

A221 Microbiology

Problem 9 Let's talk

6th Presentation



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IN TODAY'S PROBLEM

- *Aliivibrio fischeri* are marine bacteria that produce bioluminescence.
- *A. fischeri* was cultured in the laboratory to study its ability to make light.
- Photos of *A. fischeri* cultures taken at various time points at different bacterial concentration were shown.
- Your task today is to account for the observations noted at various time points when *A. fischeri* was cultured.

WHAT DO YOU RECOGNIZE?

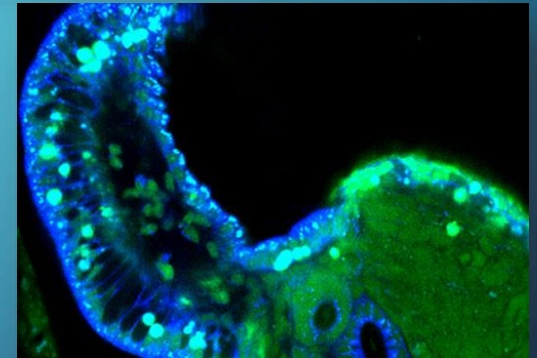
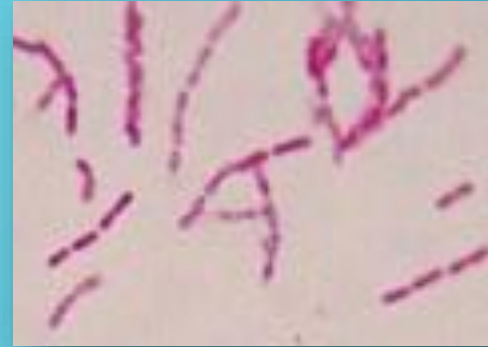
- *Aliivibrio fischeri* are marine bacteria that produce bioluminescence.
- *A. fischeri* can be cultured in the laboratory.
- The concentration of *A. fischeri* increases with time.
- Bioluminescence of *A. fischeri* is only observed at high concentration of *A. fischeri*.

AN APPROACH TO THE PROBLEM...

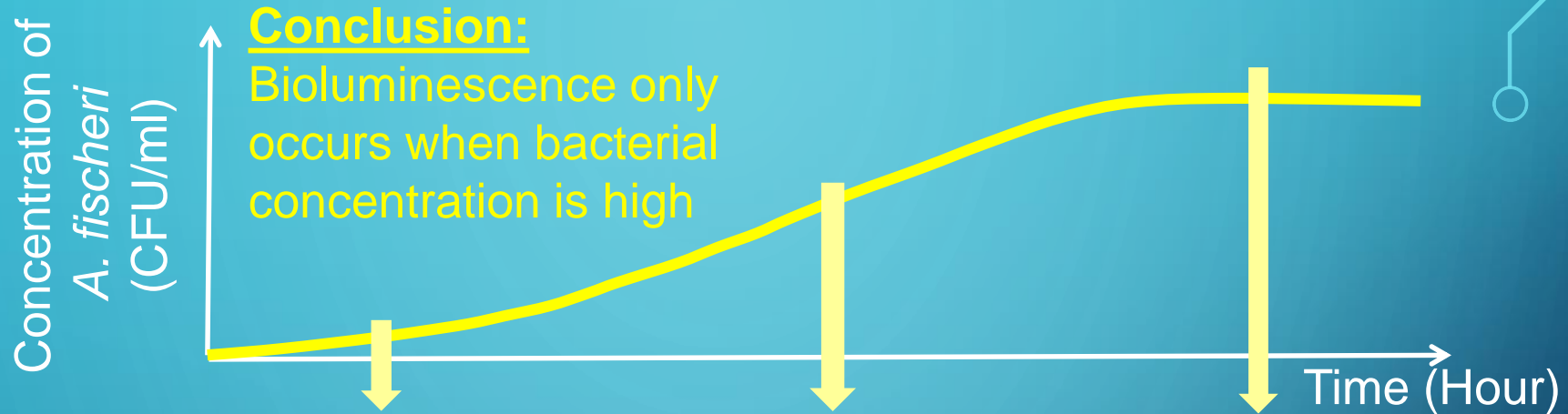
- What are the characteristics of *A. fischeri*?
- What is the relationship between *A. fischeri* concentration and bioluminescence?
- What determines the ability of *A. fischeri* to produce bioluminescence?
- What is this phenomenon of bacterial communication called?
- Is there any difference between quorum sensing in Gram-negative and Gram-positive bacteria?
- How does *A. fischeri* produce bioluminescence?
- Answering to the Problem
- *Another example of bacterial communication? – Biofilm*

What are the characteristics of *A. fischeri*?

