Cleaning and Disinfection – Basic microbiology

Your Objectives:

At the end of the lesson you should be able to report implications of the growth and optimal environment of microorganisms.

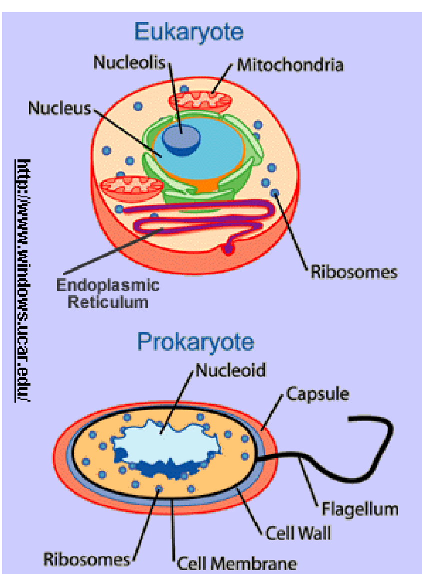
Introduction to microbiology

Microorganisms are typically invisible to the naked eye; the unit of measurement used for microorganisms is the micrometre (µm); 1 µm = 0.001 millimetre; 1 nanometre (nm) = 0.001 µm. Microorganisms are ubiquitous, which means they are found (with few exceptions*) everywhere on the planet, and are essential to organic life processes.

In regard to the food industry, microorganisms can cause spoilage, possibly causing illness in living organisms such as humans, or they may prevent spoilage (as in the process of fermentation). Bacteria, fungi, viruses, protozoa and algae are the major groups of microorganisms. The vast majority of microorganisms are not harmful to humans but, rather, beneficial. Microbiota refers to all of the microorganisms that live in a particular environment. A microbiome is the entire collection of genes found in all of the microbes associated with a particular host.

*** Exceptions:** Two known places devoid of microbial life are the hot, saline, hyperacid ponds of the Dallol geothermal field in Ethiopia, and the Atacama Desert in Chile.

Cellular organization – prokaryotic and eukaryotic cells



There are two basic types of cells found in nature: prokaryotic and eukaryotic. Prokaryotes are structurally simpler ("single-cell") than eukaryotes, which have a clearly defined nucleus.

The smaller a cell, the greater its surface-to-volume ratio. The smaller the surface-to-volume ratio, the more structurally complex (compartmentalised) a cell needs to be for it to carry out life functions.

Although a bacterium is basically simple single-celled (unicellular) organism, there are fundamental differences between prokaryotic and eukaryotic cells. One method of classification is by shape or morphology:

Cocci:

- spherical shape
- 0.4 - 1.5 µm

staphylococci, for instance, form grape-like clusters, whereas **streptococci** form bead-like chains.

Rods:

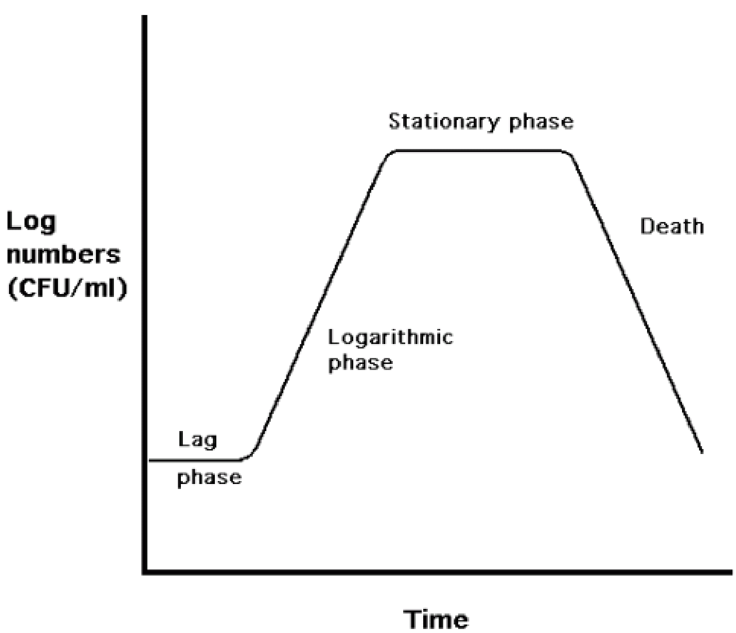
- 0.25 - 1.0 µm width by 0.5 - 6.0 µm long

bacilli are straight rods; **spirilla** form a spiral rod.

