

Microbial Pathogenicity and Diseases

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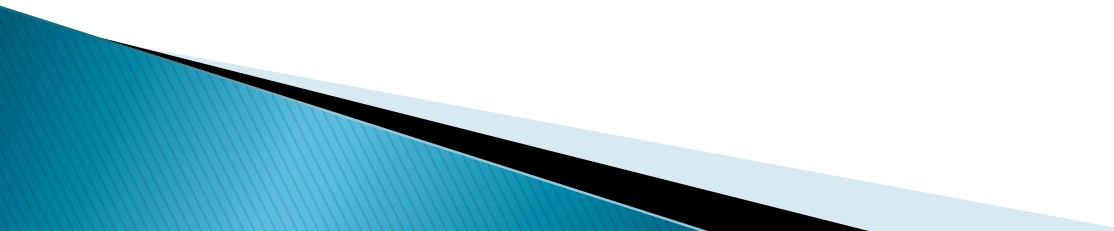
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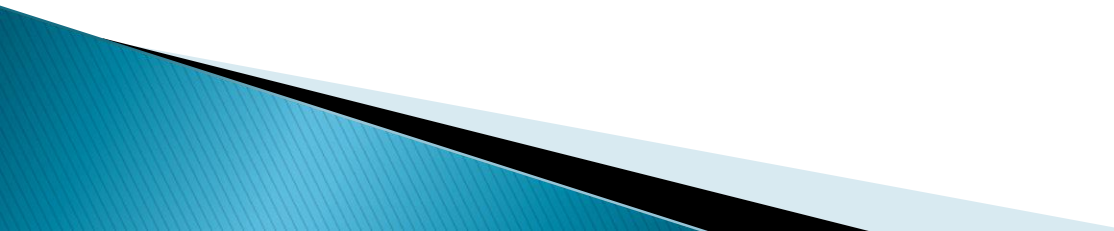


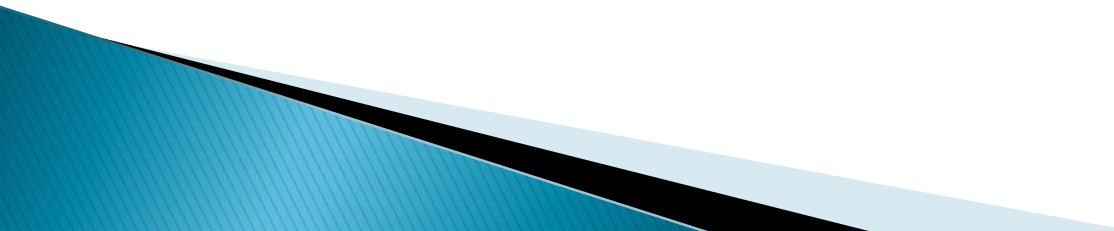
▶ **PATHOGENICITY**

- ▶ Pathogenicity is the capacity to initiate disease. It requires the attributes of transmissibility or communicability from one host or reservoir to a fresh host, survival in the new host, infectivity or the ability to breach the new host's defenses, and virulence, a variable that is multifactorial and denotes the capacity of a pathogen to harm the host. Virulence in the clinical sense is a manifestation of a complex bacterial–host relationship in which the capacity of the organism to cause disease is considered in relation to the resistance of the host.