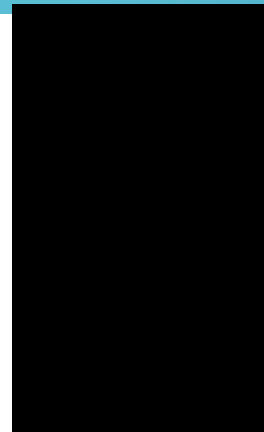
- Gram-negative rod shaped bacterium
- Found in marine environments
- Exist in both free-living and symbiotic state with macro-organisms
- Major source of bioluminescence



Relationship between the concentration of *A. fischeri* and bioluminescence



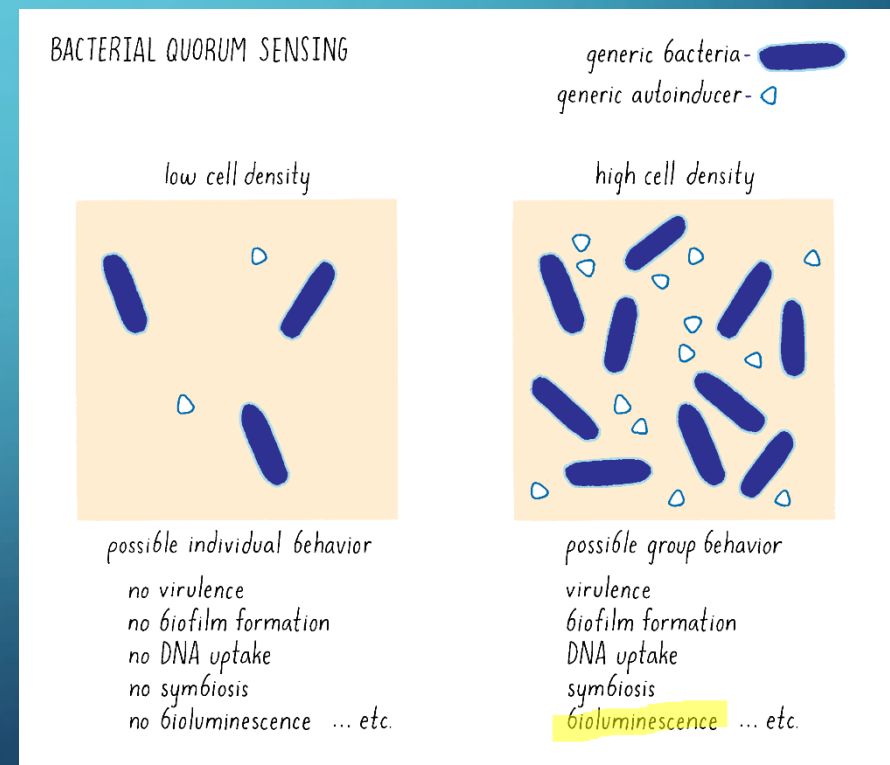
Photos of *A. fischeri* cultures taken at various time points



Bacterial Concentration	Low	Intermediate	High
Bioluminescence	No	No	Yes

What determines the ability of *A. fischeri* to produce bioluminescence?

- There is intercellular communication among *A. fischeri* using signal molecules called **autoinducers**.
- The level of autoinducers is **proportional to** the number of bacteria in the environment.
 - At low bacterial concentration, there is a **basal production** of autoinducers
- High level of autoinducers will trigger a **group response/behaviour** (e.g. bioluminescence) involving gene activation or gene deactivation.

