

***BACTERIAL GROWTH:
Diauxic Growth, Synchronous
Growth, Continuous Growth,***

Sivasangari shanmugam

Content

- **Bacterial growth**
- **How do bacteria grow?**
- **Growth affecting factors**
- **Growth phase**
 - **Lag phase**
 - **Log phase**
 - **Stationary phase**
 - **Death phase**
- **Diauxic growth**
- **Synchronous growth**
- **Continuous growth**
 - **Turbidostat**
 - **Chemosat**

Bacterial Growth

- ❖ Growth of bacterial cultures is defined as an increase in the number of bacteria in a population rather than in the size of individual cells.
- ❖ The growth of a bacterial division cycle (generation), one cell gives rise to 2 cells, then 4 cells, then 8 cells, then 16, then 32, and so forth.
- ❖ The time required for the formation of a generation.

How Do Bacteria Grow?

- Bacteria grow only when environment is suitable;
 1. In the lab, we have determined the stage of growth (closed system).
 2. Need a continuous supply of nutrients (closed system).

Factors Affecting Bacterial Growth

INTRINSIC FACTORS

- Moisture content
- Water activity
- pH
- Redox potential
- Available nutrients

EXTRINSIC FACTORS

- Temperature
- Relative humidity
- Co₂ (or) O₂
- Number of organisms in the culture

Growth Bacterial Phase

Lag Phase:

- This initial phase is characterized by cellular activity but not growth.
- A small group of cell are placed in a nutrient rich medium that allows them to synthesize protein and other molecules necessary for replication.
- These cells increase in size, but no cell divition occurs in the phase.

Bacterial Growth Phase

Exponential (Log) Phase:

- After the lag phase, bacterial cells enter the exponential or log phase.
- This is the time when the cells are dividing by binary fission and doubling in numbers after each generation time.
- Metabolic activity is high as DNA, RNA, cell wall components, and other substances necessary for growth are generated for division.
- It is in this growth phase that antibiotics and disinfectants are most effective as these substances typically target bacteria cell walls or the protein synthesis processes of DNA transcription and RNA translation.

Bacterial Growth Phase

Stationary Phase:

- Eventually, the population growth experienced in the log phase begins to decline as the available nutrients become depleted and waste products start to accumulate.
- Bacterial cell growth reaches a plateau, or stationary phase, where the number of dividing cells equal the number of dying cells.
- This results in no overall population growth.
- Under the less favorable conditions, competition for nutrients increases and the cells become less metabolically active.
- Spores forming bacteria produce endospores in this phase and pathogenic bacteria begin to generate substances that help them survive harsh conditions and consequently cause disease.

Bacterial Growth Phase

Death Phase:

- As nutrients become less available and waste products increase, the number of dying cells continues to rise.
- In the death phase, the number of living cells decreases exponentially and population growth experiences a sharp decline.
- As dying cells lyse or break open, they spill their contents into the environment making these nutrients available to other bacteria.
-
- This helps spore producing bacteria to survive long enough for spore production.
- Spores are able to survive the harsh conditions of the death phase and become growing bacteria when placed in an environment that supports life.

