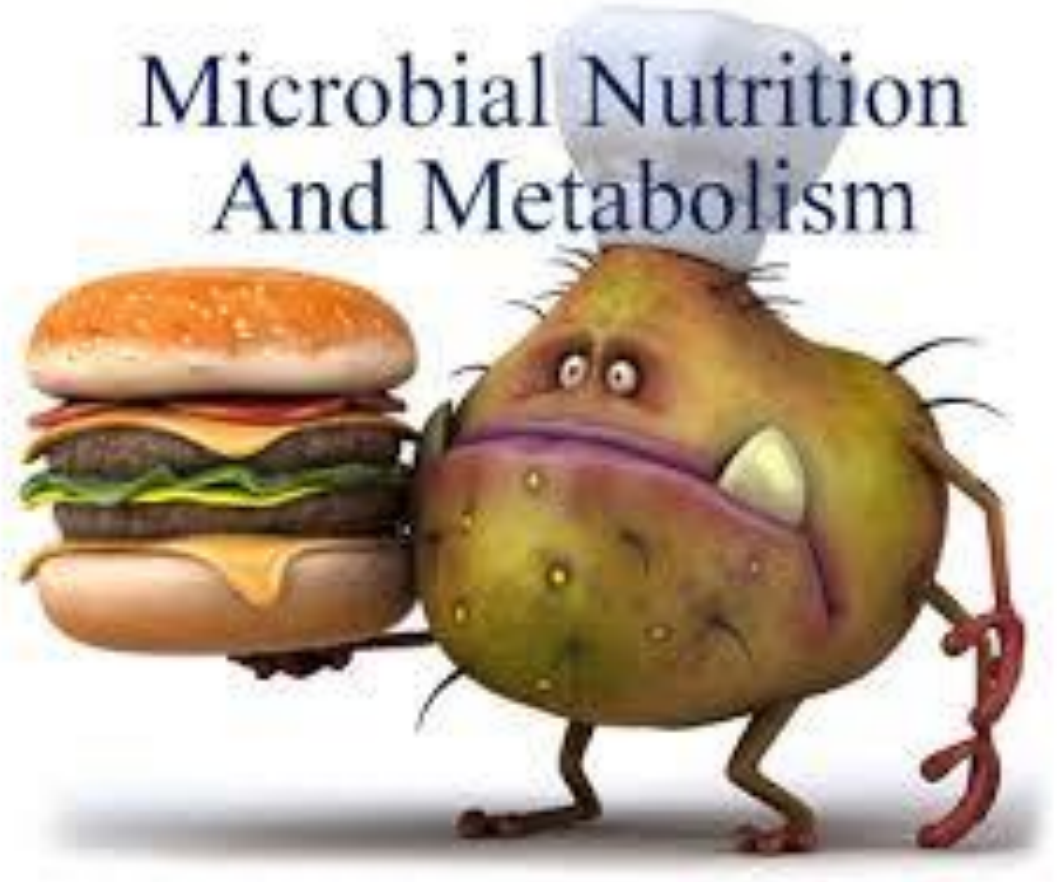

BACTERIAL NUTRITION

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- Microorganism require about 10 elements in large quantities for the synthesis of macro molecules these elements are called macro elements
- 95% of cell dry weight is made up of a few major elements :Carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorus, potassium,mcalcium, magnesium and iron
- The nutrients which are required in small amounts is called micro nutrients/trace elements
- Eg. Zinc, Manganese, Molybdenum

NUTRITIONAL TYPES OF MICROORGANISM

- Based on the sources of carbon, electron and energy micro organism are place d in different nutritional types
- A) Carbon sources
- a) Autotrophs: They use carbon dioxide as a sole source of carbon
- b) Heterotrophs : They use reduced preformed organic molecules from other organism as carbon source
- B) Energy source
- a) Phototroph : Light is used as source of energy

- b) Chemotroph: oxidation of organic / inorganic compound as a source of energy

C) Electron source

a) Litho trophs : reduced inorganic molecules

b) Organotrophs – organic molecules

Microbial growth

- Prokaryotes Reproduce by Binary fission
- Some prokaryotes reproduce by budding, fragmentation or other means

Bacterial Growth curve

- In growth curve, the growth of microorganism reproducing by binary fission is plotted as logarithm of number of viable cells versus the incubation time
- The growth curve has four distinct phases