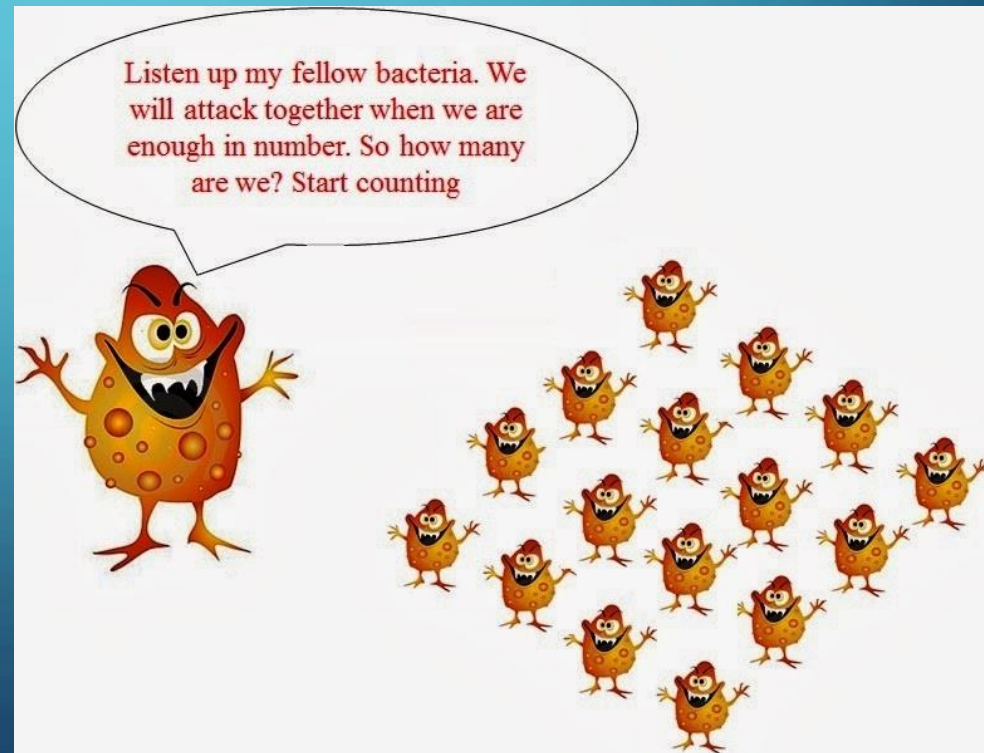


What is this phenomenon of bacterial communication called?

Quorum Sensing

The phenomenon whereby the accumulation of autoinducers enable a single cell to sense the number of bacteria (cell density).

Cell behavior changes only when a certain population density, or a threshold concentration of autoinducers is reached.