Logarithm of living bacterial cells

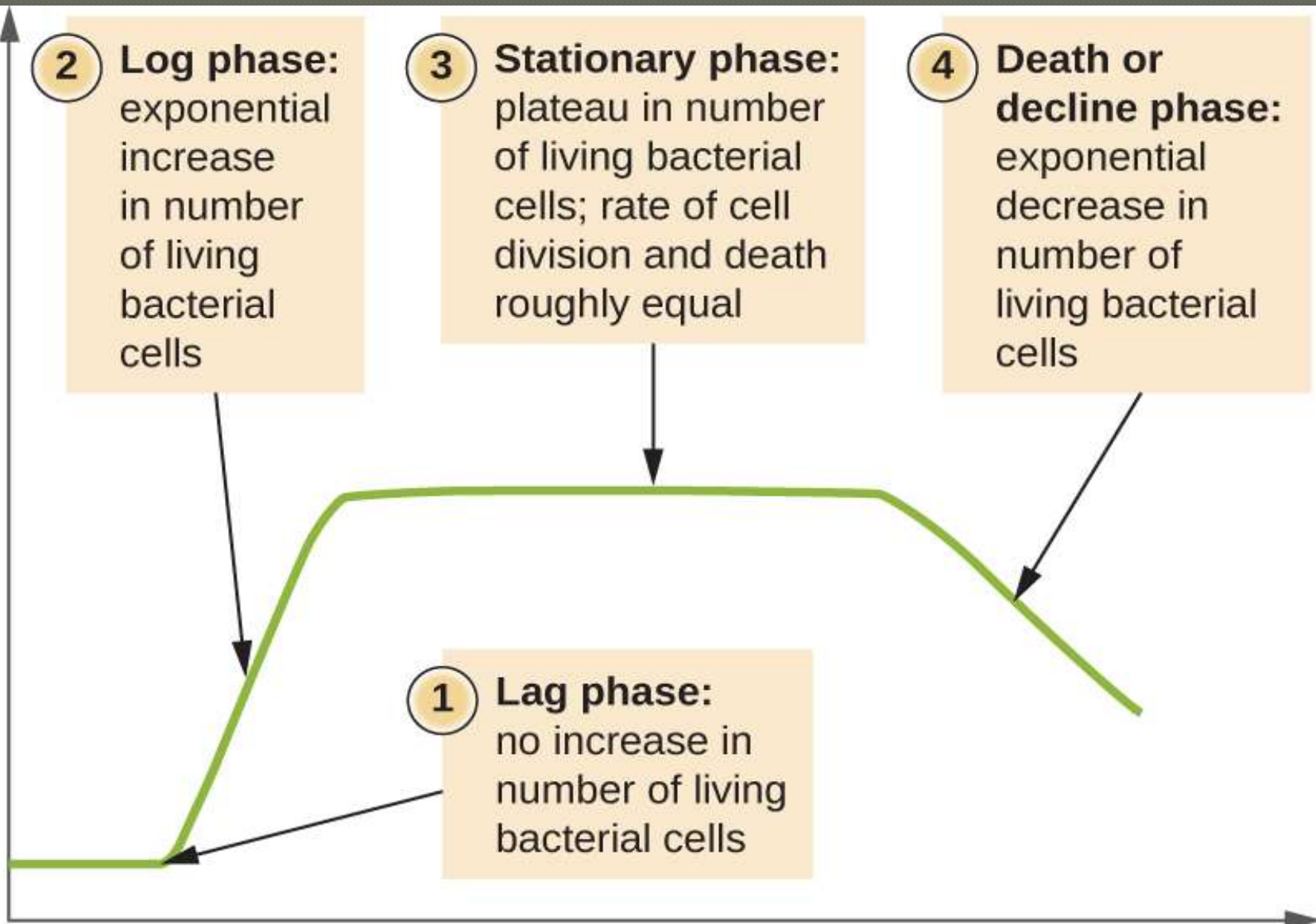
2 **Log phase:**
exponential
increase
in number
of living
bacterial
cells

3 **Stationary phase:**
plateau in number
of living bacterial
cells; rate of cell
division and death
roughly equal

4 **Death or
decline phase:**
exponential
decrease in
number of
living bacterial
cells

1 **Lag phase:**
no increase in
number of living
bacterial cells

Time



Diauxic Growth

- Diauxic growth is a diphasic growth represented by two growth curves intervened by a short lag phase produced by an organism utilizing two different substrates, one of which is glucose.
- When *E. coli* grows in a medium containing both glucose and lactose, it uses glucose preferentially until the glucose is exhausted.
- Then after a short lag phase during which bacterium synthesizes the enzymes needed for lactose use, growth resumes with lactose as a carbon source.
- If this diphasic growth of *E. coli* is plotted in respect to bacterial density against time, two growth curves follow one after the other intervened by a short lag phase to produce a diauxic growth curve.

Diauxic Growth

- The enzyme needed for lactose use is β -galactosidase, which splits lactose into glucose and galactose, and the bacterium utilizes glucose for growth.
- Galactose can also be utilized, but only after it is converted to glucose.
- It has been demonstrated that *E. coli* growing in a medium containing both glucose and galactose produces a diauxic (diphasic) growth curve as in case of glucose and lactose.
- Similar response has been found in case of other sugars such as arabinose, maltose, sorbitol, etc.
- when they are used in combination with glucose by *E. coli*. Each of these sugars is utilized only after glucose has been used up in the growth medium.