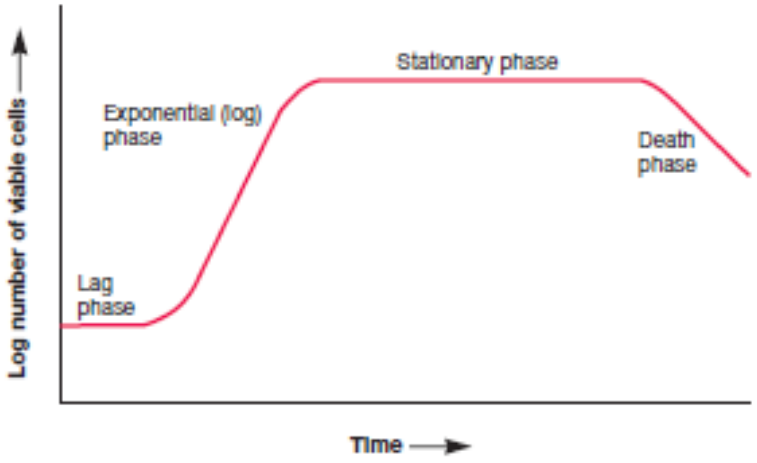


Figure 6.6 Microbial Growth Curve in a Closed System.
The four phases of the growth curve are identified on the curve and discussed in the text.

Lag phase

- When micro organism are introduced into fresh culture, there is no increase in cell number occurs
- So this period is called lag period
- There is no increase in the number of cells
- During this period bacteria is adapting itself to the new environment and synthesise the essential cofactors, ribosome and ATP which are required for growth

Exponential phase or log phase

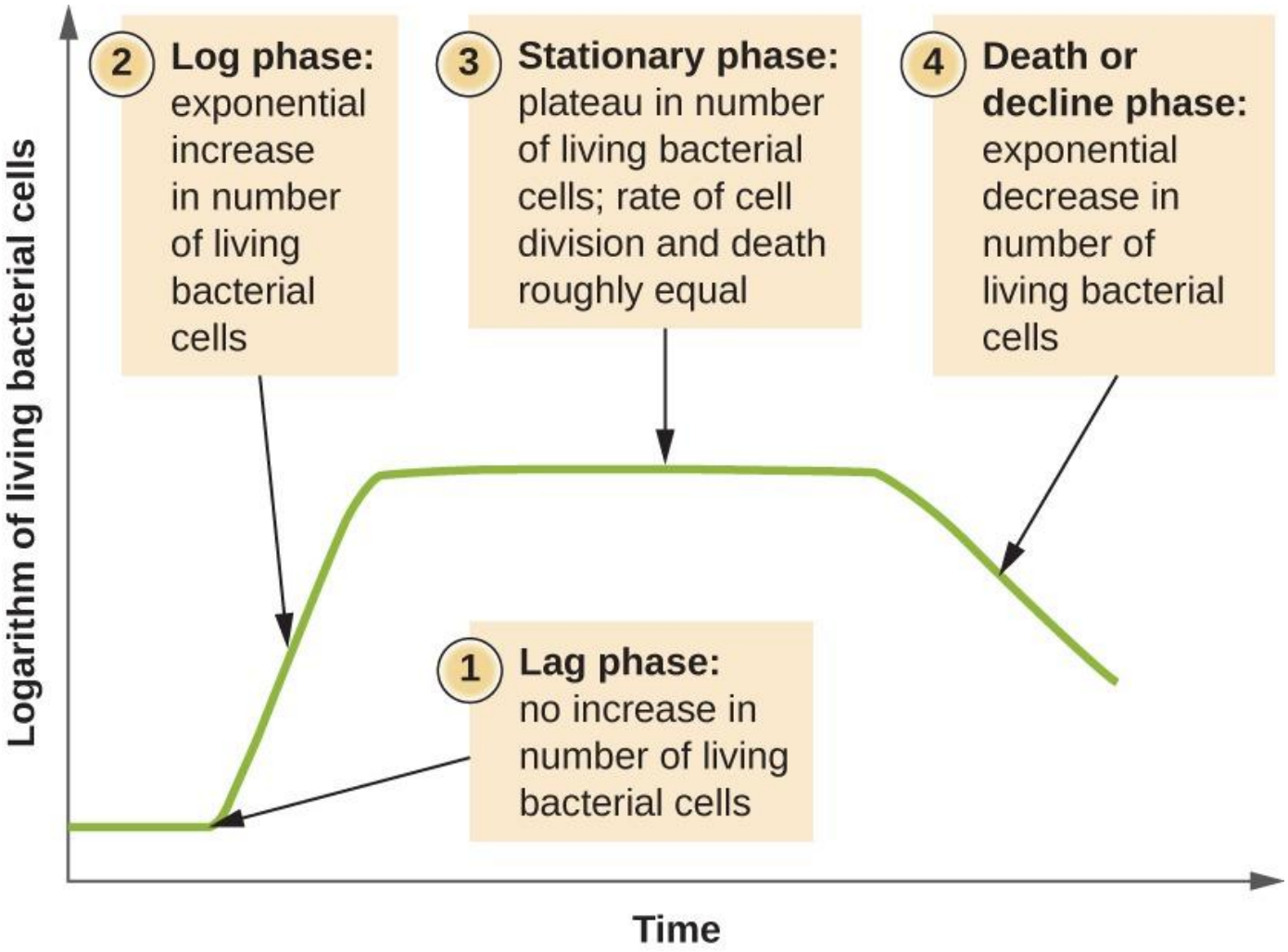
- In this phase microorganism are growing and dividing exponentially
- The rate of growth is constant in exponential phase
- The population is most uniform in terms of chemical and physiological properties during this phase

