Module 4

Chapter 6 – Microbial Growth

- Microbial growth refers to increase in _____, not _____
  - Growing microbes means an increase in _____
- Important to understand conditions necessary for microbial growth
  -
  -

The requirements for growth

- Physical requirements
  -
  -
  -
- Chemical requirements
  -
  -
  -
  -
  -

Temperature

- Microbes grow within _____ temperature range
  - Low, high temp affect _____
- **Minimum growth temp –**
- **Optimum growth temp –**
- **Maximum growth temp -**
- Microbes divided into 5 groups
  - **Psychrophiles** –
  - **Psychrotrophs** –
  - **Mesophiles** –
  - **Thermophiles** –
  - **Hyperthermophiles** –
- Psychrophiles
  - Can grow below ____ °C, optimum at ____ °C
  - Usually _____ by temperatures above ____ °C
    -
- Psychrotrophs
  - Can grow at _____ °C, optimum at _____ °C
  - Cause problems with _____, can grow _____
    - But grow _____ → proper _____ helps prevent _____
- Mesophiles
  - Many _____ grow best at ____ °C
    -
  - Mesophiles include most common _____, food _____ organisms

- Thermophiles, hyperthermophiles
  - Grow is _____, volcanic _____
  - Cannot grow below ____ °C – usually not _____ problem

pH

- pH refers to concentration of _____
  - Low pH → _____ →
  - High pH → _____ →
- Most bacteria grow best near _____
- _____ grow in acidic environments
  - _____, _____ are products of acidophiles
  - Preserved from _____ by bacterial _____
- _____ and _____ can grow between pH 5 and 6

Osmotic Pressure

- Microbes dependent on _____ to carry nutrients
  - Microbes live in _____ environments
- _____ environments causes water to _____ cell
  - Growth inhibited due to _____
- Food preserved by high osmotic pressure - add _____
- _____ tolerate high osmotic pressure
- Extreme halophiles _____ high salt conditions
  - Live in the Dead Sea, salt lakes

Chemical Requirements

- Carbon
  - Structural organic molecule, _____ source
  - _____ use organic carbon sources
  - _____ use CO_2
- Nitrogen
  - In _____, proteins, _____
  - Most bacteria decompose _____
  - Some bacteria use _____ or _____
  - A few bacteria use _____ from atmosphere
    - Called _____
- Sulfur
  - In _____, thiamine, and biotin
  - Most bacteria decompose _____
  - Some bacteria use _____ or _____
- Phosphorous
  - In _____, RNA, ATP, and _____
  - _____ is a source of phosphorous
- Trace elements
  - _____ elements required in _____ amounts
  - Usually as _____

- Organic growth factors
    - Organic compounds obtained _____
    - Vitamins, amino acids, _____, _____

Oxygen

- _____ metabolism provides more energy than _____ metabolism
- BUT, Oxygen is _____ in high amounts to ALL organisms
    - _____ forms of oxygen are highly reactive; _____ cell components
    - Many metabolic pathways exist to _____
- Singlet oxygen, $^1O_2^-$ -
- Superoxide free radicals, O_2^-
    - _____ enzyme neutralizes free radicals
- Peroxide anion, O_2^{2-}
    - Neutralized by _____ and _____ enzymes
- Hydroxyl radicals, OH^- -
- Obligate aerobes
    - Grow where _____ occurs
    - Have _____ that _____ O_2
- Facultative anaerobes
    - Grow _____ with _____
    - _____ growth via _____ or _____
- Obligate anaerobes
    - _____ to detoxify _____
    - Grow _____ than _____
- Aerotolerant anaerobes
    - Obligate _____, produce _____ that inhibit competition from _____
    - Possess enzymes to _____
- Microaerophiles
    - _____ detoxify high concentrations of _____

Biofilms

- _____ that holds _____ of bacteria together
    - Share _____
    - Sheltered from _____
- _____ is a _____ created by an extracellular polysaccharide
- Formed by _____ species in mouth
    - Only when _____ is present
- Plaque allows other microbes to _____
    - Form _____ that lead to tooth decay, gum disease
- Biofilms often form on _____ and other tubing
- Numbers are often too low to detect
    - Biofilm protects bacteria from _____
- Can grow rapidly once inside body, causing _____ and other infections

Growing Microbes in the Lab

- _____: _____ prepared for microbial _____
- _____: no _____ microbes
- _____: _____ of microbes (the _____) into sterile medium
- _____: microbes growing in/on culture medium

Agar

- Complex _____
- Used as _____ for culture media in Petri plates, slants, and deeps
- Generally not _____ by microbes
- Liquefies at 100°C
- Solidifies at ~40°C

Culture Media

- Chemically defined media: exact chemical composition _____
- Complex media: extracts and digests of yeasts, meat, or plants
    - _____ of nutrients

Biosafety Levels

- BSL-1: _____ precautions
- BSL-2: _____, gloves, eye _____
- BSL-3: _____ cabinets to prevent _____
- BSL-4: sealed, _____ pressure
    - _____ is _____ twice

The Growth of Bacterial Cultures

- Recall, microbial growth is increase in _____
- Bacteria reproduce by _____
    - A single _____ splits into _____ cells
- Some microbes reproduce by _____
    - Small growth (_____) gets larger, and _____
- Generation time, _____ – the time it takes for a _____
    - Essentially, time it takes for _____
- Varies among species
    - Can be 20 mins, can be 20 days
- Microbes can grow _____ in ideal conditions
    - Eg, if g = _____, then:
        - 1 cell → 1 _____ in _____ generations, _____
        - 1 cell → 1 _____ in _____ generations, _____
- Bacterial growth plotted on _____
    - Numbers _____ for linear or arithmetic graph
- _____ scale increases in increments of _____
    - 10, 100, 1,000, 10,000, etc …
- Converts rapidly increasing exponential growth from _____ line into _____ line

Phases of growth

- Bacteria growing in liquid have characteristic growth pattern
  - When plotted on logarithmic graph – _____
- The Lag Phase

- The Log Phase

- The Stationary Phase

- The Death Phase

Measurements of Bacterial Growth

- Bacterial cultures are quantified by two general types of measurements
  - _____ measurements – measure _____
  - Indirect Measurements – use _____ measures to determine population size

Direct measurement of microbial growth

Standard Plate Counts

- Growth microbial sample on _____
  - Count _____
  - 1 _____ = 1 _____
- Advantages
  - Only _____ counted
  - Obtain _____
- Disadvantage
  - Takes _____ for colonies to form
  - _____ intensive

Filtration

- _____ is passed through _____
  - _____ retained on _____
- _____ is transferred to _____
- Useful when _____ of bacteria in sample _____
- Often used to detect bacterial contamination of _____

Most probable number (MPN) method

- _____ tube MPN test
- _____ sample
  - Count tubes with _____
- Useful when bacteria _____
- But, numbers are _____
  - ____% accurate

Direct microscopic count

- Numbers of microbes counted _____
- _____ results, but …
  - _____ difficult to count
  - _____ cells look like _____ cells
  - Need _____ to count accurately

Indirect measurement of microbial growth

Turbidity

- _____, or _____, of a liquid culture
  - Detected using a _____
- Higher _____, increased _____
- _____ and _____ method of obtaining quantity, but ….
  - Do not obtain _____ - values are only meaningful when _____ to each other
  - _____ cells contribute to _____ just like _____ cells

Metabolic activity

- Assumes _____ of bacteria produces _____ or metabolic product
  - Eg, measure _____ build up
- Can be useful when cells _____
- Can be performed _____ without needing to _____ microbes

Dry weight

- Removal of microbes from growth medium, _____
- Useful for _____