Microbial interaction:

Microorganisms interacts with each other and can be physically associated with another organisms in a variety of ways.

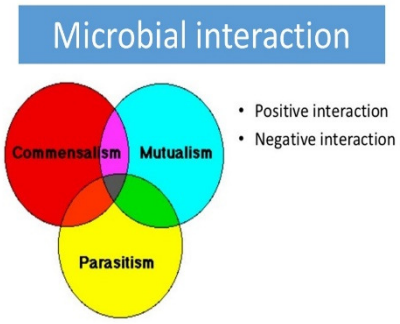
One organism can be located on the surface of another organism as an ectobiont or located within another organism as endobiont.

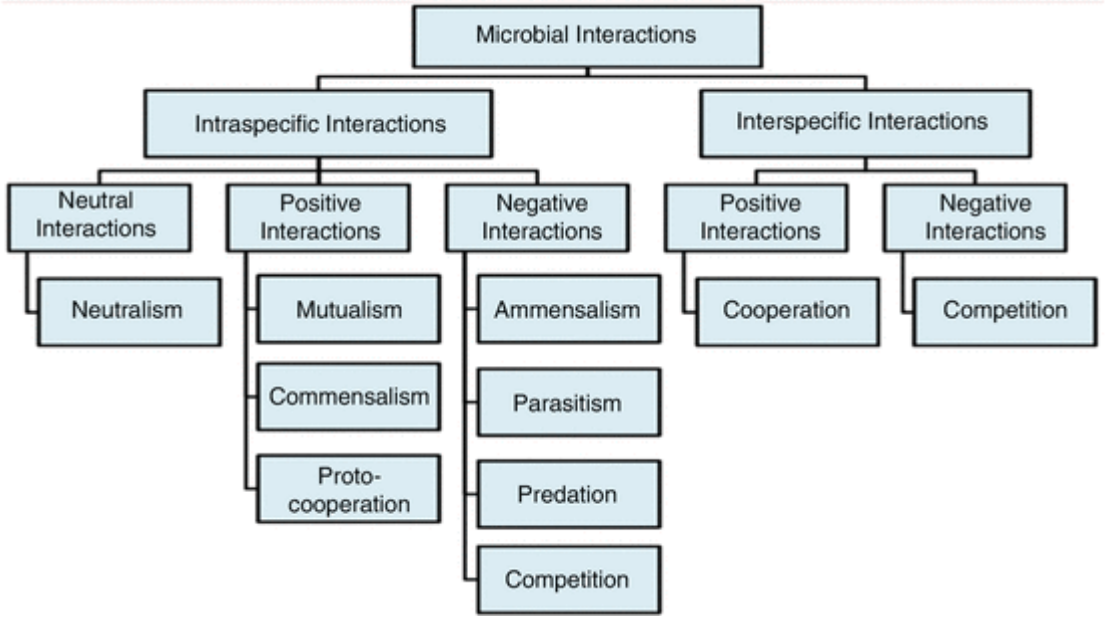
Microbial interaction may be positive such as mutualism, proto-cooperation, commensalism or may be negative such as parasitism, predation or competition

Types of microbial interaction

Positive interaction: mutualism, proto-cooperation, commensalism.

Negative interaction: Ammensalism (antagonism), parasitism, predation, competition.





I. Mutualism:

It is defined as the relationship in which each organism in interaction gets benefits from association. It is an obligatory relationship in which mutualist and host are metabolically dependent on each other.

Mutualistic relationship is very specific where one member of association cannot be replaced by another species.

Mutualism require close physical contact between interacting organisms.

Relationship of mutualism allows organisms to exist in habitat that could not occupied by either species alone.

Mutualistic relationship between organisms allows them to act as a single organism.

Examples of mutualism:

1.Lichens:

Lichens are excellent example of mutualism.

They are the association of specific fungi and certain genus of algae. In lichen, fungal partner is called **mycobiont** and algal partner is calledPhycobiont is member of cycanobacteria ad green algae (*Trabauxua*).

Because phycobionts are photoautotrophs, the fungus get its organic carbon directly from algal partner, in turn fungi protects the phycobiont from extreme conditions and also provide water and minerals to algae.

Lichen grow very slowly but are able to colonies habitat that do not permit the growth of other organisms.Most lichens are resistant to high temperature and drying.

2. Protozoan-termite:

Protozoan-termite relationship is the classical example of mutualism in which flagellated protozoan lives in the gut of termites.

Theses flagellated protozoan feeds on diet of carbohydrates acquired as cellulose or lignin by their host termites, metabolize into acetic acid which is utilized by termites.

3. Paramecium-Chlorella:

Paramecium (protozoa) can host *Chlorella* (algae) within its cytoplasm.

The algae *Chlorella* provide the protozoan partner with organism carbon and O2, in turn protozoa provide protection, mortility, CO2 and other growth factors.

The presence of *Chlorella* within *Paramecium* helps to survive protozoa in anaerobic condition as long as there is sufficient light.

II. Syntrophism:

It is an association in which the growth of one organism either depends on or improved by the substrate provided by another organism.

In syntrophism both organism in association gets benefits.