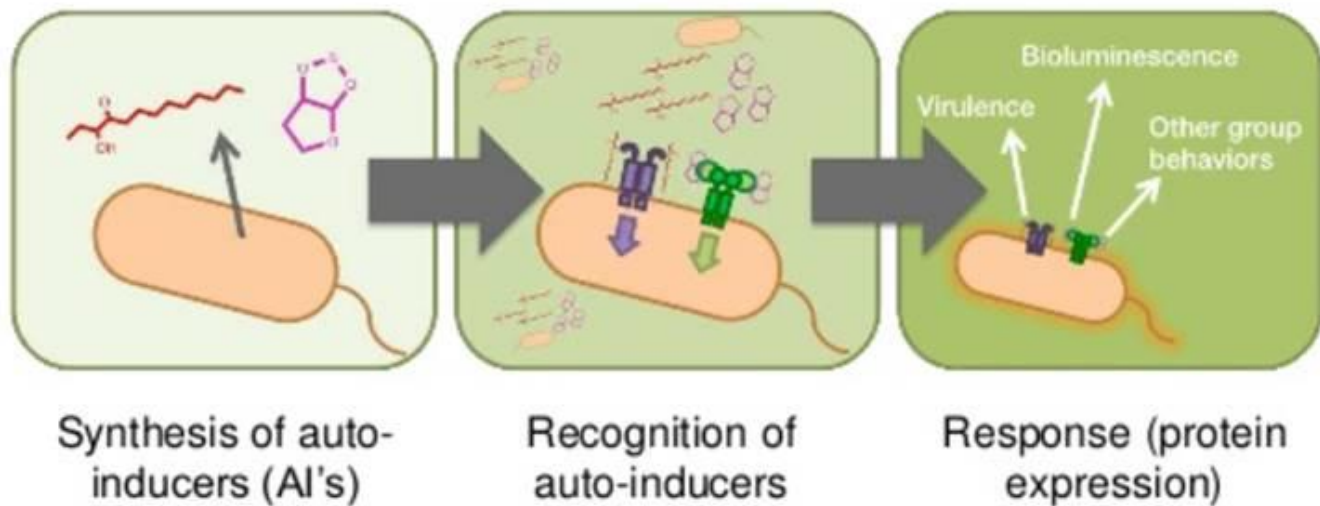


Overview of the mechanism of Quorum Sensing

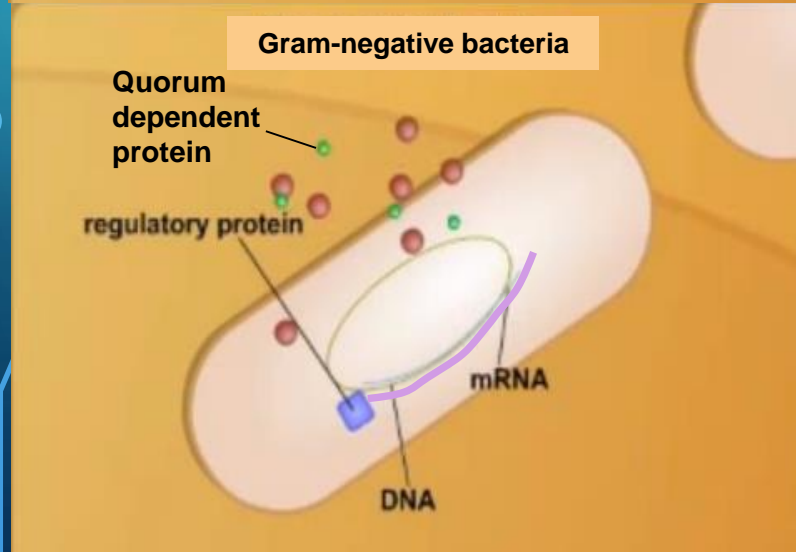
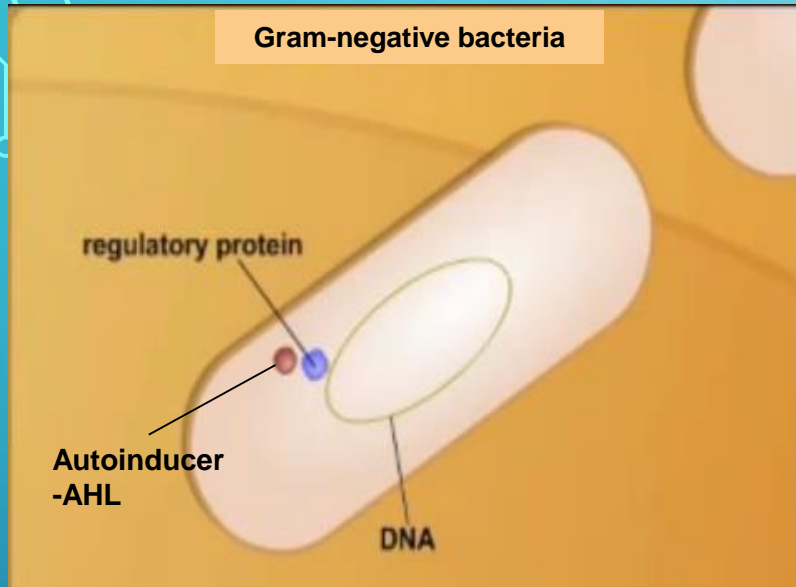
MECHANISM OF QUORUM SENSING

[Clip slide](#)

OVERVIEW



Is there any difference between quorum sensing in Gram-negative and Gram-positive bacteria?