Diauxic Growth

- The cause of diauxic growth is complex and not completely understood, it is considered that catabolite repression or the glucose effect probably plays a part in it.
- In catabolite repression of the lac-operon of *E. coli*, glucose exerts an inhibitory effect on the transcription of the lac genes.
- As a result, lactose- utilization enzymes are not synthesized, even if lactose is present in the medium.
- When glucose is completely consumed by *E. coli*, the bacterium is now competent to transcribe the lac-operon genes resulting in production of necessary enzymes that help metabolise lactose.

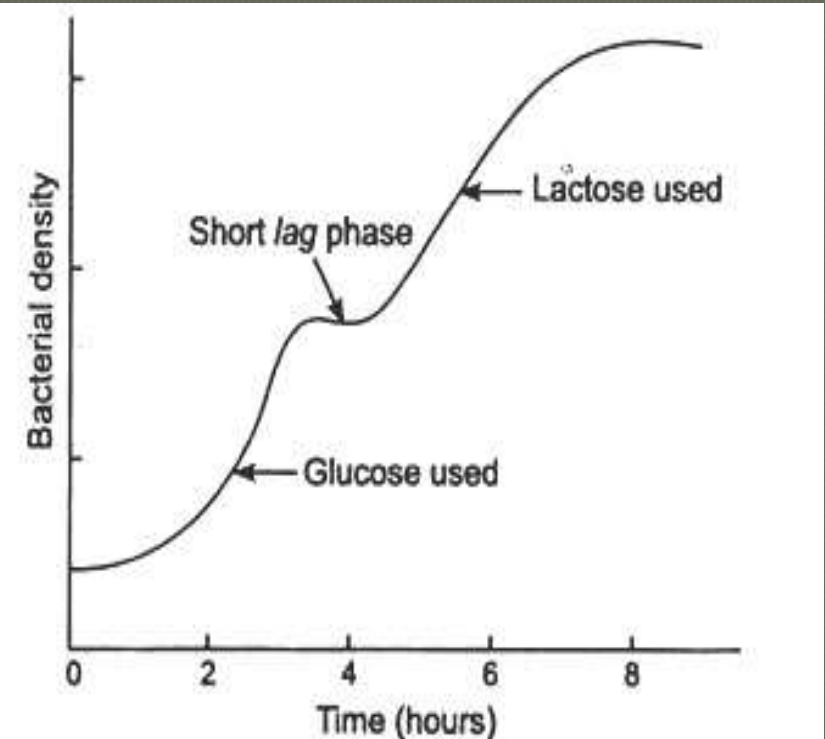
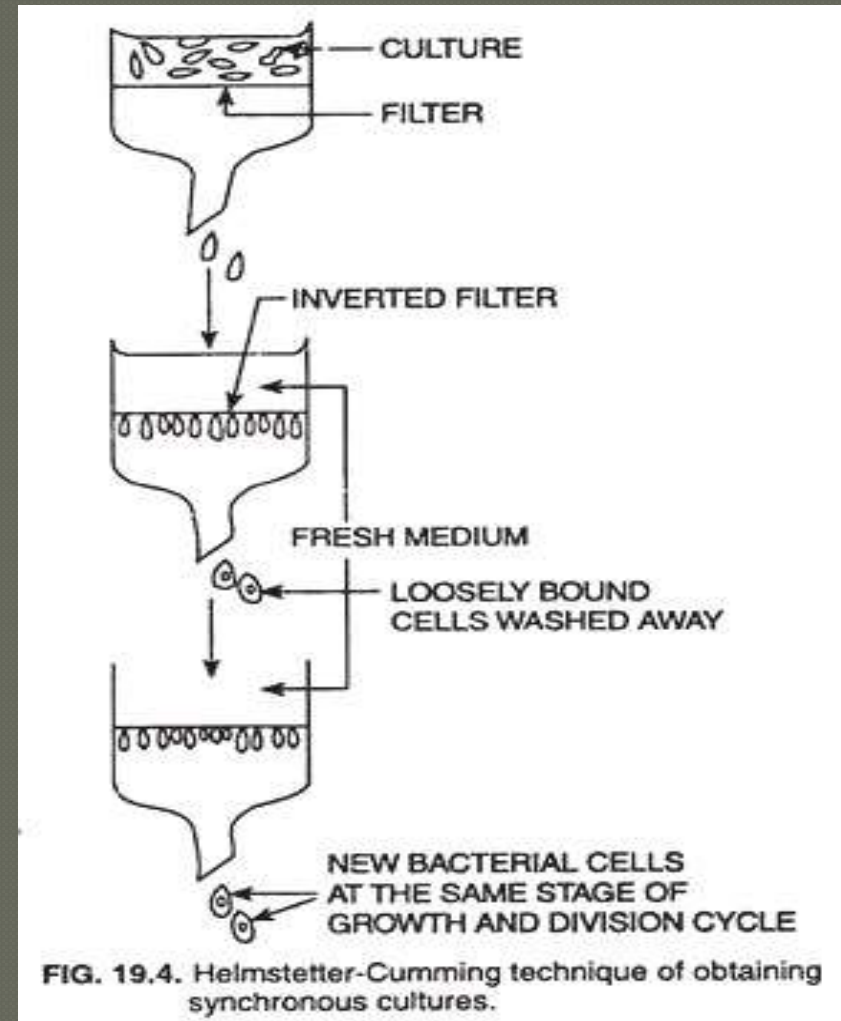