Compound A- Utilized by population 1

Compound B- Utilized by population 2

Compound C- Utilized by both Population 1+2

Products

In this theoretical example of syntrophism, population 1 is able to utilize and metabolize compound A, forming compound B but cannot metabolize beyond compound B without co-operation of population 2. Population 2is unable to utilize compound A but it can metabolize compound B forming compound C. Then both population 1 and 2 are able to carry out metabolic reaction which leads to formation of end product that neither population could produce alone.

Examples of syntrophism:

i. Methanogenic ecosystem in sludge digester

Methane produced by methanogenic bacteria depends upon interspecies hydrogen transfer by other fermentative bacteria.

Anaerobic fermentative bacteria generate CO2 and H2 utilizing carbohydrates which is then utilized by methanogenic bacteria (*Methanobacter*) to produce methane.

ii. *Lactobacillus arobinosus* and*Enterococcus faecalis*:

In the minimal media, Lactobacillus arobinosus and Enterococcus faecalis are able to grow together but not alone.The synergistic relationship between E. faecalis and L. arobinosus occurs in which E. faecalis require folic acid which is produced by L. arobinosus and in turn lactobacillus require phenylalanine which is produced by Enterococcus faecalis.

iii. Protocooperation:

It is a relationship in which organism in association is mutually benefited with each other.This interaction is similar to mutualism but the relationships between the organisms in protocooperation is not obligatory as in mutualism.

Examples of Protocooperation:

i. Association of *Desulfovibrio* and *Chromatium*: it is a protocooperation between carbon cycle and sulfur cycle.

ii. Interaction between N2-fixing bacteria and cellulolytic bacteria such as *Cellulomonas*.

IV. Commensalism:

It is a relationship in which one organism (commensal) in the association is benefited while other organism (host) of the association is neither benefited nor harmed. It is an unidirectional association and if the commensal is separated from the host, it can survive.

Examples of commensalism:

i. Non-pathogenic *coli* in intestinal tract of human:

E. coli is a facultative anaerobe that uses oxygen and lower the O2 concentration in gut which creates suitable environment for obligate anaerobes such as *Bacteroides*. *E. coli* is a host which remains unaffected by *Bacteroides*.

ii. *Flavobacterium* (host) and *Legionellapneumophila* (commensal):

Flavobacterium excrete cystine which is used by *Legionella pneumophila* and survive in aquatic habitat.Association of *Nitrosomonas* (host) and *Nitrobacter* (commensal) in Nitrification:*Nitrosomonas* oxidize Ammonia into Nitrite and finally *Nitrobacter* uses nitrite to obtain energy and oxidize it into Nitrate.

V. Amensalism (antagonism):

When one microbial population produces substances that is inhibitory to other microbial population then this inter population relationship is known as Ammensalism or Antagonism.It is a negative relationship.The first population which produces inhibitory substances are unaffected or may gain a competition and survive in the habitat while other population get inhibited. This chemical inhibition is known as antibiosis.

Examples of antagonism (amensalism):

i. Lactic acid produced by lactic acid bacteria in vaginal tract:

Lactic acid produced by many normal floras in vaginal tract is inhibitory to many pathogenic organisms such as *Candida albicans*.

ii. Skin normal flora:

Fatty acid produced by skin flora inhibits many pathogenic bacteria in skin.

iii. Thiobacillusthiooxidant:

Thiobacillusthioxidant produces sulfuric acid by oxidation of sulfur which is responsible to lowering of pH in the culture media which inhibits the growth of most other bacteria.

VI. Competition:

The competition represents a negative relationship between two microbial population in which both the population are adversely affected with respect to their survival and growth.

Competition occurs when both population uses same resources such as same space or same nutrition, so, the microbial population achieve lower maximum density or growth rate.

Microbial population competes for any growth limiting resources such as carbon source, nitrogen source, phosphorus, vitamins, growth factors etc.

Competition inhibits both population from occupying exactly same ecological niche because one will win the competition and the other one is eliminated.

Examples of competition:

i. Competition between *Paramecium cadatum* and *Paramecium aurelia:* Both species of Paramecium feeds on same bacteria population when these protozoa are placed together.

P. aurelia grow at better rate than *P. caudatum* due to competition.

VII. Parasitism:

It is a relationship in which one population (parasite) get benefited and derive its nutrition from other population (host) in the association which is harmed.The host-parasite relationship is characterized by a relatively a long period of contact which may be physical or metabolic.Some parasite lives outside host cell, known as ectoparasite while other parasite lives inside host cell, known as endoparasite.

Examples of parasitism:

i. Viruses:

Viruses are obligate intracellular parasite that exhibit great host specificity.

There are may viruses that are parasite to bacteria (bacteriophage), fungi, algae, protozoa etc.

ii. *Bdellovibrio*:

Bdellavibrio is ectoparasite to many gram negative bacteria.The parasite *Bdellovibrio* penetrate the outer membrane of its host and enters periplasmic space but not inside host cytoplasm.

VIII. Predation:

It is a wide spread phenomenon when one organism (predator) engulf or attack other organism (prey).The prey can be larger or smaller than predator and this normally results in death of prey.Normally predator-prey interaction is of short duration.

Examples of Predation:

i. Protozoan-bacteria in soil:

Many protozoans can feed on various bacterial population which helps to maintain count of soil bacteria at optimum level.

ii. *Bdellovibrio, Vamparococcus, Daptobacter*etc are examples of predator bacteria that can feed on wide range of bacterial population.