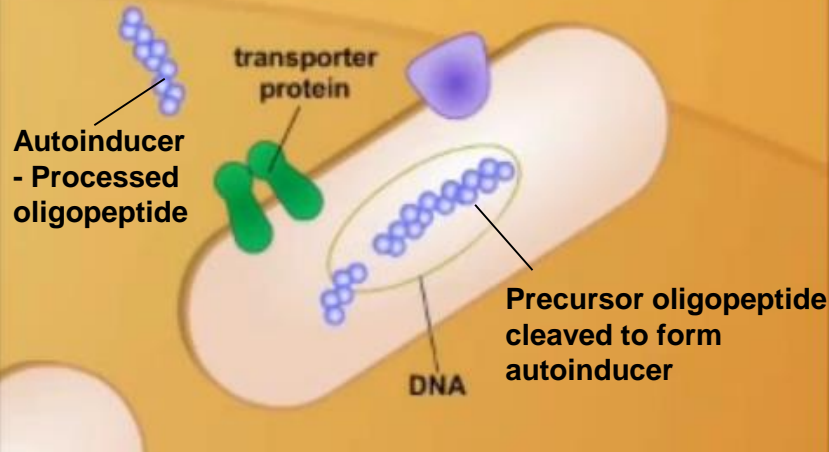


Gram-negative bacteria

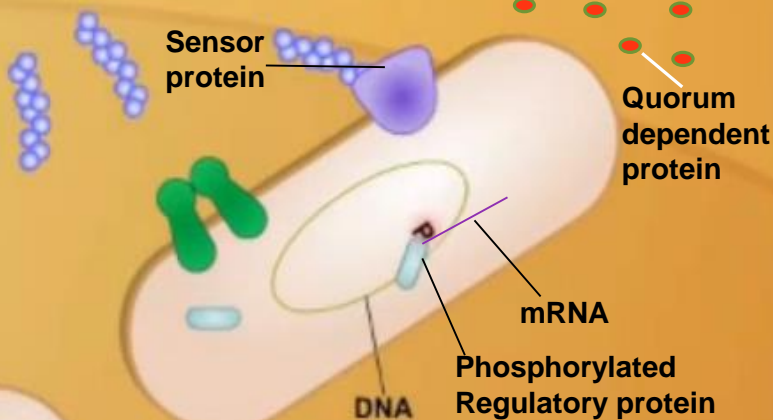
- Use **Acyl homoserine lactone (AHL)** to communicate between Gram-negative bacteria.
- When AHL reaches threshold concentration, it will bind to and activate the regulatory protein in the cytoplasm.
- Activated regulatory protein may activate or deactivate gene expression.
- Activation of gene expression may result in the production of quorum-dependent proteins and more enzyme to produce AHL.

Is there any difference between quorum sensing in Gram-negative and Gram-positive bacteria?

Gram-positive bacteria



Gram-positive bacteria

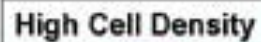


Gram-positive bacteria

- Use **processed oligopeptide/ Autoinducing peptide (AIP)** to communicate between Gram-positive bacteria.
- First, precursor oligopeptide is cleaved to form AIP, which is transported out of the cell.
- When AIP reaches threshold concentration, it will bind to and activate the membrane bound sensor protein.
- Activated sensor protein will activate regulatory protein, which may activate or deactivate gene expression.
- Activation of gene expression may result in the production of quorum-dependent proteins and AIP.