Stationary phase

- In stationary phase total number of valuable organism remain constant
- There is a balance between cell division and cell death
- In bacteria stationary phase is achieved at a population level of around 10^9 cells per ml
- Microbial population enters into the stationary phase due to
  - Depletion of essential nutrients
  - Limited availability of oxygen for aerobic organism
  - Accumulation of toxic waste products
- Spore formulation occur in this phase

Senescense and death

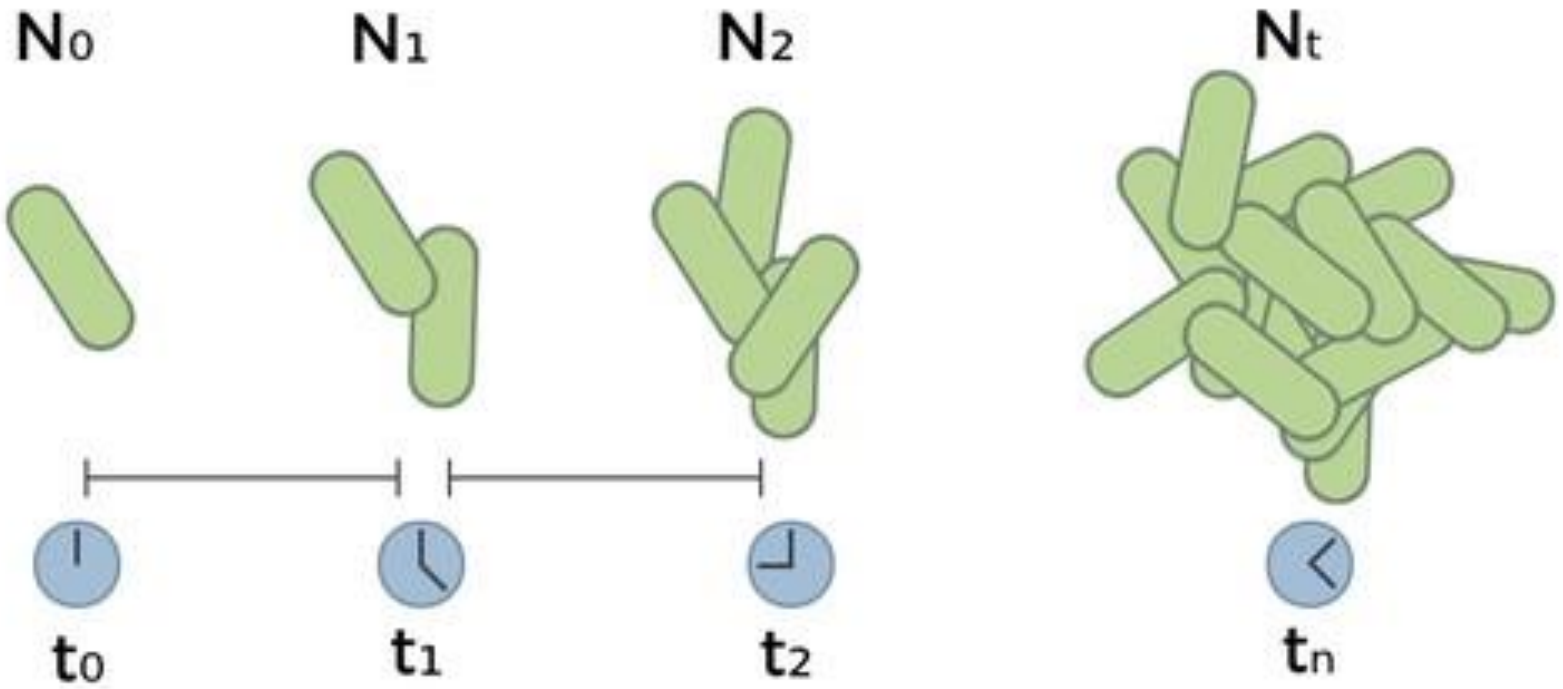
- Decline in viable count following stationary phase
- Nutrient depletion and accumulation of toxic waste is responsible for death phase


