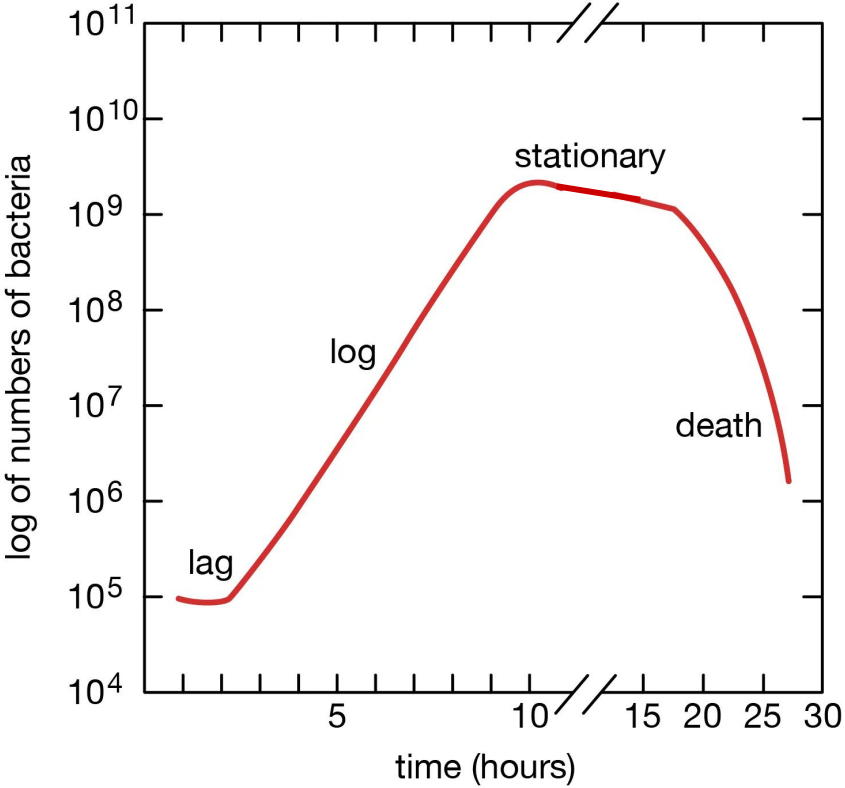
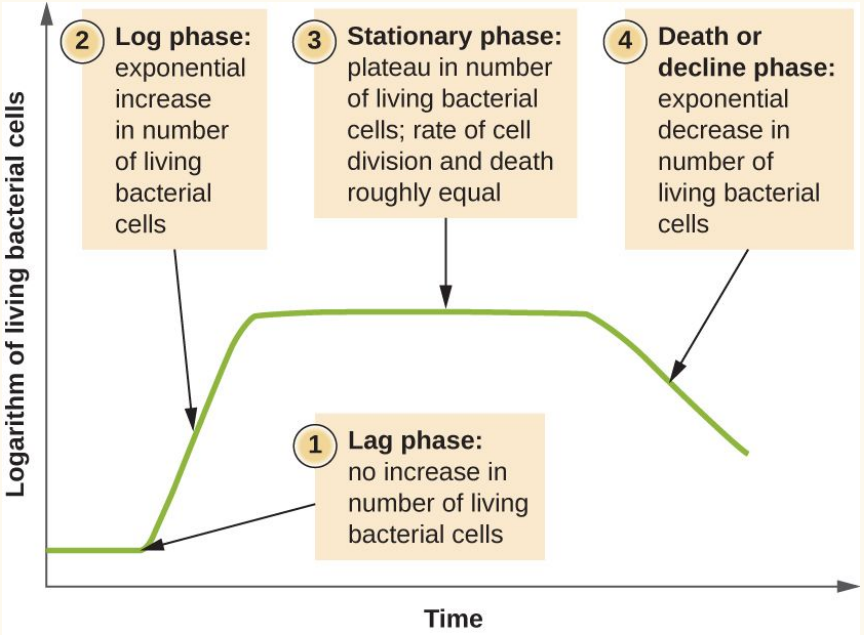


Bacteria run out of materials and space
Cells begin dying
Negative growth observed

Think, pair, share

What can you do to increase the log phase of a batch culture and push back the stationary and death phases?



How do we measure this growth?