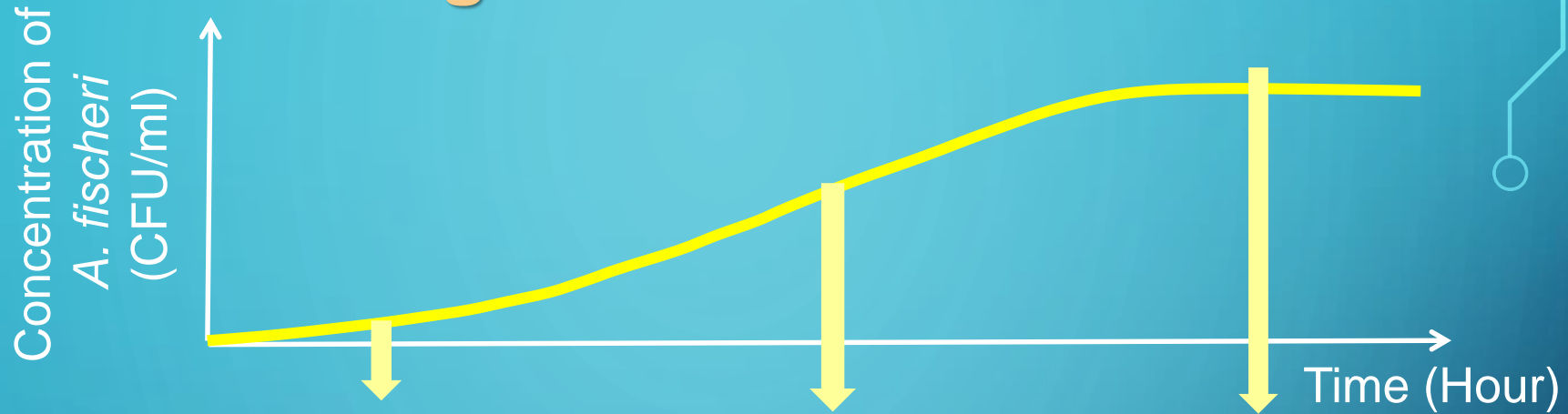
A. fischeri

Low Cell Density

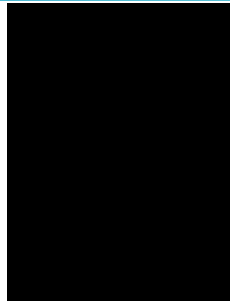


- High concentration of *A. fischeri* produces high amount of AHL.
- When AHL reaches threshold concentration, it will bind to and activate the regulatory protein, **Lux R**.
- Activated Lux R will initiate gene expression to produce more quorum-dependent protein (i.e. **luciferase**) and more enzyme to produce AHL (i.e. **Lux I**)