FIG. 19.3. Diauxic or diphasic growth curve of *E. coli* grown with a mixture of glucose and lactose. Glucose is first used, then lactose. A short lag phase in diauxic growth is present during which the bacterium synthesizes the enzymes needed for use of lactose.

Synchronous Growth

- Synchronous growth is the growth of Bacteria such as that all the bacteria are at the same stage in their growth cycle.
- Ex: 1. exponential phase.
2. stationary phase.
- “in a normal batch culture of fluid, or on an agar plate bacteria in the population exhibit a range of sizes, ages and growth rates”

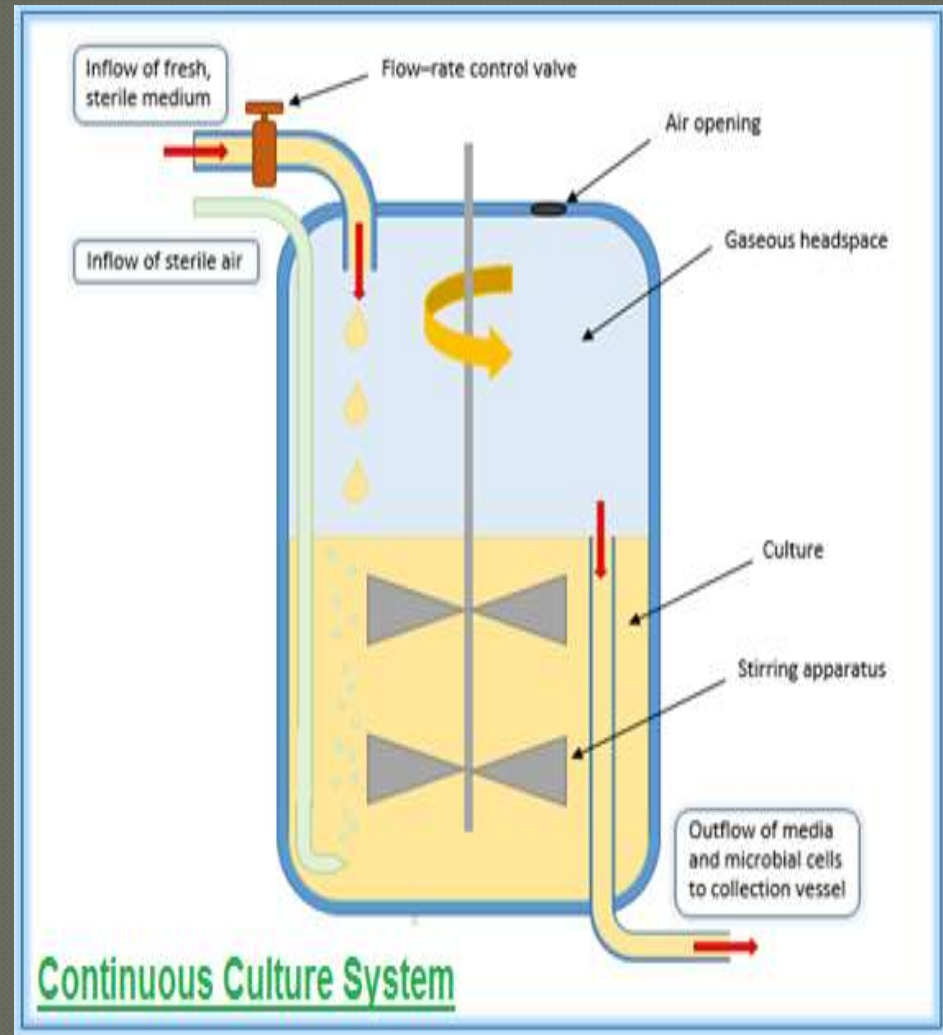


Synchronous Growth

- It means situation in a cell culture when all the **cell are divide at the same time.**
- Important in the study of **genetic** and **metabolism.**
- The easiest way to synchronize bacterial growth is to add some cytostatic agents so that cells don't divide and they all maintain the same state of metabolism and cell cycle.
- When the cytostatic agent is removed, all cells starts to divide at the same time.

Continuous Growth

- A process where inputs and outputs flow continuously through duration of process.
- In continuous processing the reactions are continuous added at one end of the reaction vessel and the products are removed at the other end.