2 Log phase: exponential increase in number of living bacterial cells
3 Stationary phase: plateau in number of living bacterial cells; rate of cell division and death roughly equal
4 Death or decline phase: exponential decrease in number of living bacterial cells
1 Lag phase: no increase in number of living bacterial cells
Logarithm of living bacterial cells
Time

Generation time/ doubling time

- The time required to double the number of microorganism in a population
- Because the population is doubling in every generation
- The increase in population always 2^n where n is the number of generations
- So the population increase is exponential or Logarithmic
- Let No is the initial population number
- Nt is the population at time t

- $Nt = No \times 2^n$


N0
N1
N2
Nt
t0
t1
t2
tn

Continuous culture system

- A microbial population can be maintained in the exponential growth phase and at constant biomass concentration for long periods in continuous culture system
- Two major types of continuous culture system commonly used
- 1) Chemostat
- 2) Turbidostat

CHEMOSTSAT

- Sterile medium is fed into the culture vessel at the same time media containing microorganism is removed
- One essential nutrient is limiting in chemostat
- Dilution rate is constant
- Chemostat is stable and effective at lower dilutions

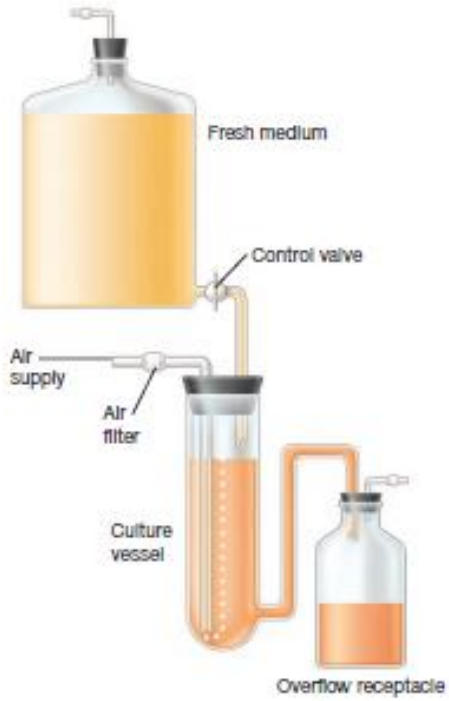


Figure 6.16 A Continuous Culture System: The Chemostat. Schematic diagram of the system. The fresh medium contains a limiting amount of an essential nutrient. Growth rate is determined by the rate of flow of medium through the culture vessel.

Turbidostat

- It has a photocell that measures the absorbance or turbidity of the culture in the growth medium
- The flow rate of media through the vessel is automatically regulated to maintain predetermined turbidity or cell density
- In turbidostat all the nutrients will be in excess
- Turbidostat operates best at high dilution rates

Classification of bacteria based on environmental factor requirement

Based on solute and water activity

- Osmotolerant : able to grow over a wide range of water activity or osmotic concentration

  Eg: *Staphylococcus aureus*

- Halophile: requires high level of Sodium chloride usually above 0.2 M to grow
- Eg, *Staphylococcus aureus*

  Halobacterium

pH

- Acidophile: Growth optimum between pH 0 to 5.5

  Eg: Sulfobolus

- Neutrophile: Growth optimum between pH 5.5 and 8.0

  Eg : *Escherichia coli*

- Alkalophile: Growth optimum between pH 8.0- and 11.5

Temperature

- Psychrophile: Grows well at 0°C and has an optimum growth temperature of 15°C or lower

  Eg: *Bacillus psycrophilus*
- Psychrotroph: can grow at 0-7°C has an optimum growth temperature between 20-30°C and maximum around 35°C.