Viable count: plate a small representative sample of the culture, then count the number of colonies that can form

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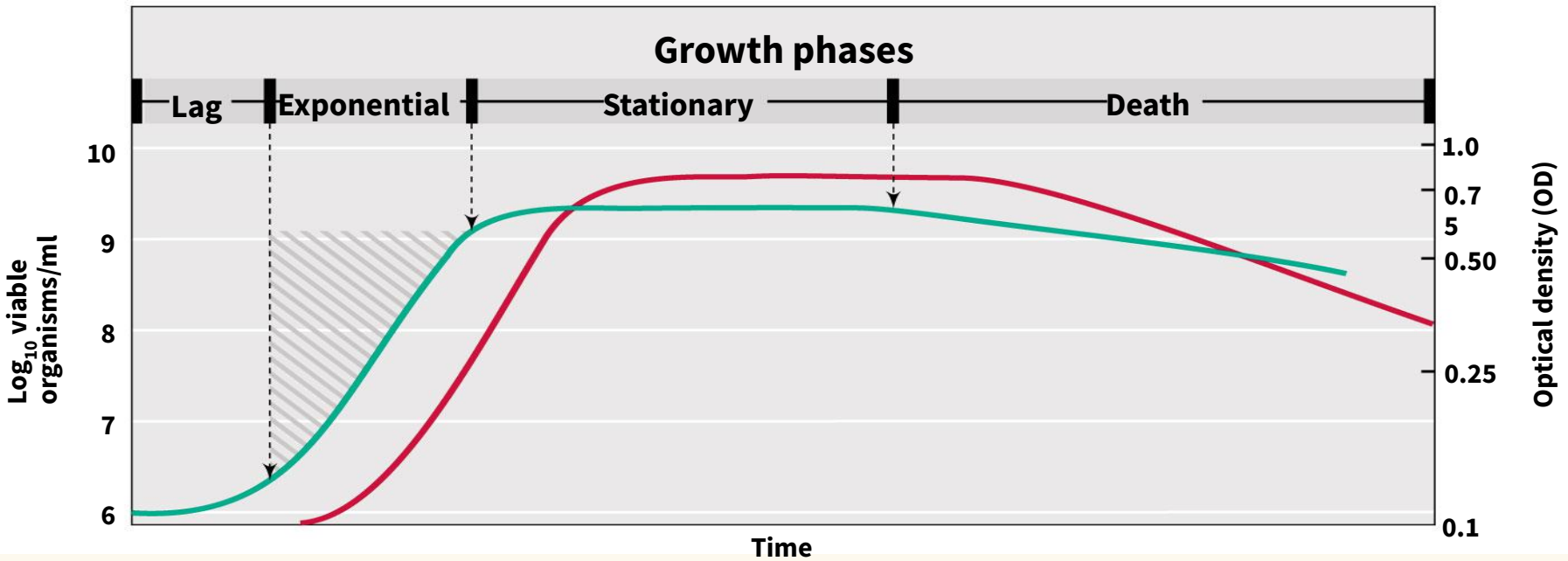
Advantages and disadvantages to these measures?

How do we measure this growth?



Which line represents measuring through cell viability, and which represents measuring through turbidity?

