MBL 221
GENERAL MICROBIOLOGY II

BY

DR. I. A. ADESINA

Department of Biological Sciences,

University of Medical Sciences, Ondo, Ondo State

OUTLINE

- Nutrition and nutritional factors that influence microbial growth
- Role of metabolism in biosynthesis and microbial growth
- Environmental factors that influence microbial growth
- Survival of microorganisms in the natural environment
- Principles of microbial growth (binary fission, generation time)
- Microbial growth in laboratory conditions (Growth curve, colony growth, continuous culture)
- Enumeration of microorganisms in food and environment

NUTRITION AND NUTRITIONAL FACTORS THAT INFLUENCE MICROBIAL GROWTH

- **Nutrition**
  - process by which chemical substances called **nutrients** are acquired from the environment and used in cellular activities such as metabolism and growth.
- **Required Elements**
  - Elements that make up cell constituents are called **major elements.**
  - include carbon, oxygen, hydrogen, nitrogen, sulfur, phosphorus, potassium, magnesium, calcium, and iron.
  - essential components of proteins, carbohydrates, lipids, and nucleic acids.

REPRESENTATIVE FUNCTIONS OF THE MAJOR ELEMENTS

Chemical	Function
Carbon, oxygen, and hydrogen	Component of amino acids, lipids, nucleic acids, and sugars
Nitrogen	Component of amino acids and nucleic acids
Sulfur	Component of some amino acids
Phosphorus	Component of nucleic acids, membrane lipids, and ATP
Potassium, magnesium, and calcium	Required for the functioning of certain enzymes; additional functions as well
Iron	Part of certain enzymes

- **Growth Factors**
  - A growth factor is an organic compound that a cell must contain to grow but that it is unable to synthesize
  - Cell constituents, such as amino acids, vitamins, purines, and pyrimidines
  - Low molecular weight compounds required by a particular bacterium
  - Fastidious refers to organisms (bacteria) such as *Neisseria,& Lactobacilli* that require many growth factors (nutritionally demanding organisms)

- **Energy Sources**
  - Organisms that harvest the energy of sunlight are called **phototrophs** (*photo* means "light")
    - These include plants, algae, and photosynthetic bacteria
  - Organisms that obtain energy by oxidizing chemical compounds are called **chemotrophs** (*chemo* means "chemical")
    - Mammalian cells, fungi, and many types of bacteria oxidize organic compounds such as sugars, amino acids, and fatty acids

Nutritional Diversity

- Microbiologists often group microbes according to the energy and carbon sources they utilize:
- **Photoautotrophs**
  - use the energy of sunlight and the CO_2 in the atmosphere to make organic compounds
  - These are eventually consumed by other organisms, including humans. Because of this, photoautotrophs are called **primary producers.**
  - Cyanobacteria are important examples that inhabit soil and both freshwater and saltwater environments.

- **Chemolithoautotrophs** (chemoautotrophs or chemolithotrophs)
  - use inorganic compounds for energy and derive their carbon from CO_2
  - In some regions of the ocean depths, chemoautotrophs serve as the primary producers, supporting rich communities of life in these habitats utterly devoid of sunlight
- **Photoheterotrophs**
  - use the energy of sunlight and derive their carbon from organic compounds
  - for example, some members of a group of bacteria called the purple nonsulfur bacteria can grow anaerobically using light as an energy source and organic compounds as a carbon source

- **Chemoorganoheterotrophs** (chemoheterotrophs or chemoorganotrophs)
  - use organic compounds for energy and as a carbon source
  - individual species of chemoheterotrophs differ in the number of organic compounds they can use
  - for example, certain members of the genus *Pseudomonas* can derive carbon and/ or energy from more than 80 different organic compounds
  - *Bacillus fastidiosus* can use only urea and certain of its derivatives as a source of both carbon and energy

Energy and carbon sources used by different groups of microbes

Type	Energy Source	Carbon Source
Photoautotroph	Sunlight	CO_2
Photoheterotroph	Sunlight	Organic compounds
Chemolithoautotroph	Inorganic chemicals	CO_2
Chemoorganohetero-troph	Organic compounds	Organic compounds

