GROWTH AND REPRODUCTION OF BACTERIA

Reproduction of microorganisms

- Bacteria multiply by transverse division.
- Yeasts multiply by budding.
- Actinomycetes by fragmentation of filaments.

- Bacterial replication is a coordinated process in which two equivalent daugther cells are produced.

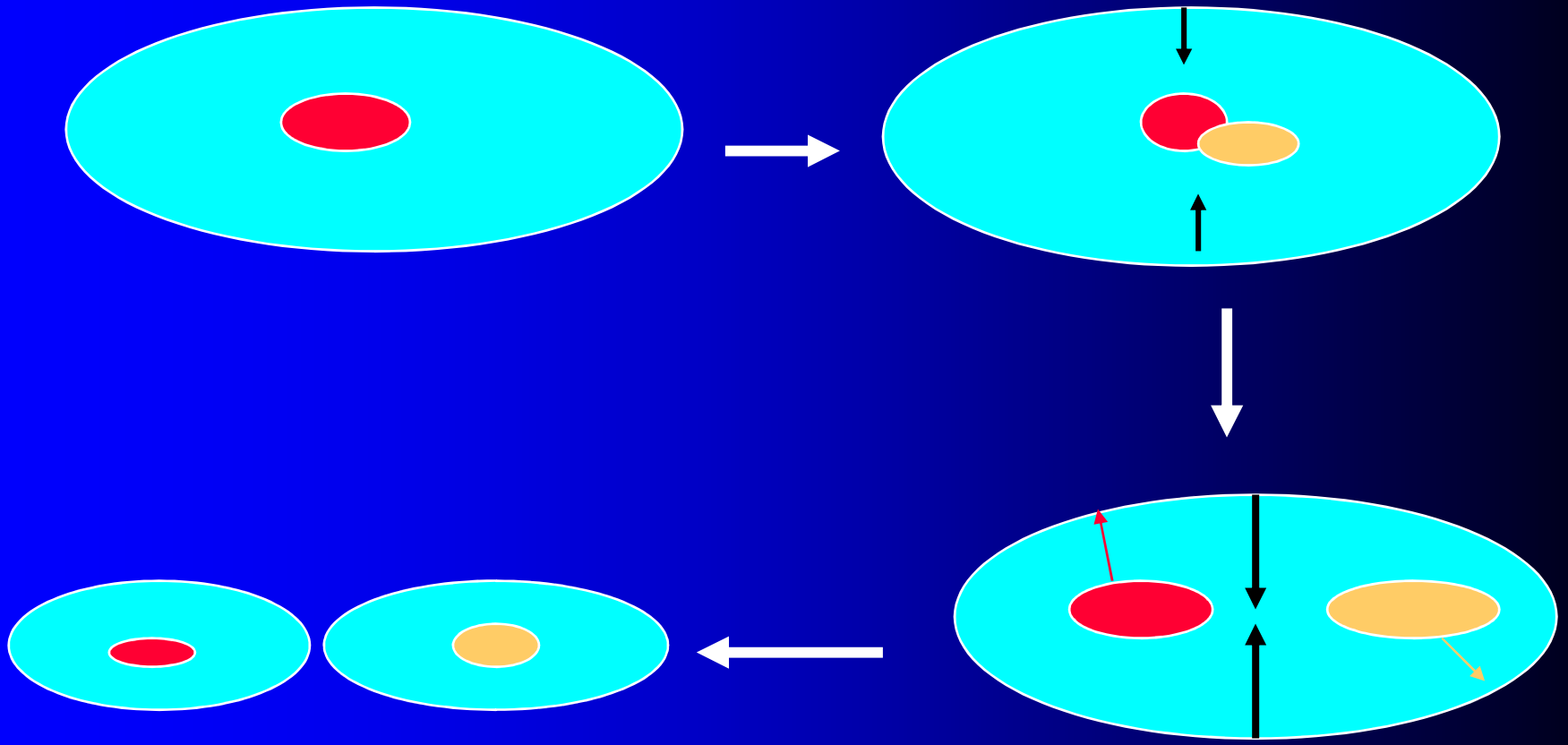
- For growth to occur, there must be sufficient metabolites to support the synthesis of the bacterial components and especially the nucleotides for DNA synthesis.