Continuous Growth

- Also called as open system of cultivation.
- In this technique fresh sterile medium is added.
- In this technique bacterial grow continuously heir log phase.
- This growth of the cell density in continuous culture remains contain.
- It is achieved b maintaining consan dilution and flow rate.

Continuous Growth

Advantages :

1. Growth rate can be controlled and maintained.
2. Biomass concentrations can maintained.
3. Effect of changes in physical & chemical parameter can be examined.
4. High productivity of biomass.
5. Good utilization of reactors.
6. Automation may be very appealing.
7. Constant product quality.
8. To study the microbial growth at low nutrient level.

Continuous Growth

- Conjugation of limiting nutrient.
- Products do not accumulates.
- Nutrients are no completely depleted these forms bacterial never reach in stationary phase because fresh nutrients are supplied continuously and end products are removed continuously.

Continuous Growth

Disadvantages :

Continuous production is failed by,

- Infection.
- Spontaneous mutation of microorganisms to non producing strain.

Continuous Growth

Types of continuous growth

1. Chemosat

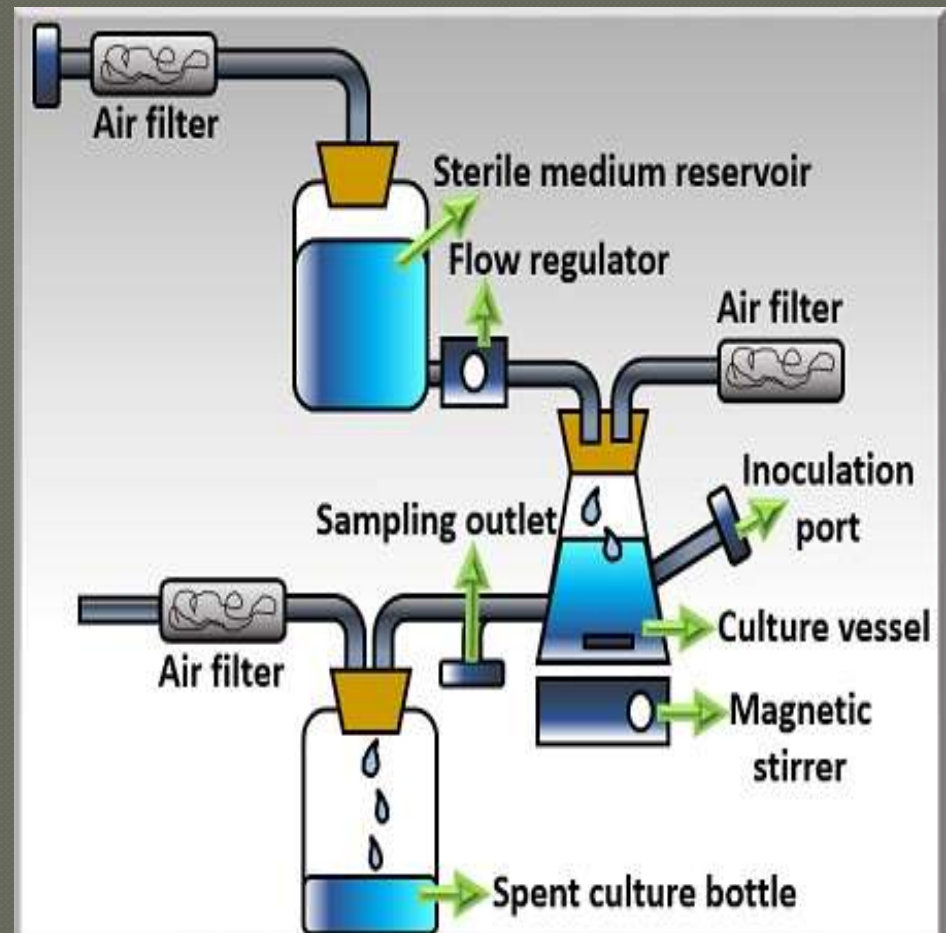
(Growth rate is determined **Externally**, vigorous mixing)