  Eg: *Listeria monocytogenes*

  Pseudomonas flourescens
- Mesophile : Has optimum growth around 20-45°C

  Eg: *Escherichia coli*
- Thermophile: Can grow at 55°C or higher. Optimum temperature of growth often between 55-65°C
- Hyper thermophile: has an optimum temperature between 80-113^{0}C

Pressure

- Barophilic: Grow more rapid at high hydrostatic pressures

Oxygen requirement

- Obligate aerobe: Completely dependent on atmospheric O_2 for growth

  Eg : micrococcus

  Psuedomonas

  Mycobacterium

- Facultative anaerobe: Does not require oxygen for growth, but grows better in its presence

  Eg. *E. Coli*

- Aerotolerant anaerobe: grows equally well in presence or absence of O2

  Eg. *Streptococcus pyogenes*

- Obligate anaerobe: Do not tolerate O_2 and dies in its presence

  Eg. Clostridium, Bacteriodes

- Microaerophile: Require O_2 levels below 2-10% for growth and is damaged by atmospheric level O_2

  Eg. Campylobacter

  Treponema pallidum

Pathogenicity and virulence

Pathogenicity and virulence

- Any organism that produce disease is called pathogen
- The ability to cause disease is called pathogenicity

- Primary pathogen: Any organism that cause disease in healthy host by direct interaction
- Opportunistic pathogen: Refers to an organism that is part of host's normal microbiota, but is able to cause disease when the host is immunocompromised or when it has gained access to other tissue sites
- Latent stage: there is no shedding of organism and no symptoms present in the host
- Virulence refers to the degree or intensity of pathogenicity

Pathogenicity vs Virulence

- Pathogenicity is the quality or state of being pathogenic, the potential ability to produce disease
- Pathogenicity is a qualitative term, an "all-or-none" concept

- Virulence is the disease producing power of an organism the degree of pathogenicity within a group or species
- Virulence is a term that quantifies pathogenicity

In two minutes

Virulence factors

- The individual characteristic that contributes to virulence are called virulence factors