ASSIGNMENT

- Read on “Role of metabolism in biosynthesis and microbial growth” and summarize in 2 – 3 pages

ENVIRONMENTAL FACTORS THAT INFLUENCE MICROBIAL GROWTH

Temperature Requirements

- Prokaryotes are commonly divided into five groups based on their optimum growth temperatures
- **Psychrophiles** have their optimum between: -5°C and 15°C
  - These organisms are usually found in such environments as the Arctic and Antarctic regions and in lakes fed by glaciers.
- **Psychrotrophs** have a temperature optimum between 20°C and 30°C
  - They are an important cause of food spoilage.

- **Mesophiles** have their optimum temperature between 25°C and about 45°C
  - Disease-causing bacteria typically have an optimum between 35°C and 40°C
- **Thermophiles** have an optimum temperature between 45°C and 70°C
  - These organisms commonly occur in hot springs and compost heaps.
- **Hyperthermophiles** have an optimum growth temperature of 70°C or greater
- Why can some prokaryotes withstand very high temperatures but most cannot?
  - proteins from thermophiles are not denatured at high temperatures
  - This thermostability is due to the sequence of the amino acids in the protein

Oxygen (O_2) Requirements

- Based on their O_2 requirements, prokaryotes can be separated into these groups:
- **Obligate aerobes** have an absolute requirement for oxygen (O_2)
- **Obligate anaerobes** cannot multiply if any O_2 is present
- **Facultative anaerobes** grow better if O_2 is present, but can also grow without it
- **Microaerophiles** require small amounts of O_2 (2% to 10%) for aerobic respiration; higher concentrations are inhibitory
- **Aerotolerant anaerobes** are indifferent to O_2. They can grow in its presence, but they do not use it to transform energy

pH

- **Neutrophiles** multiply within the range of pH 5 (acidic) to pH 8 (basic) and have a pH optimum near neutral (pH 7).
- **Acidophiles** grow optimally at a pH below 5.5
- **Alkalophiles** grow optimally at a pH above 8.5

WATER AVAILABILITY

- Prokaryotes able to live in high-salt environments maintain the availability of water in the cell by increasing their internal solute concentration
- **Halotolerant** can tolerate high concentrations of salt, up to approximately 10% NaCl
- **Halophiles** require high levels of sodium chloride to grow

SURVIVAL OF MICROORGANISMS IN THE NATURAL ENVIRONMENT

- The population of microorganisms in the biosphere remains roughly constant because the growth of microorganisms is in turn balanced by the death of these organisms
- The survival of any microbial group, within a specific niche, is ultimately influenced by successful competition for nutrients and by maintenance of a pool of living cells
- Most microorganisms compete in the natural environment under nutritional stress