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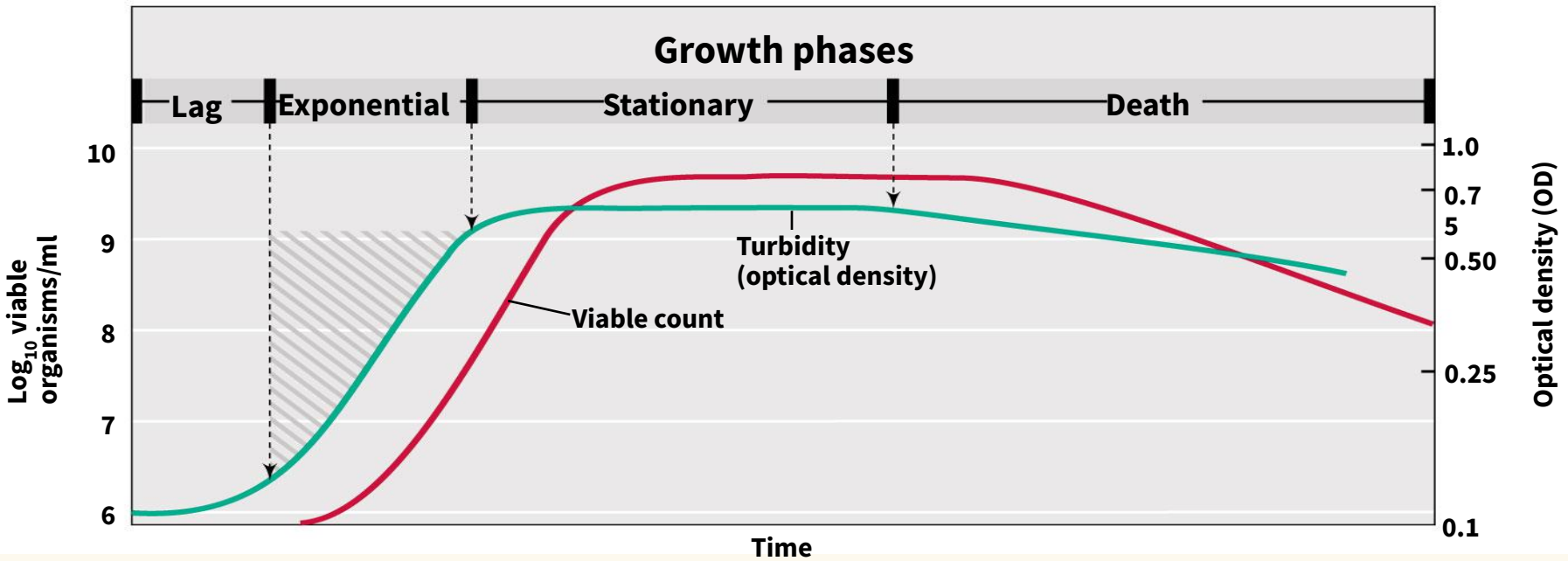

Biofilms!

(A special type of growth)

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What do we know about biofilms?

Biofilm

Definition: a surface-associated microbial community, protected by an extracellular matrix

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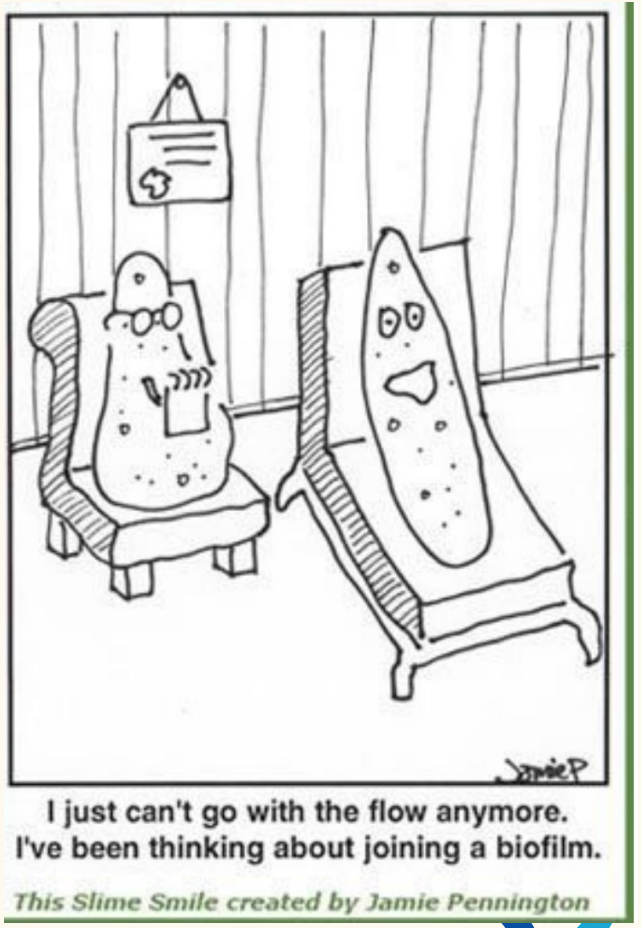