  Eg: Capsule, Pili, and toxins

- Virulence is characterised by the characteristic of pathogen

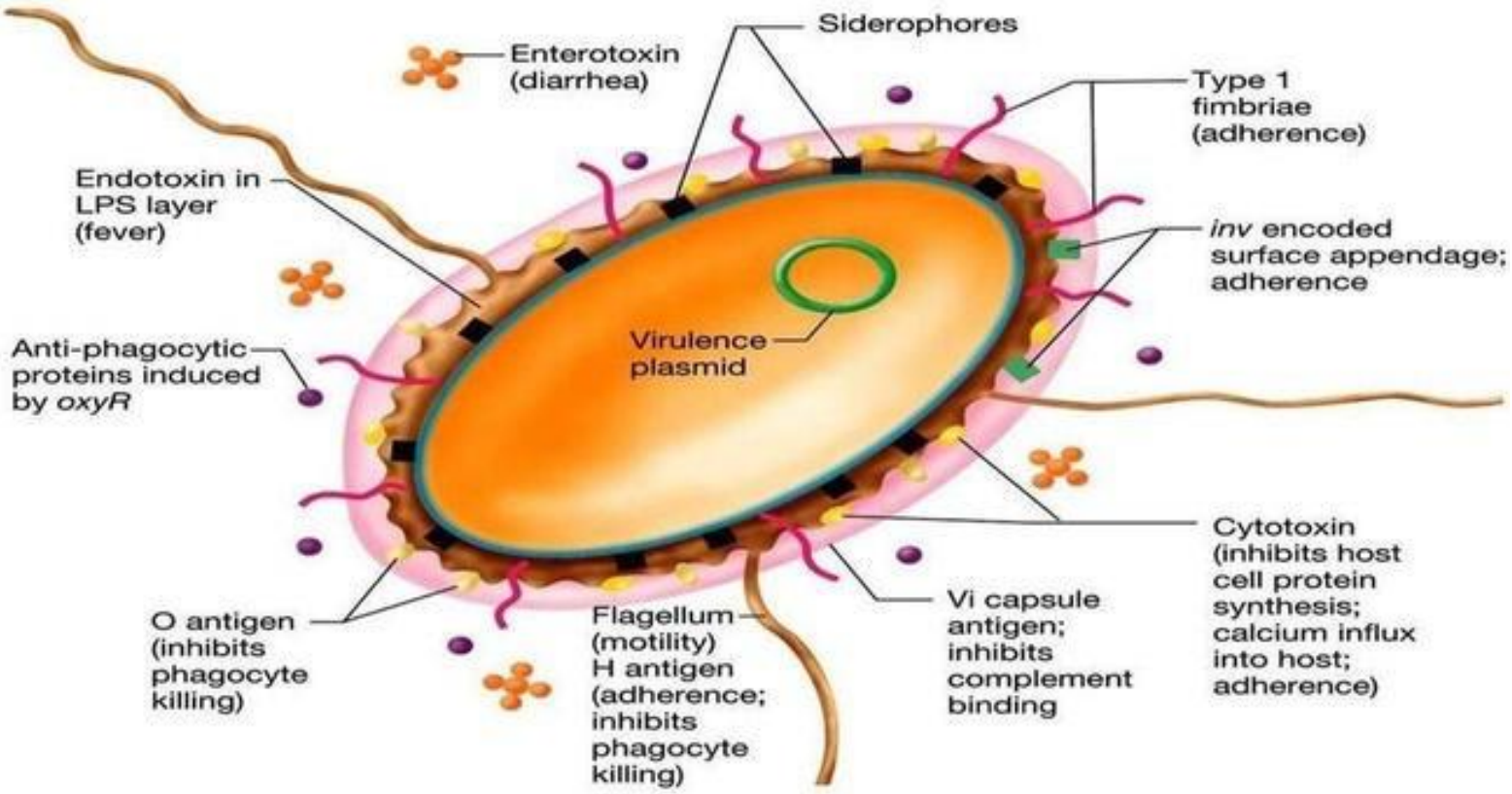
  a) Invasiveness

  b) Infectivity

  c)Pathogenic potential

- Invasiveness : is the ability of organism to spread to adjacent /other tissues
- Infectivity is the ability of organism to establish a focal point of infection
- Pathogenic potential: refers to the degree that the pathogen causes damage
- Toxigenicity: is the pathogens ability to produce toxins, chemical substance that damage the host and produce disease