- The production of two daughter bacteria requires the growth and extension of the cell wall components followed by the production of a septum (cross wall) to divide the daughter bacteria into two cells.

- Septum formation is initiated at the cell membrane. The septum grows from opposite sides toward the center of the cell, causing cleavage of the daughter cells.

- Chromosome replication is initiated at the membrane, and each daughter chromosome is anchored to a different portion of membrane.
- In some bacterial cells, the DNA associates with mesosomes.
- As the bacterial membrane grows, the daughter chromosomes are pulled apart.
- Commencement of chromosome replication also initiates the process of cell division, which can be visualized by the start of septum formation between the two daughter cells.

Bacterial cell division



Generative (or doubling) time

- It is the time, covering the beginning of division of the mother cell up to the formation of two new cells.
- The average generative time is about 20 – 30 minutes in a majority of medically important bacteria.
- They are some exceptions among pathogenic bacteria:
  - *Mycobacterium tuberculosis* has the generative time about 18 hours,
  - *Mycobacterium leprae* has even much longer generative time than other species (10 – 20 days).

- The length of the generative time is in a direct dependance on the length of an incubation or prodromed period of infections.
- In a certain extent, the same rule is applied for antibiotic therapy.

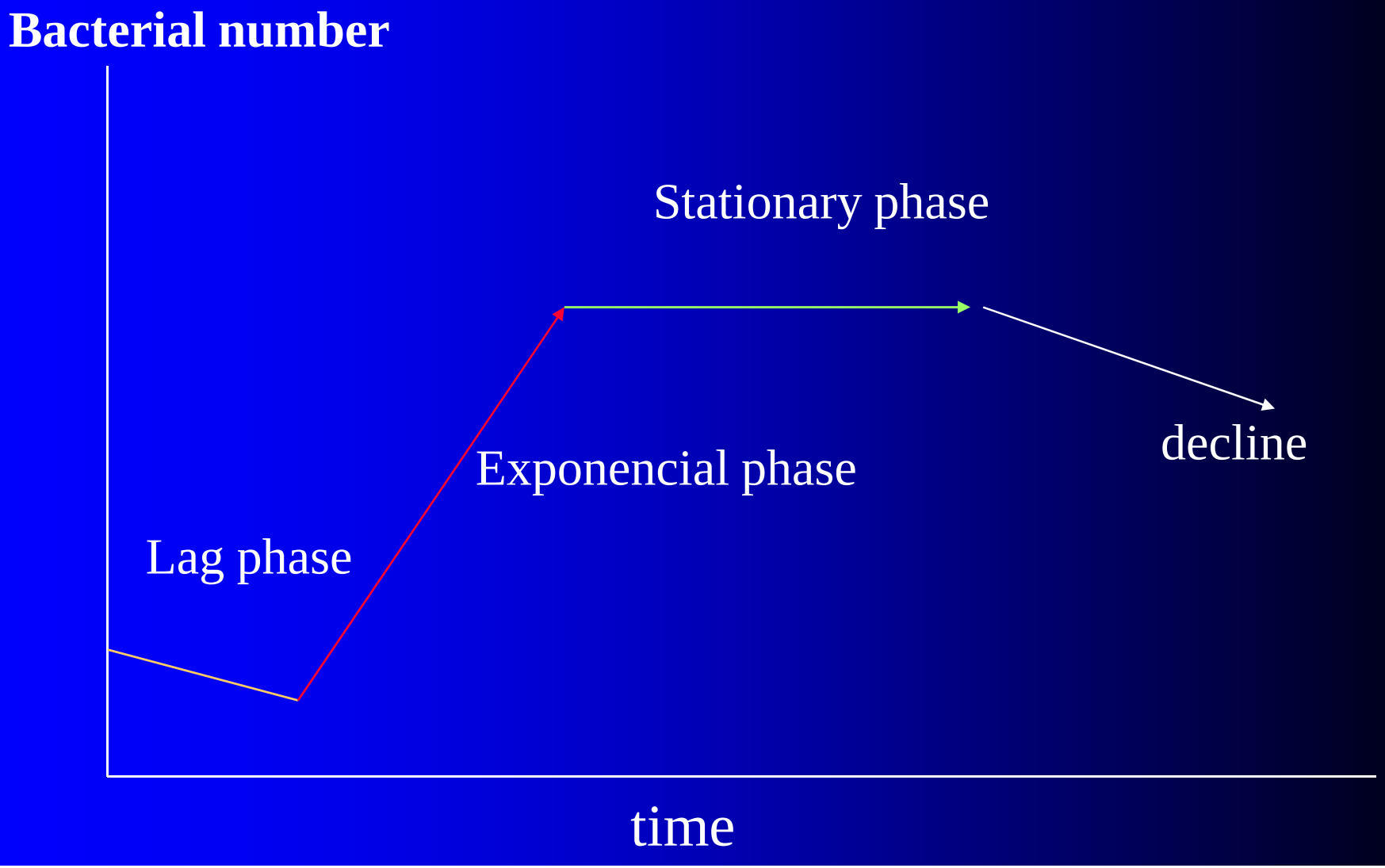
Population dynamics

- When bacteria are added to a medium, they require time to adept to the new environment before they begin dividing. This hiatus is known as *lag phase* of growth.
- The bacteria will grow and divide at a doubling time characteristic of the strains and determined by the conditions during the *exponencial phase*. During this phase, the number of bacteria will increase to 2^n , in which n is the number of generations.
- The cultures runs out of metabolites, or a toxic substances builds up in the medium. The bacteria then stop growing and enter the *stationary phase*.

The multiplication of bacteria in a closed system is limited by exhaustion of nutrients and increase of hydrogen ions and toxic metabolites

- Growth cycle in a closed system:
  - After inoculation of a fresh medium of the closed system, bacteria grow and multiply in successive phases:
