BACTERIAL GROWTH

Culture
Increase in the population of cells
Generation time
the time it takes to divide (double) is called

BINARY FISSION
division exactly in half
most common means of bacterial reproduction
forming two equal size progeny
genetically identical offspring
cells divide in a geometric progression doubling cell number

CULTURE GROWTH
Growth of culture goes through four phases with time
1) Lag phase
2) Log or Logarithmic phase
3) Stationary phase
4) Death or Decline phase

LAG PHASE
Organisms are adjusting to the environment
little or no division
synthesizing DNA, ribosomes and enzymes in order to breakdown nutrients, and to be used for growth

LOGARITHMIC PHASE
Division is at a constant rate (generation time)
Cells are most susceptible to inhibitors

STATIONARY PHASE
Dying and dividing organisms are at an equilibrium
Death is due to reduced nutrients, pH changes, toxic waste and reduced oxygen
Cells are smaller and have fewer ribosomes
In some cases cells do not die but they are not multiplying

DEATH PHASE
The population is dying in a geometric fashion so there are more deaths than new cells
Deaths are due to
1) factors in stationary phase
2) lytic enzymes that are released when bacteria lyse

ENUMERATION OF BACTERIA
1) viable plate count
2) direct count
3) most probable number (MPN)

VIABLE PLATE COUNT
Most common procedure for assessing bacterial numbers
1) serial dilutions of a suspension of bacteria are plated and incubated
2) the number of colonies developing are then counted. It is assumed that each colony arises from an individual bacterial cell
3) by counting the colonies and taking into account the dilution factors the concentration of bacteria in original sample can be determined
4) only plates having between 30 and 300 colonies are used in the calculations
5) multiply the number of colonies times the dilution factor to find the number of bacteria in the sample
Example
  Plate count = 54
  Dilution factor = 1:10,000 ml

Calculation
  \[ 54 \times 10,000 = 540,000 \text{ bacteria/ml} \]

“TNTC”
  if the number of colonies is too great (over 300) the sample is labeled “TNTC”
  Too Numerous To Count

limitation of viable plate count
  selective as to the bacterial types that will grow given the incubation temperature
  and nutrient type

Calculate:
  42 colonies
  dilution factor of 100,000
  \[ 42 \times 100,000 = ??? \]
  \[ 4,200,000 \text{ bacteria/ml} \]

DIRECT COUNT
  Dilutions of samples are observed under a microscope
  the number of bacterial cells from a given volume of sample are counted
  dead cells are also counted
  automated particle counters can be used

MOST PROBABLE NUMBER
  Statistical method based on probability theory
  multiple serial dilutions are performed to reach a point of extinction
  dilution level at which no cells are deposited
  Criteria have been developed for indicating whether a dilution tube has bacteria present
  the pattern of positive and negative results are compared with a table of statistical
  probabilities for obtaining those results
  The pattern to tubes that show growth (brown) and those that do not (orange) are compared with a statistical table to calculate MPN

FACTORS INFLUENCING BACTERIAL GROWTH
  Rates of growth and death are greatly influenced by environmental parameters
  each bacterial species has a specific tolerance range for specific environmental factors
  outside this range of environmental conditions bacteria lose their viability
  ability to reproduce

FACTORS INFLUENCING BACTERIAL GROWTH
  1) Nutrition
  2) Temperature
  3) Oxygen
  4) Salinity
  5) pH
  6) Pressure
  7) Radiation

NUTRITION
  Basic bacterial requirements
    water
    carbon
    nitrogen
    other

WATER
  Used to dissolve materials to be transported across the cytoplasmic membrane
CARBON
required for the construction of all organic molecules
autotrophs use inorganic carbon (CO₂) as their carbon source
heterotrophs use organic carbon

NITROGEN
Obtained from
\textit{inorganic} source
e.g. Nitrogen gas (N₂), Nitrate (NO₃), Nitrite (NO₂), and Ammonia (NH₃)
\textit{organic} source
e.g. Proteins, broken down to amino acids
Many organisms use nitrogen gas by nitrogen fixation to produce ammonia

OTHER NUTRIENTS
Required in small amounts are
Iron
Sulfur
Phosphorus

TEMPERATURE
One of the most important factors
optimal growth temperature
temperature range at which the highest rate of reproduction occurs
optimal growth temperature for human pathogens ????
Microorganisms can be categorized based on their optimal temperature requirements
\textbf{Psychrophiles}
0 - 20 °C
\textbf{Mesophiles}
20 - 40 °C
\textbf{Thermophiles}
40 - 90 °C
Most bacteria are mesophiles especially pathogens that require 37 °C
\textbf{Psychrophiles}
some will exist below 0 °C if liquid water is available
oceans
refrigerators
freezers
\textbf{Mesophiles}
most human flora and pathogens
\textbf{Thermophiles}
hot springs
effluents from laundromat
deep ocean thermal vents

OXYGEN
Required for aerobic respiration and energy production
Organisms are classified according to their gaseous requirements
\textbf{Obligate aerobes}
\textbf{Facultative anaerobes}
\textbf{Obligate anaerobes}
\textbf{Obligate aerobic}
grow only when oxygen is available
\textbf{Obligate anaerobic}
grow in the absence of oxygen
Facultative anaerobe
require oxygen but exhibit maximal growth rates at reduced oxygen concentrations

SALINITY

Halophiles
bacteria that specifically require NaCl for growth

Moderates
grow best at 3% NaCl solution
many ocean dwelling bacteria

Extreme
grow well at NaCl concentrations of greater than 15%
salt lakes, pickle barrels
Halophiles growing within salt lakes often turn the water pink
this sometimes occurs in Great Salt Lake, Utah
Staphylococcus are salt tolerant up to concentrations of 10% NaCl
grow on surface of skin

BACTERIAL pH REQUIREMENTS
microbes have different optimum pH requirements

ACIDOPHILES
some bacteria can grow in acid substrates

NEUTROPHILES
most microbes prefer a pH near neutrality

ALKALINOPHILES
microbes which can grow in very alkaline substrates

PRESSURE

Osmotic Pressure
exerted on the plasma membranes due to solute concentrations of a solution

osmotolerant
bacteria able to grow in solutions with a high solute concentration

Hydrostatic Pressure
exerted by the weight of water

barotolerant
bacteria able to grow at deep ocean depths

RADIATION

Photosynthetic microorganisms
require light at minimum levels of intensity and proper wavelengths
exposure to light can cause the death of some microorganisms
some bacteria will produce pigments that protect them from exposure to lethal
effects of light
Ultraviolet radiation is harmful to the DNA of bacteria
causes abnormalities in cell growth and division

END

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