Virulence factors of bacteria

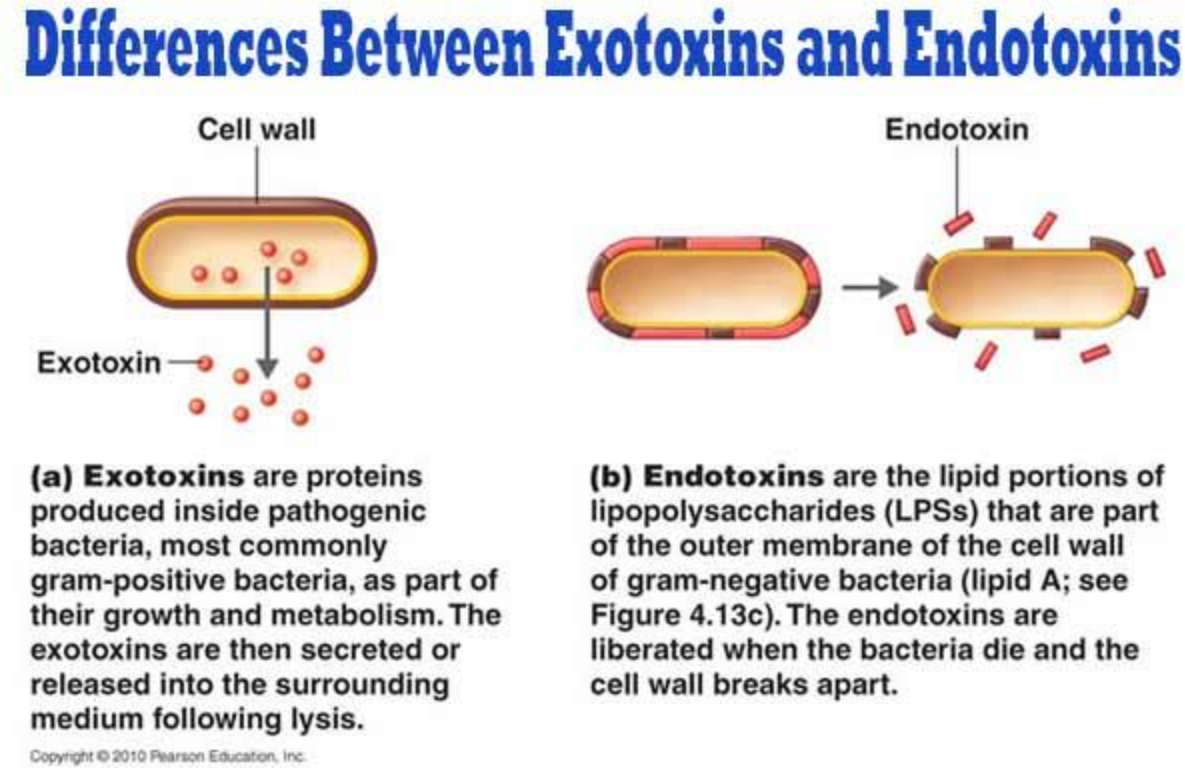


Pathogenicity islands

- The genes that encode major virulence factors in many bacteria are found in large segments of DNA called pathogenicity islands which carry genes responsible for virulence

  Eg: Yersinia, Salmonella
- Intoxications: Are disease that result from specific toxin produce by bacteria
- Toxaemia is a condition caused by toxins that have entered into the blood of host
- Toxins produced by bacteria is classified into two groups: exotoxins and endotoxins

Exotoxin and endotoxin



Exotoxins

- They are soluble heat labile proteins that are released into the surroundings as the bacterial pathogen grows
- In general exotoxins are produced by Gram positive bacteria, although some Gram negative bacteria also produce exotoxins
- Exotoxins are usually encoded by plasmids and prophages
- Exotoxins are among the most lethal substances known: Botulinum toxin
- They are heat labile and can be inactivated by at 60-80oC

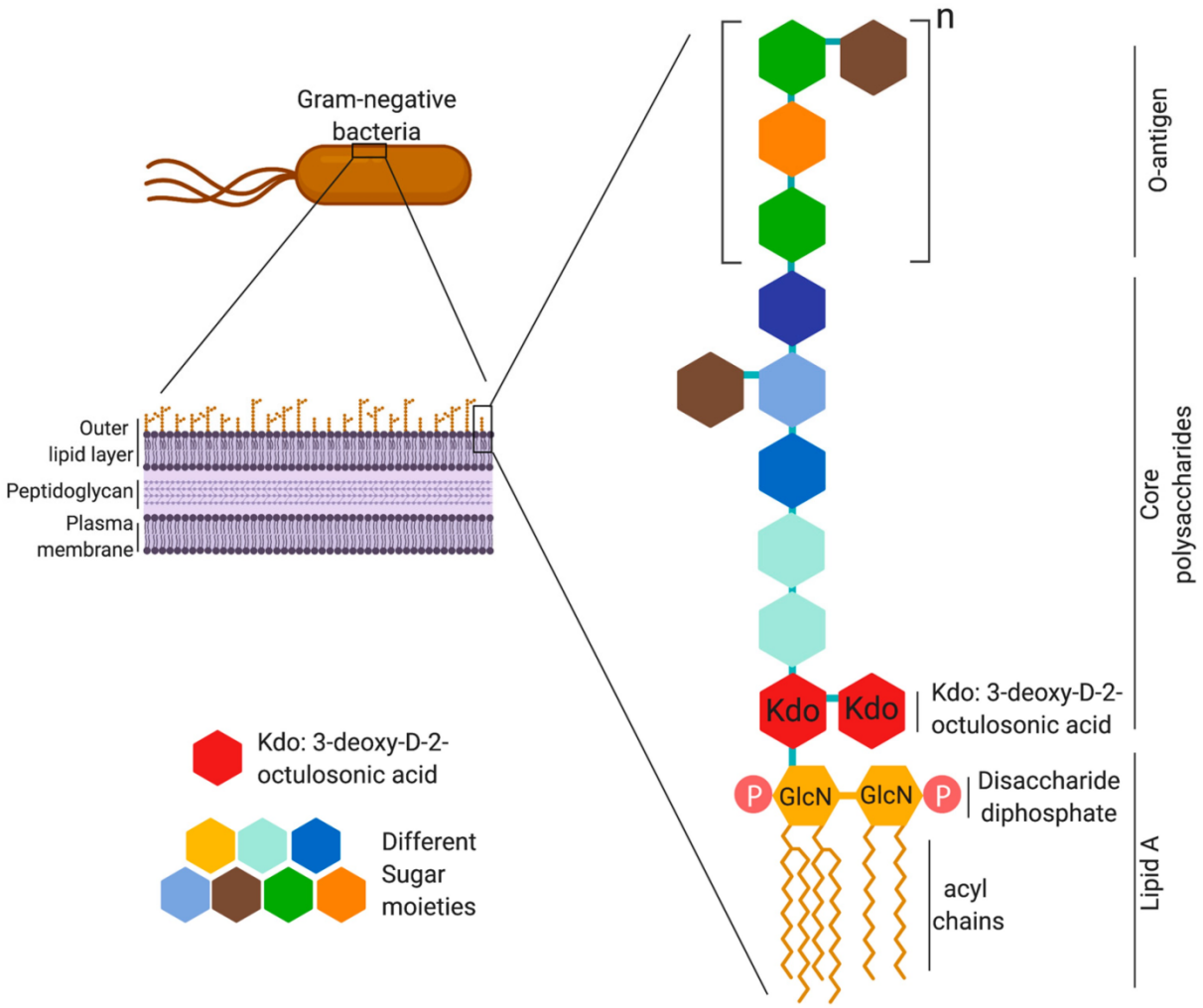
- Exotoxins are highly immunogenic and can stimulate production of neutralising antibodies called antitoxins
- The toxin protein can also be inactivated by fromaldehyde, iodine and other chemicals to form immunogeneic toxoids