    - lag phase (or phase of adaptation)
    - phase of acceleration (or phase of physiological youth)
    - phase of exponential growth
    - stationary growth phase
    - phase of decline

Phases of bacterial growth



- The majority of bacterial and fungal species of medical importance grow in artificial media in the laboratory.
- Some bacteria cannot be cultivated on solid nutrient media surfaces and can only be grown in cell cultures (e.g. chlamydia, chlamydophila, rickettsia).
- Some bacterial species cannot be grown at all except in experimental animals (e.g. *Treponema pallidum*).
- Viruses must be grown in cell or tissue cultures as they are incapable of free-living existence.
- Some parasites (e.g. *Trichomonas vaginalis*) can be cultivated in liquid media but it is easier to detect them by microscopic examination (Giemsa staining).

There are some basic conditions for cultivation of bacteria:

- **Optimum environmental moisture**. It is possible to cultivate bacteria in liquid media or in solid media with a gelling agent (agar) binding about 90 % of water.
- **Optimum temperature** for cultivation of bacteria of medical importance is about 37 °C. Saprophytic bacteria are able to grow at lower temperatures.
- **Optimum pH** of culture media is usually 7.2-7.4. *Lactobacillus* sp. needs acid pH and *Vibrio cholerae* alkaline pH reaction for the growth.
- **Optimum constituents** of bacteriological culture media. All culture media share a number of common constituents necessary to enable bacteria to grow in vitro.

Optimum quantity of oxygen in cultivation environment

- Bacteria obtain energy either by oxidation or by fermentation, i.e. oxidation-reduction procedure without oxygen. Bacteria are classified into four basic groups according to their relation to atmospheric oxygen:
  - **Obligate aerobes –** reproduce only in the presence of oxygen.
  - **Facultative anaerobes –** reproduce in both aerobic and anaerobic environments. Their complete enzymatic equipment allows them to live and grow in the presence or absence of oxygen.
  - **Obligate anaerobes –** grow only in the absence of free oxygen (i.e. unable to grow and reproduce in the presence of oxygen). Some species are so sensitive that they die if exposed to oxygen.
  - **Anaerobic aerotolerant** microbes do not need oxygen for their growth and it is not fatal for them.
  - **Some aerobic and anaerobic bacteria need 5-10 % CO_2 in the environment.**