Answering the Problem Statement

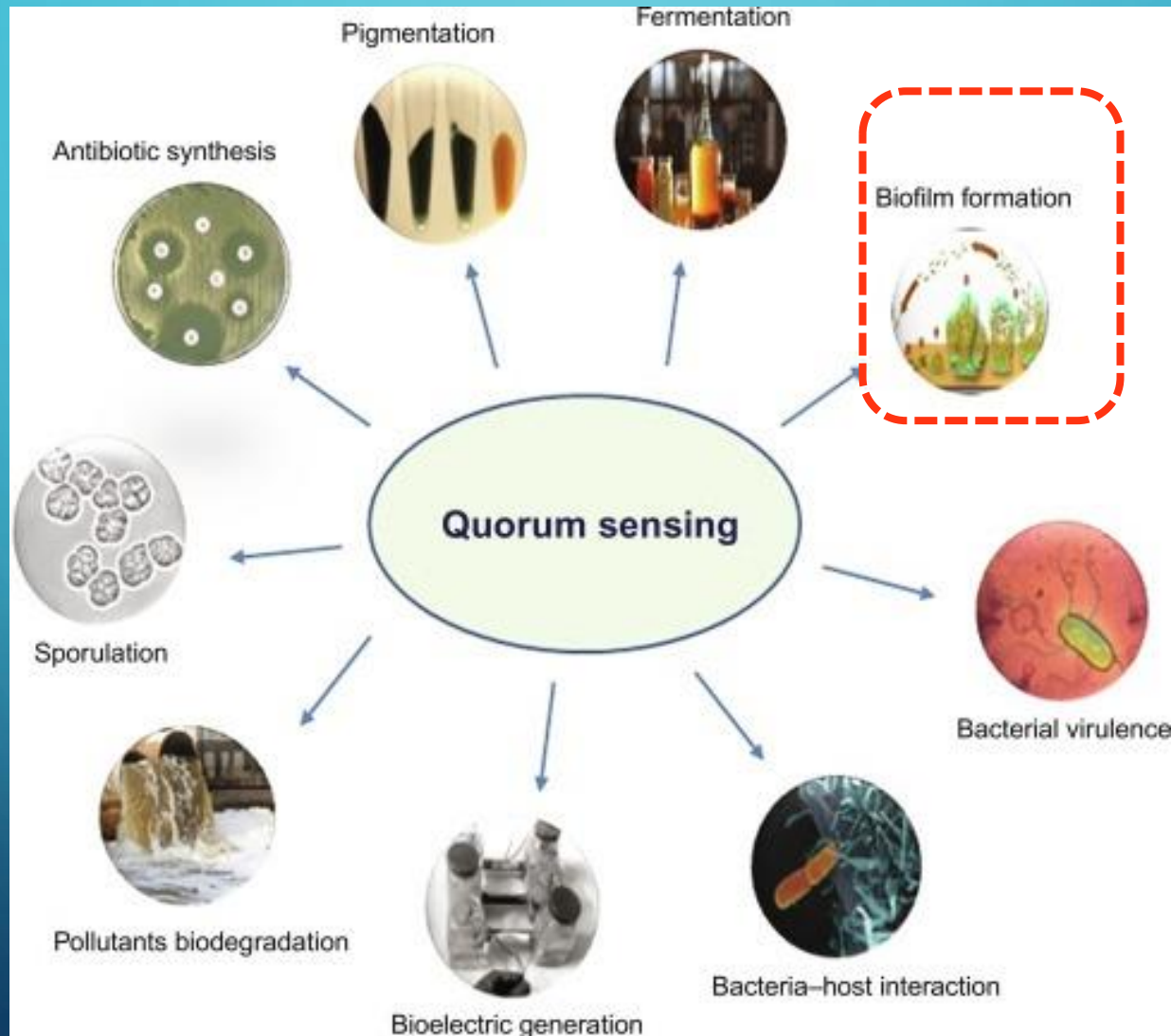


Photos of *A. fischeri* cultures taken at various time points



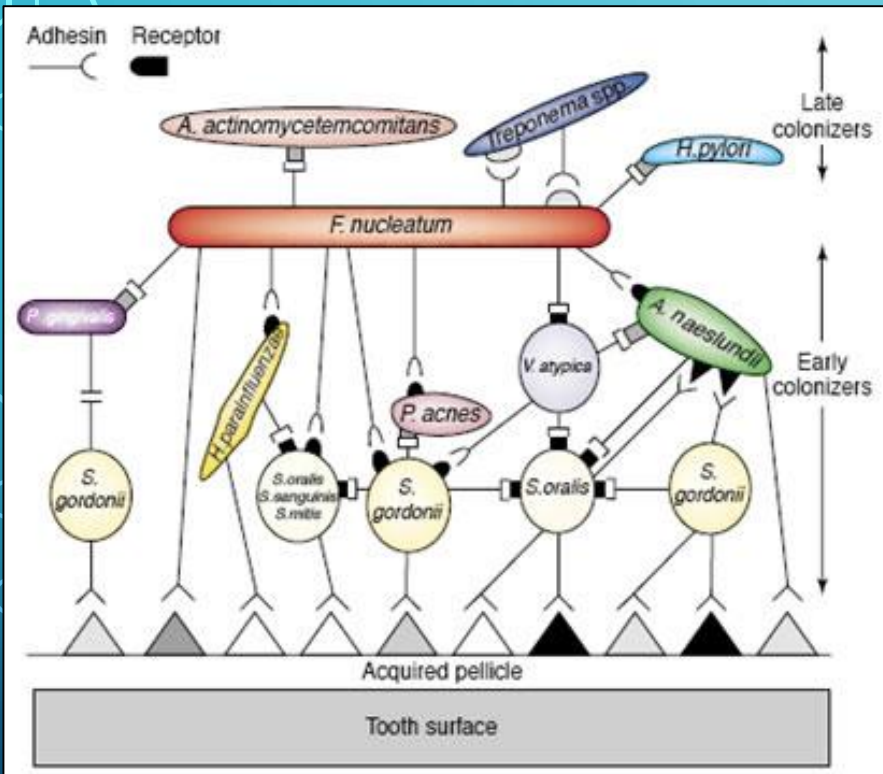
Bacterial Concentration	Low	Intermediate	High
AHL concentration	Low	Intermediate	High (reached threshold concentration)
Luciferase gene	Off	Off	On
Bioluminescence	No	No	Yes