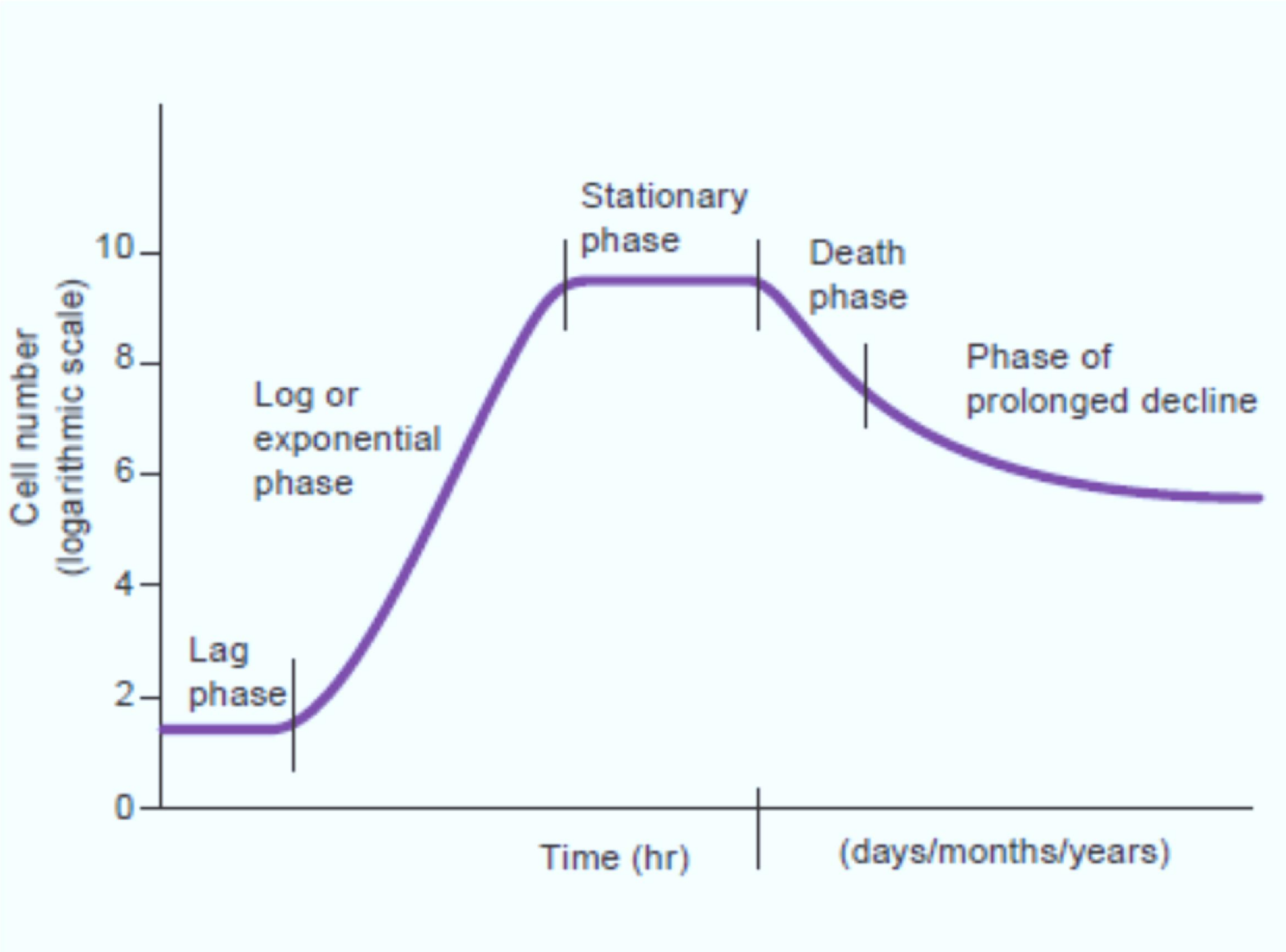
PRINCIPLES OF MICROBIAL GROWTH

- Bacteria generally multiply by the process of **binary fission**
- After a cell has increased in size and doubled its components, it divides
- **Microbial growth** is defined as an increase in the number of cells in a population
- The time it takes for a population to double in number is the **generation,** or **doubling, time**

- A simple equation expresses the relationship between the number of cells in a population at a given time (N_t),
- the original number of cells in the population (N_0), and
- the number of divisions those cells have undergone during that time (n).
- If any two values are known, the third can be easily calculated from the equation:

$$N_t = N_0 \times 2^n$$

The Growth Curve



Colony Growth

- After a lag phase, cells multiply exponentially and eventually compete with one another for available nutrients and become very crowded
- Unlike a liquid culture, the position of a single cell within a colony markedly determines its environment
- Cells multiplying on the edge of the colony face relatively little competition and can use O_2 in the air and obtain nutrients from the agar medium
- In contrast, in the center of the colony the high density of cells rapidly depletes available O_2 and nutrients

Continuous Culture

- Bacteria can be maintained in a state of continuous exponential growth by using a **chemostat**
- This device continually drips fresh medium into a liquid culture contained in a growth chamber
- With each drop that enters, an equivalent volume—containing cells, wastes, and spent medium—leaves through an outlet