Tetanus toxoid

- Anthrax toxin
- Tetanus toxin
- Botulinum toxin
- Cholera toxin

Endo toxin

- Endo toxin is the lipopolysacharide of Gram negative bacteria. So it is produced only by Gram negative bacteria
- It is bound to the bacterium and released only when the microorganism dies
- The toxic component of lipopolysacharide is Lipid A


Gram-negative bacteria
Outer lipid layer
Peptidoglycan
Plasma membrane
Kdo: 3-deoxy-D-2-octulosonic acid
Different Sugar moieties
n
O-antigen
Core polysaccharides
Kdo
Kdo
Kdo: 3-deoxy-D-2-octulosonic acid
P
GlcN
GlcN
P
Disaccharide diphosphate
acyl chains
Lipid A

General characteristic of bacterial endotoxin

- Heat stable
- Toxic (nanogram amounts)
- They are weakly immunogenic
- Generally similar despite the source
- Capable of producing general systemic effects like fever, shock, blood coagulation , weakness, diarrhoea, inflammation, intestinal haemorrhage, fibrinolysis
- The test used for detection of endotoxin is Limulus amoebocyte lysate test (LAL test)

Differentiation between endotoxin and exotoxin

Characteristic	Exotoxins	endotoxins
Chemical composition	protein	Lipopolysacharide complex on outer membrane Lipid A portion is toxic
Disease examples	Botulism Diphtheria Tetanus	Gram negative infection
Effect on host	Highly variable between different toxins	Similar for all endotoxins
Fever	Usually do not produce fever	Produce fever by induction of IL-1 and TNF
Genetics	Frequently carried by extra chromosomal genes such as plasmids	Sythesiszed directly from chromosomal genes

CONTD..

Heat stability	More heat sensitive and inactivated at 60-80°C	Heat stable at 250°C
Immune response	Anti toxins provide host immnuity, Highly antigenic	Weakly immunogenic and immunogenicity associated with polysacharide
Location	Usually excreted outside the living cell	Part of outer membrane of Gram negative bacteria
Production	Produced by both Gram positive and Gram negative bacteria	Found only on Gram negative bacteria and released on bacterial death
Toxicity	Highly toxic and fatal in nanogram quantities	Less potent and less specific than exotoxin. It causes septic shock
Toxoid production	Converted to antigenic non toxic toxoids are used for immunization	Toxoids can not be made

THANK YOU