Biofilm

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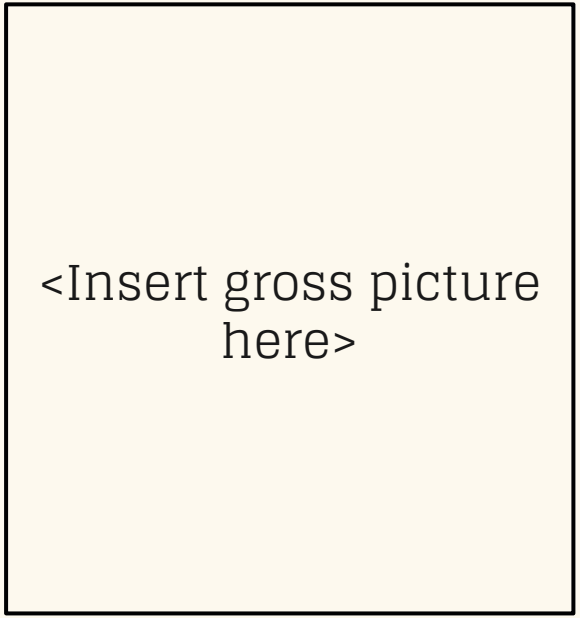

Biofilm

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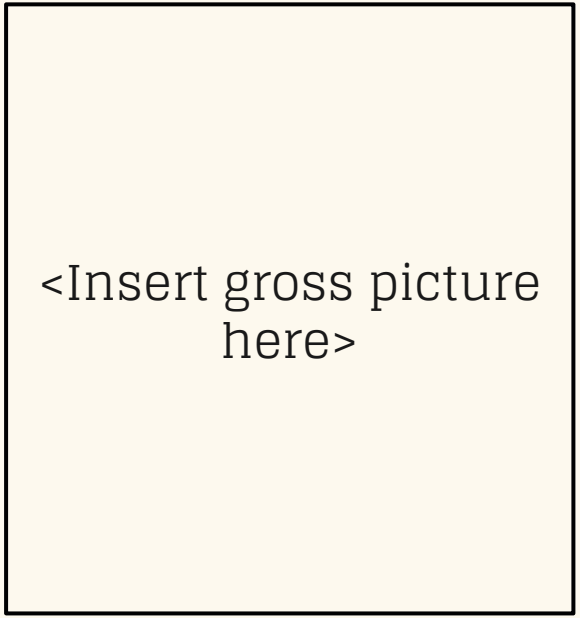
Found in streams, oceans, medical instrumentation, even your own mouth



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Three key steps, which are found in pretty much all biofilm-forming species (highly conserved)

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Secret fourth step: dispersal

Imagine you're a *Pseudomonas aeruginosa* cell...

Step 1: Attachment

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Need **flagella** and **pili** in order to attach to the surface and spread

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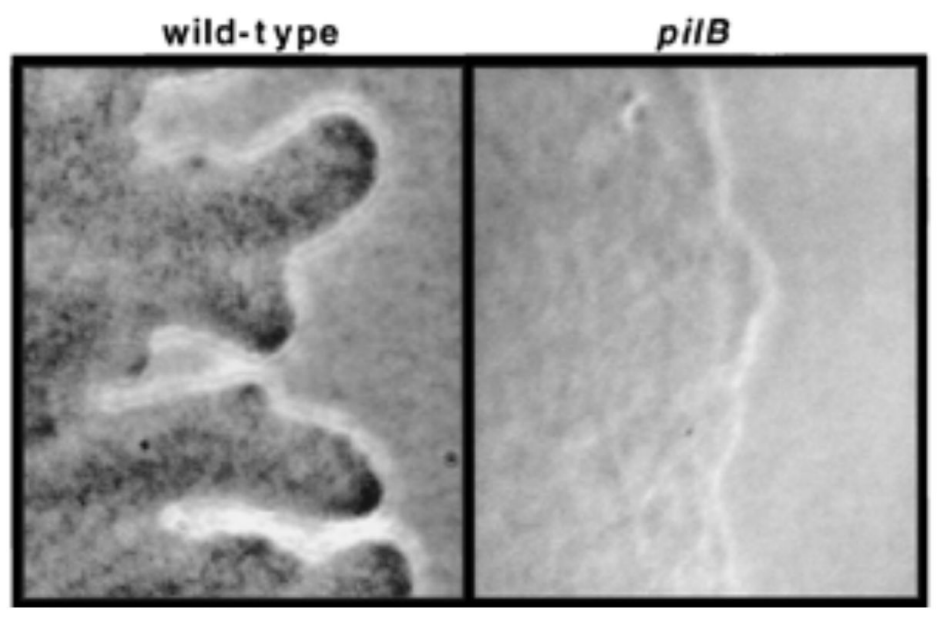

