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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.
- The initial phase of the growth curve is called the lag phase, during which cells are preparing for the next phase of growth.
- The number of cells does not change 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 their number increases exponentially.
- 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 intrinsic growth rate.
- 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, the number of new cells created by cell division is now equivalent to the number of cells dying.
- 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 Staphylococcus aureus 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.
- The number of dying cells exceeds the number of dividing cells, 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 persisters, 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.