Other examples of group response to quorum sensing

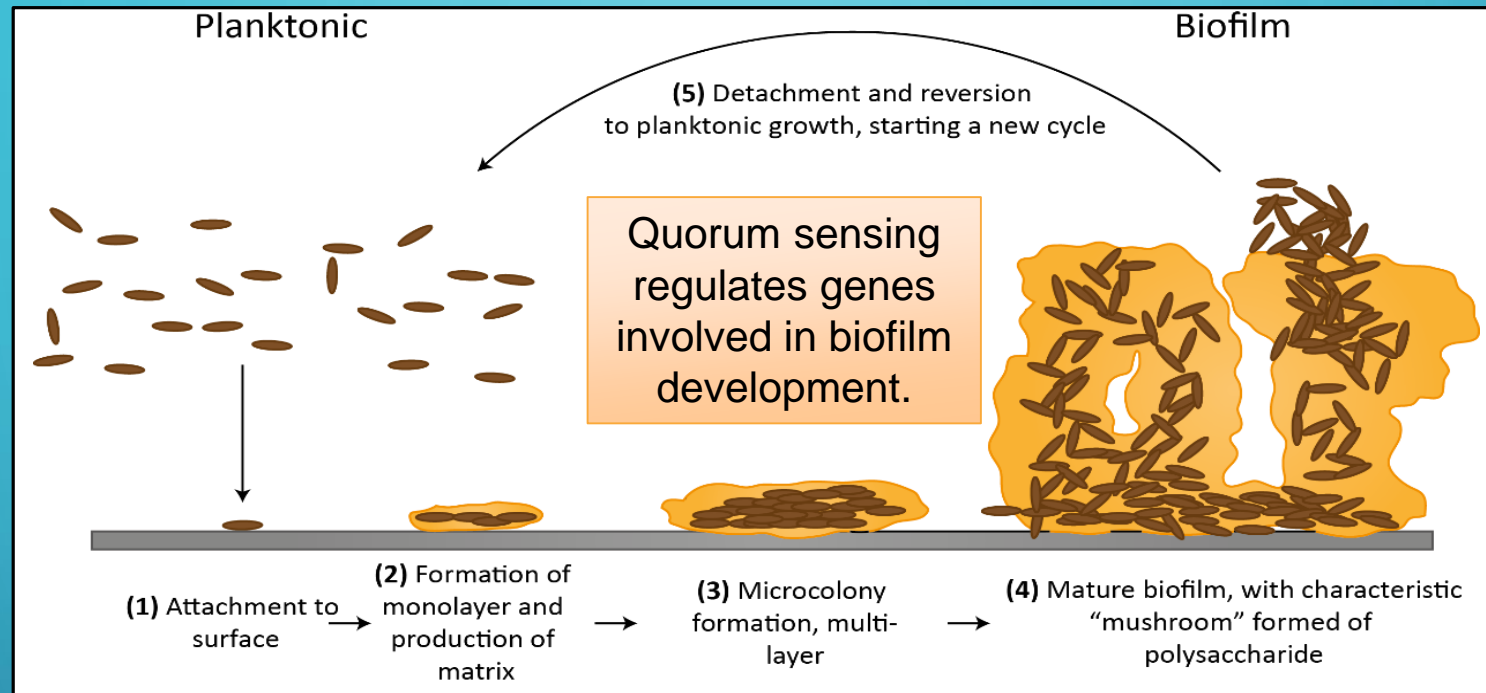


Biofilm formation

- Biofilm is an **aggregate of microorganisms** where bacteria adhere to each other **on a surface**.
- May consist of **more than one type of microorganisms**.
- Different species might be able to communicate to one another** through communication signals that are very similar.



Benefits of the biofilm to microorganisms



- Extracellular polymeric substances (EPS) provide mechanical support and anchorage, as well as protection from external environment (e.g. desiccation or antibiotics).
- Allow synergistic growth.
- Genetic material exchange may enhance survivability (e.g. transfer of genes responsible for antibiotic resistance).

WHAT HAVE YOU LEARNT? (PART I)

- Explain how microbes communicate within their community
 - Know that bacteria can communicate with each other
 - Discuss the significance of quorum sensing bacterial communication
 - Explain the mechanism of quorum sensing
 - Describe how quorum sensing can result in gene activation or deactivation
- Explain the role of signal molecules in quorum sensing
 - Know that autoinducers are signal molecules.
 - List the communication signals used by Gram-negative and Gram-positive bacteria
 - Explain that similar signal molecules can be used for communication between different microorganisms
 - Associate the level autoinducers to the concentration of bacteria in the environment
 - Explain how high level of autoinducers will result in behavioral change of the bacteria in the community

WHAT HAVE YOU LEARNT? (PART II)

- Discuss how quorum sensing control the production of bioluminescence in *A. fischeri*
 - Describe the relation between *A. fischeri* concentration and the level of AHL
 - Explain how the level of AHL affects the production of bioluminescence in *A. fischeri*
- Describe how microbes benefit by forming community
 - Describe the role of microbial communication in the formation of bacterial communities
 - List the benefits of communal organization among bacteria