INTERACTIONS BETWEEN MICROORGANISMS

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OBJECTIVES

- Microorganism interactions
- Normal flora of the human
- Parasitism
- Virulence factors
- Defense mechanism

- Positive interactions

  (mutualism,protocooperation,commensalism)

- Negative interactions

  (predation,parasitism,amensalism,and competition)

- **Mutualism** : A mutualistic relationship is when two organisms of different species "work together," each benefiting from the relationship.
- Benefical relationship between two species.
- Mutualist and host are dependent on each other.
- Bacteria in human colon: *Escherichia coli* – Synthesizes Vitamin K & B complex vitamins – In return, we provide a warm, moist, nutrient rich environment for *E. coli*

- *Lactobacillus arabinosus* and *Enterococcus faecalis* can not develop and breed alone in an environment free of phenyl alanine. If these two microorganisms are found together, both of them are abundant. Each microorganism synthesizes the factor that is required by each other, and thus both easily growth (*S. faecalis* synthesis phenyl alanine and *L. arabinosus* synthesis folic acid). Thus, microorganisms provide mutual benefits to each other.
- Mutation based on nutrition is called syntrophism.

- **Commensalism** is a relationship between two species in which one is benefited and the other is not affected.
- We have no commensalistic relationships with bacteria

✓If Bacteria are in or on our body, they are either helping us (Microbial Antagonism) or harming us.

- Some microbes do not have enzymes that will break down some of the foods in the feed. For this reason they can not benefit from these substances. In such an environment, if there is a second microorganism that can break up the substance that the first microorganism can not dissolve, the food substance is separated by the second microorganism. The first microorganism also benefits from the resulting intermediates. So both microbes survive. But the latter does not provide benefit from first microorganism.

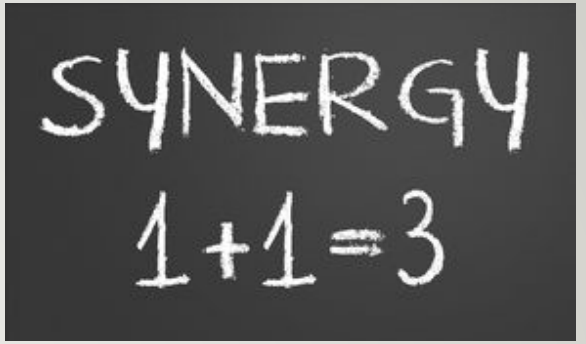
- in the human colon, when oxygen is used up by the facultatively anaerobic *E. coli*, obligate anaerobes such as Bacteroides are able to grow in the colon.

- **Parasitisim:** It is a releationship between two species in which one benefits from the other (host).
- Mutualism: **+ / +**
- Commensalism: **+ / 0**
- Parasitism: **+ /-**

The Three Types of Symbiotic Relationships

Table 14.1 The Three Types of Symbiotic Relationships

	Organism 1	Organism 2	Example
Mutualism	Benefits	Benefits	Bacteria in human colon
Commensalism	Benefits	Neither benefits nor is harmed	*Staphylococcus* on skin
Parasitism	Benefits	Is harmed	Tuberculosis bacteria in human lung



- **Synergism** refers to a phenomenon, infection or condition that two or more microorganisms co-create, supporting each other's action. None of these factors can bring them to the same conclusion. Some of the mixed infections seen in humans and animals are produced in a synergetic manner.

- That is, two or more microorganisms work together to bring about the disease. For example, *Treponema vinc*entii and *Fusobacterium nucleatum* together with the other microorganisms, which are among the oral microflora of humans cause Plain Vincent angina, gingivitis, stomatitis, etc.,
- In some cases, microorganisms, which are harmless on their own, can cause disease when given together.

- **Antagonism**: Some microorganisms can inhibit the growth of other microorganisms or kill with direct or indirect effects of a number of soluble substances that secreted by microorganisms.
- For example; *S. viridans* which is being in human nasopharynx, has negative effect on pathogenic *C. diphtheriae*,

- Colicin produced by *E. coli*, pyocyanin synthesized by *P. aeruginosa* has inhibitory effect on other microorganisms.

- The metabolic residues of microorganisms (organic acids, etc.) usually alter the pH of the medium, (pH drop) and prevent of growing highly sensitive microorganisms.