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Need **flagella** and **pili** in order to attach to the surface and spread

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Performed by a cell in its **swimmer** state

Step 2: Matrix

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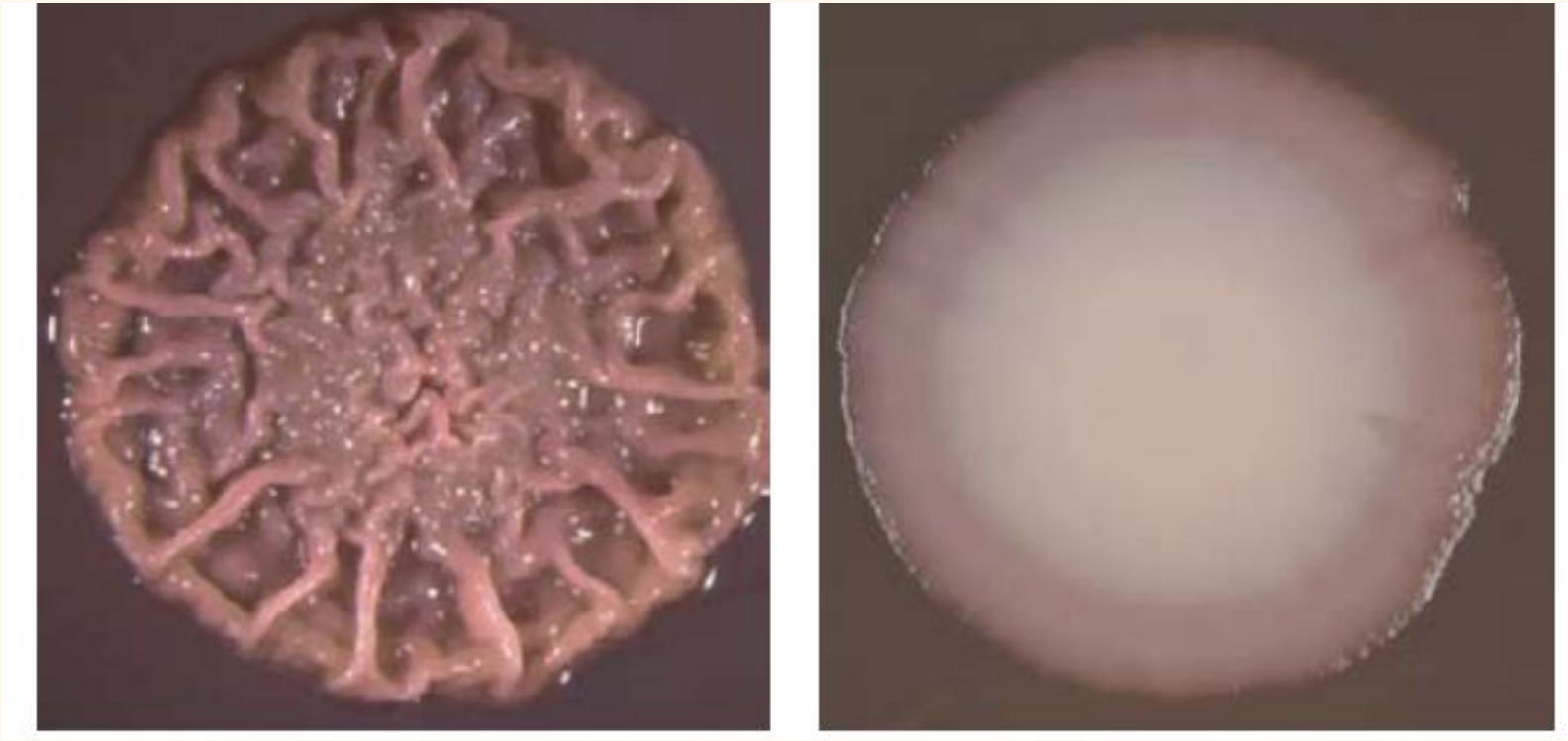
Secondary metabolites: not necessary for cell growth, reproduction, or development

Exopolysaccharides: a specific type of sugar polymer

How could you disrupt this step of biofilm formation?