Based on the science of genetics, there is internationally recognised taxonomy, or classification system, of the bacterial system with its family, genera and species divisions.

Some bacteria have the ability to form resting cells known as **endospores**. Spores form in moments of environmental stress, such as lack of nutrients and moisture needed for growth and is, as such, a survival strategy. Spores have no metabolism; thus, they can withstand adverse conditions like heat, disinfectants and ultraviolet light. Once the environment becomes more favourable a spore may germinate, giving rise to a single vegetative bacterial cell. Some examples of spore-formers important to the food industry are members of ***Bacillus*** and ***Clostridium*** genera.

Bacterial growth generally proceeds through a series of phases:



Hypothetical bacterial growth curve.

- **Lag phase**: time for microorganisms to become accustomed to their new environment. There is little or no growth during this phase.
- **Log phase**: bacteria logarithmic, or exponential, growth begins; the rate of multiplication is the most rapid and constant.
- **Stationary phase**: the rate of multiplication slows down due to lack of nutrients and build-up of toxins. At the same time, bacteria are constantly dying so the numbers actually remain constant.
- **Death phase**: cell numbers decrease as growth stops and existing cells will die off.

The shape of the curve on the graph (on the previous page) varies with temperature, nutrient supply, and miscellaneous growth factors.

Microbial Growth

There are a number of factors that affect the survival and growth of microorganisms in food. The parameters that are inherent to the food, or **intrinsic factors**, include the following:

- nutrient content
- moisture content
- pH
- available oxygen
- biological structures
- antimicrobial constituent

Moisture Content

All microorganisms require $H^2 0$, but the amount necessary for their growth varies between species. The amount of water available in food is expressed in terms of water activity (a_w), where the aw of pure water is 1.0. Each microorganism has a maximum, optimum, and minimum aw for growth and survival. Generally speaking, bacteria dominate in foods with high aw (minimum approximately 0.90 a_w), while yeasts and moulds, which require less moisture, dominate in low aw foods (minimum 0.70 a_w). The water activity of, say, fluid milk is approximately 0.98 a_w.

pH

Most microorganisms have approximately a neutral pH optimum (pH 6.5 – 7.5). Yeasts (and some fungi) are able to grow in a more acid environment, compared to bacteria. Moulds can grow over a wide pH range, but they prefer only slightly acid conditions. Milk has a pH of 6.6 — an ideal average pH level for the growth of many microorganisms.

Presence or absence of Oxygen

Microorganisms can be classified according to the amount of oxygen needed for growth and survival:

Obligate anaerobes: Oxygen is required

- Facultative: grow in the presence or absence of oxygen
- Microaerophilic: grow best at very low levels of oxygen
- Aerotolerant anaerobes: oxygen is not required for growth but is not harmful if present
- Obligate anaerobes: grow only in complete absence of oxygen; if present it can be lethal

Temperature

As a group, microorganisms are capable of growth over an extremely wide temperature range. However, in a given environment, the types and numbers of microorganisms will depend greatly upon temperature(s). According to temperature, microorganisms can be placed into one of three broad groups:

- **Psychrophiles,** or **cryophiles**: optimum growth at temperatures of between 20°C and 30°C with a growth capacity, nevertheless, at less than 7°C. Psychrophilic organisms, for instance, are prominent in the spoilage of refrigerated dairy products.
- **Mesophiles**: optimum growth between 30°C and 40°C and cease to grow at refrigeration temperatures.
- **Thermophiles**: optimum growth between 55°C and 65°C.

NB: For each group, growth rate increases as temperature(s) increase(s) up to an optimum, after which the growth rate rapidly declines.