Microorganisms - Environment

- Microbial flora of Air: Air is not a suitable environment for microorganisms to live and multiply. Microorganisms stay alive in the air for a short or long time depending on the resistant to dryness, being together with the organic matter, environmental heat and the humidity of the air.
- Particles suspended in air are 1 to 5 micron particles.
- Air control is necessary.

- Microbial flora of Soil: Soil is the medium in which organic matter and water are constantly condensed and N, S, C transformed.
- Numerous organisms such as bacteria, fungi, algae, viruses, protozoa and microscopic organisms ranging from invertebrates to vertebrates are found in soil.

- Microbial flora of water : The bacteria found in the soil can pass to the water. The most important ones are the sickly bacteria that are mixed into the water due to human and animal. *Vibrio cholerae*, Salmonella, Shigella, Escherichia, Leptospira, *Entamoeba histolytica*.
- It is very important to prevent pollution of drinking and usage waters and disinfection of contaminated waters.

Microorganism – Organism Interaction

- The microorganisms grouped in various regions of the body, living together with the organism, harmless to the organism, or even providing some benefits, is called the body's normal flora. Or definition of normal flora is the mixture of microorganisms (bacteria and fungi) that are regularly found at any anatomical site of human body.

NORMAL FLORA (MICROBIOTA)

- It is estimated that 500 to 1000 species of bacteria live in the human body
- Though normal flora are found on all surfaces exposed to the environment (on the skin and eyes, in the mouth, nose, small intestine), the vast majority ofbacteria live in the large intestine
- Composition of normal flora depends upon many various factors: - genetics, age, sex, stress, nutrition, diet…
- The composition of the normal flora It has been calculated that the normal human is host to about 10^{12} bacteria on the skin, 10^{10} in the mouth and 10^{14} in the gastrointestinal tract.

Flora is two types

- Resident Flora: Microbes that are always present .
- Transient Flora: Microbes that live in or on your body for a period of time (hours, days, weeks, months) then move on or die off

- **Resident (continuous) flora**: A flora that occurs in a certain area, usually unchanged at certain ages, even if it is forcibly removed under various influences, then formed again after a short or long period of time.

- These microorganisms in the flora do not make any illness unless they have passed through other places, the balance between them has not deteriorated and the organism's defense weakened.
- These are called opportunistic pathogenic microorganisms. Under normal conditions, microbe does not cause disease, but if conditions become conducive , it can cause disease.

- *Escherichia coli* - normally in our gastrointestinal tract where it causes no problems, but if it gets into the urinary tract it can become pathogenic. *Staphylococcus aureus* – commonly found in the upper respiratory tract, but if it gets into a wound or a burn it can become pathogenic.

Resident flora;

- Reflects age of person
- Changes continuously through out life
- Reflects nutrition of person
- Reflects genetics of person
- Reflects environment of person
- Reflects sex of person

- Transient flora:
- Remain in the body for only hours to months before disappearing
- Found in the same regions as resident microbiota

Cannot persist in the body…because…

- Competition from other microorganisms
- Elimination by the body's defenses cells
- Chemical or physical changes in the body

Sterile tissues;

- In a healthy human, the internal tissues such as: blood, brain, muscle, cerbrospinal fluid (csf.) are normally free of microorganisms.

There are many factors that determine the distribution & composition of the normal microbiota

- Nutrients: bacteria can colonize only those body sites that can supply the appropriate nutrientsNutrients may be derived fromsecretary products of cells.Body fluids, Dead cells, food in gastrointestinal tract

- Physical & chemical factors: temperaturepH, O_2 , CO_2

- Defenses of the host: Defenses=immune response=variety of molecules & activated cells that kill microbes or inhibit their growth or prevent adhesion & neutralize toxins
- Mechanical factors =may affect colonization by normal flora e.g.Chewing action of the teeth remove microorganism attachment
- G.I.T. – flow of saliva & digestive secretions
- R.T –mucus membrane

Other factors that also affect the normal microbiota;

- Age
- Nutritional status
- Diet
- Health status
- DisabilityClimate\geography
- Personal hygiene
- Life style

The importance of the normal flora

Advantages

1. They constitute a protective host defense mechanism, prevent colonization by pathogens

2. They produce vitamin B and vitamin K in intestine.

3.The oral flora contribute to immunity by inducing low levels of circulating and secretory antibodies that may cross react with pathogens.

