Factors Affecting Microbial Growth

Other Environmental Conditions that Affect Growth

- Microorganisms interact with their environment along more dimensions than pH, temperature, and free oxygen levels although these factors require significant adaptations.
- It is also find microorganisms adapted to varying levels of salinity, barometric pressure, humidity, and light.

Osmotic and Barometric Pressure

- Most natural environments tend to have lower solute concentrations than the cytoplasm of most microorganisms.
- Rigid cell walls protect the cells from bursting in a dilute environment. Not much protection is available against high osmotic pressure.
- In this case, water, following its concentration gradient, flows out of the cell. This results in plasmolysis (the shrinking of the protoplasm away from the intact cell wall) and cell death.
- This fact explains why brines and layering meat and fish in salt are time-honored methods of preserving food.
- Microorganisms called **halophiles** ("salt loving") actually require high salt concentrations for growth. These organisms are found in marine

  environments where salt concentrations hover at 3.5%.
- Extreme halophilic microorganisms, such as the red alga Dunaliella salina and the archaeal species Halobacterium grow in hypersaline lakes such as the Great Salt Lake, which is 3.5–8 times saltier than the ocean, and the Dead Sea, which is 10 times saltier than the ocean.

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- **Dunaliella spp.** counters the tremendous osmotic pressure of the environment with a high cytoplasmic concentration of glycerol and by actively pumping out salt ions.
- **Halobacterium spp**. accumulates large concentrations of K+ and

other ions in its cytoplasm. Its proteins are designed for high salt concentrations and lose activity at salt concentrations below 1–2 M.

- Although most halotolerant organisms, for example Halomonas spp. in salt marshes, do not need high concentrations of salt for growth, they will survive and divide in the presence of high salt.
- Not surprisingly, the staphylococci, micrococci, and corynebacteria that colonize our skin tolerate salt in their environment.
- Halotolerant pathogens are an important cause of food-borne illnesses because they survive and multiply in salty food.
- For example, the halotolerant bacteria S. aureus, Bacillus cereus, and V. cholerae produce dangerous enterotoxins and are major causes of food poisoning.

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- Microorganisms depend on available water to grow.
- Available moisture is measured as water activity (aw), which is the ratio of the vapor pressure of the medium of interest to the vapor pressure of pure distilled water; therefore, the aw of water is equal to 1.0.
- Bacteria require high aw (0.97–0.99), whereas fungi can tolerate drier environments; for example, the range of aw for growth of Aspergillus spp. is 0.8–0.75.
- Decreasing the water content of foods by drying, as in jerky, or through freeze-drying or by increasing osmotic pressure, as in brine and jams, are common methods of preventing spoilage.
- Microorganisms that require high atmospheric pressure for growth are called **barophiles**. The bacteria that live at the bottom of the ocean must be able to withstand great pressures. Because it is difficult to retrieve intact specimens and reproduce such growth conditions in the laboratory, the characteristics of these microorganisms are largely unknown.

Light

- Photoautotrophs, such as cyanobacteria or green sulfur bacteria, and photoheterotrophs, such as purple nonsulfur bacteria, depend on sufficient light intensity at the wavelengths absorbed by their pigments to grow and multiply.
- Energy from light is captured by pigments and converted into chemical energy that drives carbon fixation and othermetabolic processes.
- The portion of the electromagnetic spectrum that is absorbed by these organisms is defined as **photosynthetically active radiation (PAR).**
- It lies within the visible light spectrum ranging from 400 to 700

nanometers (nm) and extends in the near infrared for some photosynthetic bacteria.

- A number of accessory pigments,such as fucoxanthin in brown algae and phycobilins in cyanobacteria, widen the useful range of wavelengths for

photosynthesis and compensate for the low light levels available at greater depths of water.

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- Other microorganisms, such as the archaea of the class Halobacteria, use light energy to drive their proton and sodium pumps.
- The light is absorbed by a pigment protein complex called **bacteriorhodopsin,** which is similar to the eye pigment **rhodopsin.**
- Photosynthetic bacteria are present not only in aquatic environments but also in soil and in symbiosis with fungi in lichens.
- The peculiar watermelon snow is caused by a microalga Chlamydomonas nivalis, a green alga rich in a secondary red carotenoid pigment (astaxanthin) which gives the pink hue to the snow where the alga grows.

Media Used for Bacterial Growth

- The study of microorganisms is greatly facilitated if we are able to culture them, that is, to keep reproducing populations alive under laboratory conditions.
- Culturing many microorganisms is challenging because of highlyspecific nutritional and environmental requirements and the diversity of these requirements among different species.

Nutritional Requirements:

- The number of available media to grow bacteria is considerable. Some media are considered genera**l all-purpose media** and support growth of a large variety of organisms.
- A prime example of an all-purpose medium is **tryptic soy broth (TSB)**. **Specialized media** are used in the identification of bacteria and are supplemented with dyes, pH indicators, or antibiotics.
- One type, **enriched media,** contains growth factors, vitamins, and other essential nutrients to promote the growth of fastidious organisms, organisms that cannot make certain nutrients and require them tobe added to the medium.

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- When the complete chemical composition of a medium is known, it is called a **chemically defined medium.**
- For example, in EZ medium, all individual chemical components are identified and the exact amounts of each is known.
- In **complex media,** which contain extracts and digests of yeasts, meat, or plants, the precise chemical composition of the medium is not known.
- Amounts of individual components are undetermined andvariable.
- Nutrient broth, tryptic soy broth, and brain heart infusion, are all examples of complex media.
- Media that inhibit the growth of unwanted microorganisms and support the growth of the organism of interest by supplying nutrients and reducing competition are called selective media.
- An example of a selective medium is MacConkey agar. It contains bile salts and crystal violet, which interfere with the growth of many gram-positive

bacteria and favor the growth of gram-negative bacteria, particularly the Enterobacteriaceae

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- These species are commonly named enterics, reside in the intestine, and are adapted to the presence of bile salts.
- The enrichment cultures foster the preferential growth of a desired microorganism that represents a fraction of the organisms present in an inoculum.
- For example, if we want to isolate bacteria that break down crude oil, hydrocarbonoclastic bacteria,sequential subculturing in a medium that supplies carbon only in the form of crude oil will enrich the cultures with oil-eating bacteria.
- The **differential media** make it easy to distinguish colonies of different bacteria by a change in the color of the colonies or the color of the medium.
- Color changes are the result of end products created by interaction of bacterial enzymes with differential substrates in the medium or, in the case of hemolytic reactions, the lysis of red blood cells in the medium

- The differential fermentation of lactose can be observed on

MacConkey agar. The lactose fermenters produce acid, which turns the medium and the colonies of strong fermenters hot pink.

- The medium is supplemented with the pH indicator neutral red, which turns to hot pink at low pH.
- Selective and differential media can be combined and play an important role in the identification of bacteria by biochemical.