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Lec. 4

Medical microbiology

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Growth and death of bacteria

The Growth Curve

Microorganisms grown in closed culture (also known as a batch culture), in which no nutrients are added and most waste is not removed, follow a reproducible growth pattern referred to as the growth curve.

1- Lag Phase

- The beginning of the growth curve represents a small number of cells, referred to as an inoculum, that are added to a fresh culture medium, a nutritional broth that supports growth.
- <u>The initial phase</u> of the growth curve is called the lag phase, during which cells are preparing for the next phase of growth.
- <u>The number of cells does not change</u> during the lag phase; however, cells grow larger and are metabolically active, synthesizing proteins needed to grow within the medium.
- If any cells were damaged or shocked during the transfer to the new medium, repair takes place during the lag phase.

• The duration of the lag phase is determined by many factors, including the species and genetic make-up of the cells, the composition of the medium, and the size of the original inoculum

2- Log Phase

- In the logarithmic (log) growth phase, sometimes called exponential growth phase
- the cells are actively dividing by binary fission and <u>their number increases</u> <u>exponentially.</u>
- For any given bacterial species, the generation time under specific growth conditions (nutrients, temperature, pH, and so forth) is genetically determined.
- this generation time is called the <u>intrinsic growth rate</u>.
- During the log phase, the relationship between time and number of cells is not linear but exponential.

3- Stationary phase

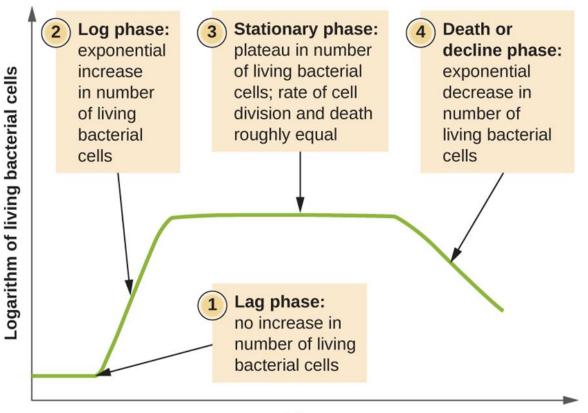
- As the number of cells increases through the log phase, several factors contribute to a slowing of the growth rate.
- Waste products accumulate and nutrients are gradually used up. In addition, gradual depletion of oxygen begins to limit aerobic cell growth.
- This combination of unfavorable conditions slows and finally stall population growth.
- The total number of live cells reaches a plateau referred to as the stationary phase.
- In this phase, <u>the number of new cells created by cell division is now equivalent to</u> <u>the number of cells dying</u>.
- the total population of living cells is relatively remaining the same.
- The culture density in a stationary culture is constant.

- The culture's carrying capacity, or maximum culture density, depends on the types of microorganisms in the culture and the specific conditions of the culture; however, carrying capacity is constant for a given organism grown under the same conditions.
- During the stationary phase, cells switch to a survival mode of metabolism. As growth slows, so too does the synthesis of peptidoglycans, proteins, and nucleic-acids; thus, stationary cultures are less susceptible to antibiotics that disrupt these processes.
- In bacteria capable of producing endospores, many cells undergo sporulation during the stationary phase.
- Secondary metabolites, including antibiotics, are synthesized in the stationary phase.
- In certain pathogenic bacteria, the stationary phase is also associated with the expression of virulence factors, products that contribute to a microbe's ability to survive, reproduce, and cause disease in a host organism. For example, quorum sensing in <u>Staphylococcus aureus</u> initiates the production of enzymes that can break down human tissue and cellular debris, clearing the way for bacteria to spread to new tissue where nutrients are more plentiful.

4- death Phase

- As a culture medium accumulates toxic waste and nutrients are exhausted, cells die in greater and greater numbers.
- <u>The number of dying cells exceeds the number of dividing cells</u>, leading to an exponential decrease in the number of cells. This is the aptly named death phase, sometimes called the decline phase.
- Many cells lyse and release nutrients into the medium, allowing surviving cells to maintain viability and form endospores.

• A few cells, the so-called <u>persisters</u>, are characterized by a slow metabolic rate. Persister cells are medically important because they are associated with certain chronic infections, such as tuberculosis, that do not respond to antibiotic treatment.



Time