2. Turbidosat

(Growth rate is determined **Internally**)

Chemostat

- Addition of fresh medium to the vessel – exponential growth.
- Medium is substrate limited.
- Over flow devises – added medium displaces equal volume of culture for continuous production of cell.
- Formation of new biomass balanced by loss of cells from vessel.



Continuous Culture By Chemostat

Turbidostat

- In turbidostat, a photoelectric device is used to monitor the cell density.
- The culture in the vessel.
- Flow rate is adjusted to maintain contain cell density in the culture.

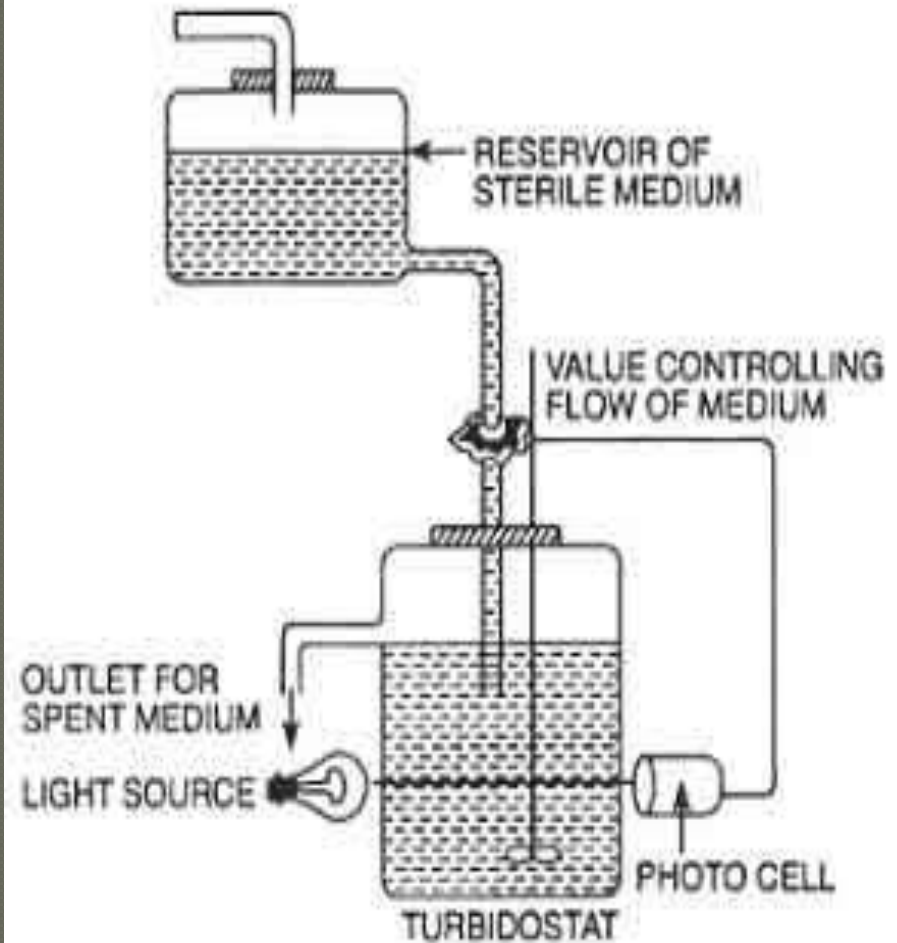


FIG. 19.6. The turbidostat.

Reference

1. <https://www.thoughtco.com/bacterial-growth-curve-phases-4172692>
2. <https://cmr.asm.org/content/28/1/208>
3. <http://www.2hawaii.edu/johnb/micro/medmicro/medmicro.5.html>

THANK YOU