4.The oral bacteria flora exert microbial antagonism against nonindigenous species by production of inhibitory fatty acids, peroxides, bacteriocins, etc.

5. The normal flora may antagonize other bacteria through the production of substances which inhibit or kill nonindigenous species.

Disadvantages

1. They can cause disease in the following:

a) When individuals become immunocompromised.

b) When they change their usual anatomic location.

Normal flora of the skin

The skin is typically dry and salty, providing an environment inhospitable to many microorganisms.Skin can acquire any transient bacteria from the environment but it either get washed off or die because the skin inhospitable environment.

- Skin flora are normally harmless microbes present on the skin
- Made up of various microbes
- May produce disease If penetrate epidermis or if immune system is suppressed

Transient microbes: in contact with environment

Resident microbes:

- Areas of high moisture content;
- Axilla, groin, toe webs, perineum, scalp: Because of the high moisture of content of the axill is a good place for „cultivation“ of bacteria and fungi

Most of the microbial skin inhabitants can be categorized in three groups:

- Diptheroids: Propionibacteriumacneswhich lives in hair follicle where conditions are anaerobic. Its growth is enhanced by the oily secretion of the sebaceous glands.

- Staphylococci : Staphylococci are the salt-tolerant organisms that grow well on the salty skin surface. The are able to grow aerobicaly and the most common of species is:
- e.g. *S. epidirmidis*. (Major inhabitant making up more than 90% of the flora)
- They protect the skin from other pathogens by outcompeting them for space on the skin and by secreting substances that inhibit the growth of other organisms.

- Yeasts/fungi: Some fungi and yeasts can cause opportunistic infections
- e.g. *Candida albicans*

- *Staphylococcus epidermidis*
- *Staphylococcus aureus*
- *Propionibacterium acnes*
- *Candida albicans*
- *Streptococcus species*
- *Corynebacterium*

- **Eye normal flora**
- Normal healthy people commonly have no bacteria on their conjunctivae, because of the frequent automatic washing of the eye with lysozyme-rich tears and from the eyelids blinking reflex, which cleans the eye.
- Any organisms recovered from the normal conjunctiva are usually few in number and originate form the skin flora.

Normal flora of the oral cavity

- Birth: sterile mouth
- Neonate

  Within 4-12 hours (lactobacilli, streptococci)

  Colonized from environment (especially first feeding)

Streptococcus salivarius, staphylococci, Neisseriae, *Moraxella catarrhalis*

- Teeth appear

  Streptococcus mutans, *Streptococcus parasanguis*

  Gingival crevice area (supporting structures of teeth): Anaerobic species, yeasts

- Puberty: Bacteroides, Spirochetes
- 10^8 bacteria/mL of saliva; potentially >700 species

- **Tooth decay:** *Streptococcus mutans* and Peptostreptococcus make dextran and levan polymers from sucrose and other sugars. They create a layer called plaque that covers the enamel. Lactobacilli and *Streptococcus mutans* in plaque form acid from carbohydrates.
- Genetic, hormonal and nutritional habits are also important.

Normal flora of the Gastrointestinal Tract

- There are 10^{14} microorganisms in the GIT.
- Colonization of the gastrointestinal tract begins immediately after birth
- Initial bacterial colonization (normal) starts from a “Germ free” intrauterine environment and is populated through maternal vaginal/fecal flora and oral feeding (breast milk vs formula)
- Complete adult colonization : by 3 yrs of life

- Birth: sterile
- Breast-fed: Bifidobacteria species
- Switch to cow's milk: Bifidobacteria species joined Enteric, bacteroides, enterococci, lactobacilli and clostridia
- Switch to solid food: Microflora similar to parents

Normal flora of vagina

It is different in four periods depending on age.