Step 2: Matrix



Step 3: Multicellular Complex

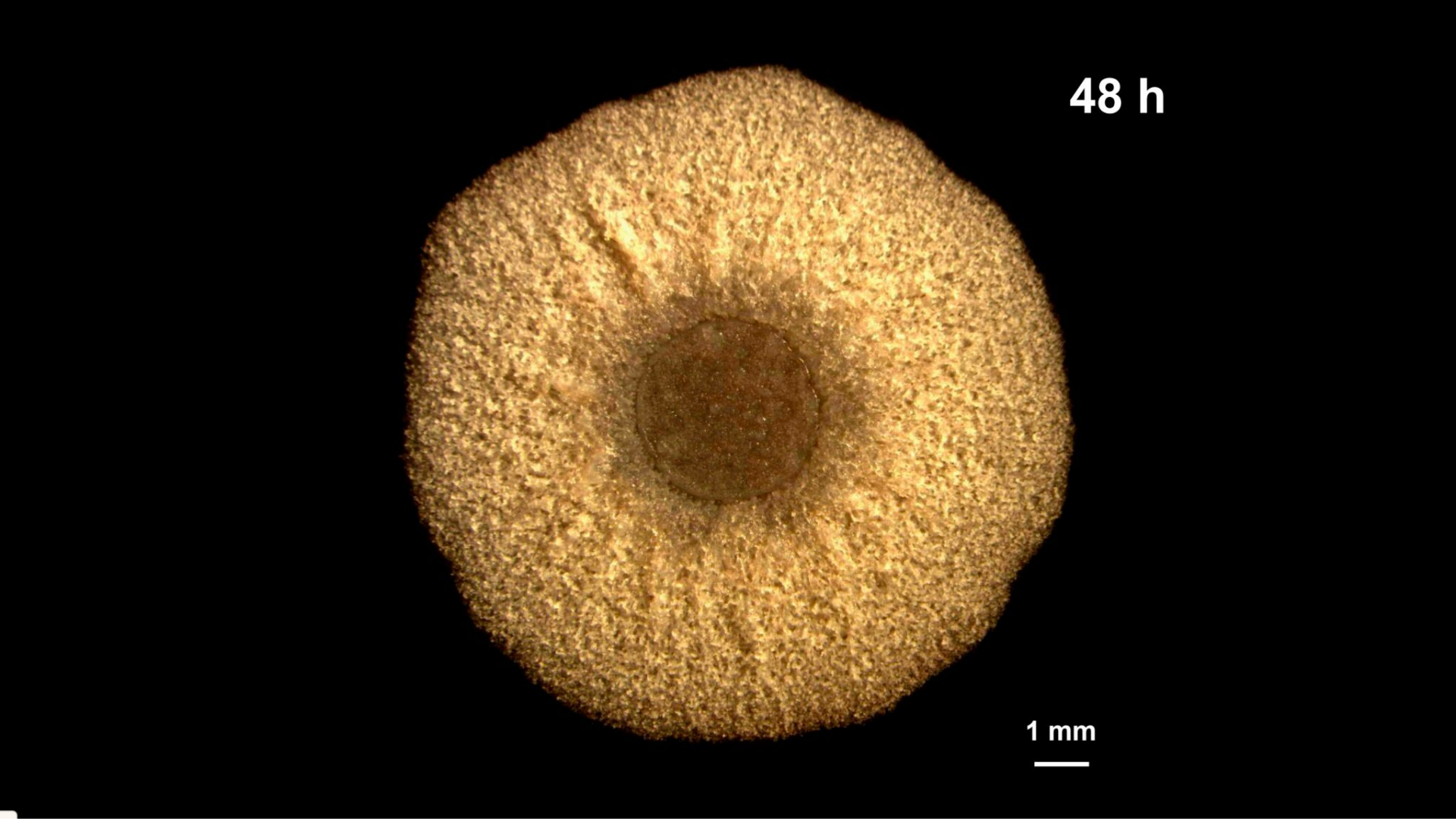
A series of snapshots...