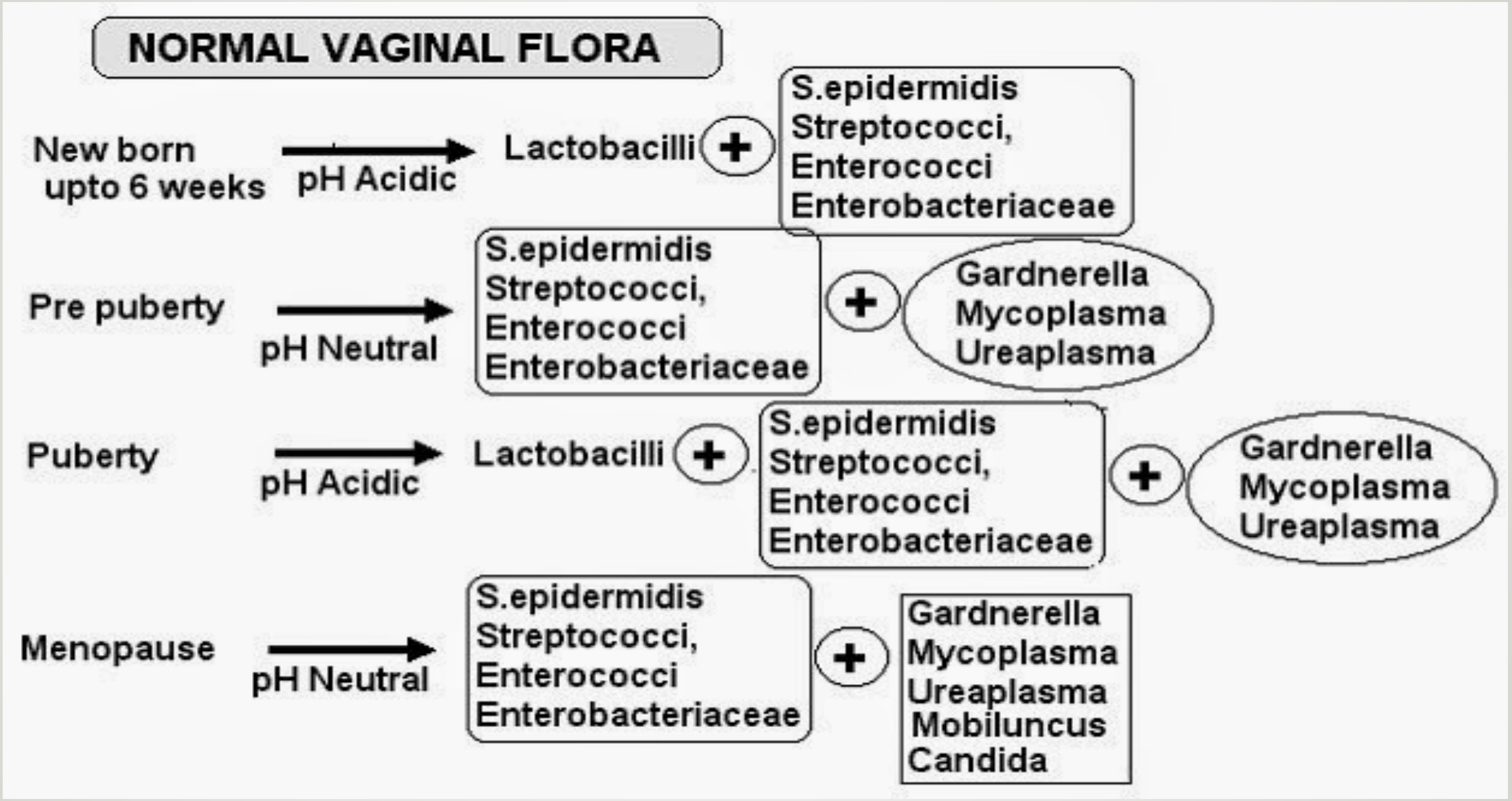
1. Domestic aerobic lactobacilli (Doederlein basilis) dominated a few weeks after birth. pH acid.

2. The vaginal flora is mixed up to puberty. The pH becomes neutral.

3. In puberty, lactobacilli is dominated again.

4. After the menopause, a mixed flora of bacteria is formed.

Lactobacillus spp. keeps the pH acidic to protect the vagina from opportunistic infections such as: *Candida albicans*(yeast vaginitis), Bacteroides, or *Gardnerella vaginalis* (bacterial vaginosis).


NORMAL VAGINAL FLORA
New born upto 6 weeks
pH Acidic
Lactobacilli
+
S.epidermidis
Streptococci,
Enterococci
Enterobacteriaceae
Pre puberty
pH Neutral
S.epidermidis
Streptococci,
Enterococci
Enterobacteriaceae
+
Gardnerella
Mycoplasma
Ureaplasma
Puberty
pH Acidic
Lactobacilli
+
S.epidermidis
Streptococci,
Enterococci
Enterobacteriaceae
+
Gardnerella
Mycoplasma
Ureaplasma
Menopause
pH Neutral
S.epidermidis
Streptococci,
Enterococci
Enterobacteriaceae
+
Gardnerella
Mycoplasma
Ureaplasma
Mobiluncus
Candida

Parasitism

Parasitism: Relationship between two species in which one benefits (parasite) from the other (host); usually involves detriment to the host.

- **Obligatory parasites**: They absolutely need a host organism to reproduce and to survive. They can not live outside the organism.

- **Facultative (interchangeable) parasites**: While they are parasitic with the organism, they can survive if left from it.

- **INFECTION:** the **colonization** and/or **invasion** and **multiplication** of pathogenic microrganisms in the host **with or without** the manifestation of **disease**

- **DISEASE:** an **abnormal condition** of body function(s) or structure that is considered to be harmful to the affected individual (host); any deviation from or interruption of the normal structure or function of any part, organ, or system of the body

- Pathogen microorganism: Any microorganism capable of injuring its host,
- Saprophyte: An organism that grows on dead organic matter, plant or animal
- Potantial (Oportunistic) pathogen : An infectious microorganism that is normally a commensal or does not harm its host but can cause disease when the host's resistance is low. Escherichia coli - normally in our digestive tract where it causes no problems, but if it gets into the urinary tract it can become pathogenic. • Staphylococcus aureus – commonly found in the upper respiratory tract, but if it gets into a wound or a burn it can become pathogenic.

- Exogenous infection:

  An infection caused by organisms that are not normally present in the body but have gained entrance from the environment.

- Endogenous infection:

Infection caused by an infectious agent already present in the body.

- **EPIDEMIC**: disease occuring suddenly in numbers clearly in access of normal expectancy

- **ENDEMIC**: disease present or usually prevalent in a population or geographic area at all times

- **PANDEMIC**: a widespread epidemic distributed or occuring widely throughout a region, country, continent, or globally

To cause disease , most pathogens must

- Enter the host
- Adhere to host tissues
- Penetrate or evade host defenses
- Damage the host tissues
- Exit from the host

Microorganism's factors related with parasitism

1. Anatomic barrier: It has an important role in getting disease.

- Sites through which pathogens enter the body
- Four major types
  - Skin
  - Mucous membranes
  - Placenta
  - Parenteral route

- **Skin:** Outer layer of packed, dead, skin cells usually acts as a barrier to pathogens • Some pathogens can enter through openings or cuts • Others enter by burrowing into or digesting the outer layers of skin
- Solid skin is the entrance door for very few microorganisms.
- *Bacillus anthracis* infects according to the place of entry. Skin, lung and intestinal anthrax

- **Mucos membranes**: Line the body cavities that are open to the environment • Provides a moist, warm environment that is hospitable to pathogens • Respiratory tract is the most commonly used site of entry – entry is through the nose, mouth or eyes • Pathogens able to survive the acidic pH of the stomach may use the gastrointestinal tract as a route of entry. Influenza and Pox virus caused infection by entering respiratory tract.
- Shigella, Brucellar, Vibrio cholerae, most Salmonella cause infection via only entering the gastrointestinal tract alone.
- Some Pathogens Cross the **Placenta**: *Treponema pallidum*, *Listeria monocytogenes*
- **Parenteral Route**

2. The number of microorganisms that enter the organism

3. Virulence: Virulence is a pathogen or microbe's ability to infect or damage a host.

Virulence Factors

1- Adhesion

Its the ability to adhere to host cells and resist physical removal:

-Bacteria resist physical removal by:

- Producing fimbriae (pili)
- Non fimbiral adhesins
- Biofilm-producing glycocalyx

These enable bacteria to adhere to receptors on target host cells.

2-Invasion

It’s the ability of microorganisms to inter host’s tissues, multiply their and spread to other tissues. This invasion is helped by enzymes,

- collagenase (breaks down collagen).
- Hyaluronidase (breaks down hyaluronic acid).
- Lecithinase (breaks down lecthin of cell membrane).

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