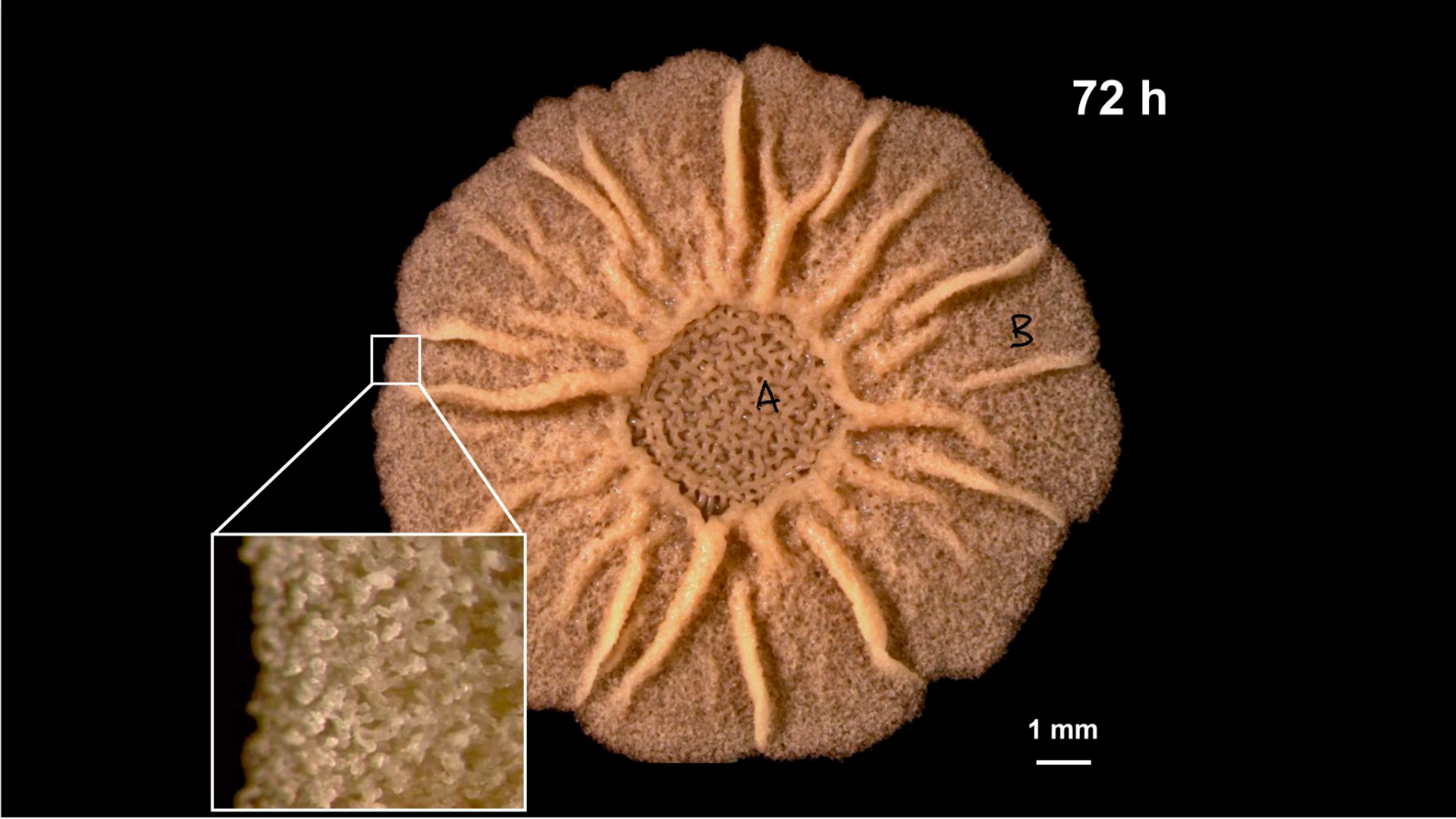
B. subtilis biofilm on agar

12 h

1 mm


24 h
1 mm


48 h
1 mm


72 h
A
B
1 mm

Step 3: Multicellular Complex

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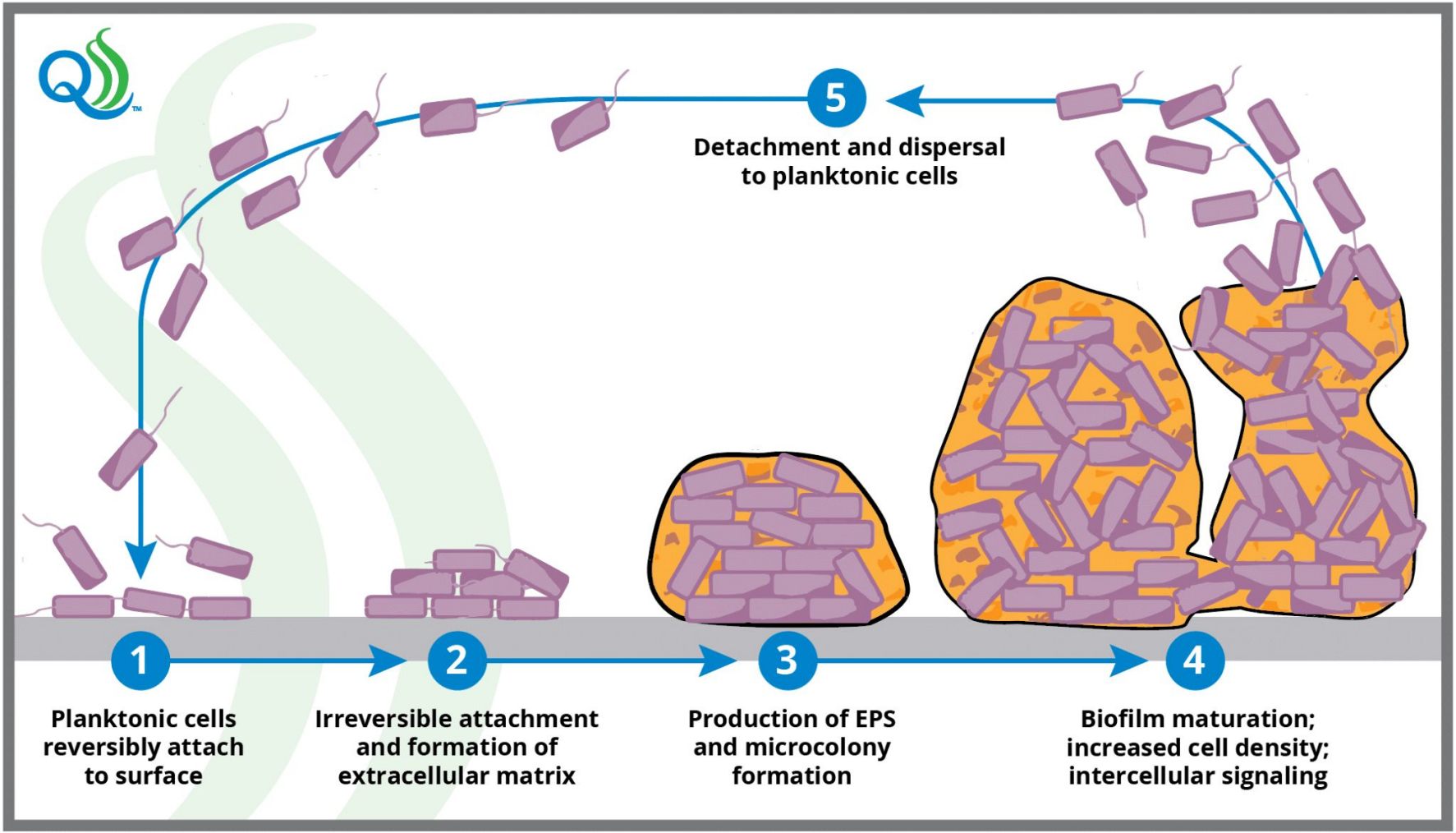
Why might cells want to leave a biofilm behind?

What resources or abilities might they need?


5
Detachment and dispersal to planktonic cells
1
Planktonic cells reversibly attach to surface
2
Irreversible attachment and formation of extracellular matrix
3
Production of EPS and microcolony formation
4
Biofilm maturation; increased cell density; intercellular signaling

Assessment

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Prompt: You're working with *Candida albicans*, a yeast species that often causes infection in humans. You're trying to design a culture system that will grow a large amount of cells, keep them happy and satisfied, but prevent biofilm formation. Describe the kinds of nutrients that will be available, the environmental conditions, and any other things you might do to this system to meet these goals.