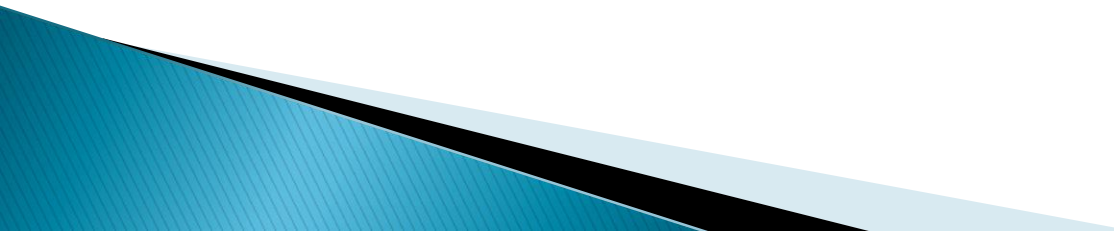
▶ **Types of bacterial pathogens**


- ▶ Bacterial pathogens can be classified into two broad groups, primary and
 - ▶ opportunistic pathogens.
 - ▶ **Primary pathogens** are capable of establishing infection and causing disease in previously healthy individuals with intact immunological defenses. However, these bacteria may more readily cause disease in individuals with impaired defenses.
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- ▶ **Opportunistic pathogens** rarely cause disease in individuals' with intact immunological and anatomical defenses. Only when such defenses are impaired or compromised, as a result of congenital or acquired disease or by the use of immunosuppressive therapy or surgical techniques, are these bacteria able to cause disease. Many opportunistic pathogens, e.g. coagulase negative staphylococci and *Escherichia coli*, are part of the normal human flora and are carried on the skin or mucosal surfaces where they cause no harm and may actually have beneficial effects, by preventing colonization by other potential pathogens. However, introduction of these organisms into anatomical sites in which they are not normally found, or removal of competing bacteria by the use of broad-spectrum antibiotics, may allow their localized multiplication and subsequent development of disease.
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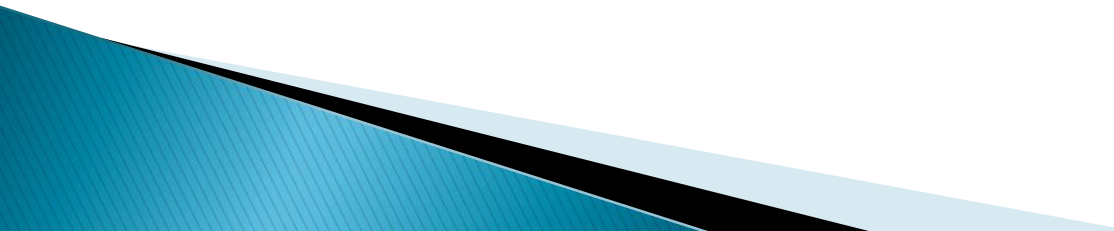
- ▶ The above classification is applicable to the vast majority of pathogens; however, there are exceptions and variations within both categories of bacterial pathogens. Different strains of any individual bacterial species can vary in their genetic makeup and virulence capacity. For example, the majority of *Neisseria meningitidis* strains are harmless commensals and considered
 - ▶ Although the vast majority of bacteria are harmless or beneficial, quite a few bacteria are pathogenic. Pathogenic bacteria are bacteria that cause bacterial infection. One of the bacterial diseases with highest disease burden is tuberculosis, caused by the bacterium *Mycobacterium tuberculosis*, which kills about 2 million people a year, mostly in sub-Saharan Africa.
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- ▶ Pathogenic bacteria contribute to other globally important diseases, such as pneumonia, which can be caused by bacteria such as Streptococcus and Pseudomonas, and food borne illnesses, which can be caused by bacteria such as Shigella, Campylobacter, and Salmonella. Pathogenic bacteria also cause infections such as tetanus, typhoid fever, diphtheria, syphilis, and leprosy. Koch's postulates are criteria designed to establish a causal relationship between a causative microbe and a disease. Four criteria that were established **by Robert Koch to identify the causative agent of a particular disease, these include:**
 - ▶ 1. The microorganism or other pathogen must be present in all cases of the disease
 - ▶ 2. The pathogen can be isolated from the diseased host and grown in pure culture
 - ▶ 3. The pathogen from the pure culture must cause the disease when inoculated into a healthy, susceptible laboratory animal
 - ▶ 4. The pathogen must be reisolated from the new host and shown to be the same as the originally inoculated pathogen.
- ▶ The changes to the host, manifested as a set of symptoms, may be due to the effect of microbial products such as toxins or the result of the host's immune reactions to the presence of the bacteria. Pain, fever, redness and swelling are common symptoms of bacterial disease.

- ▶ A pathogen is a microorganism that is able to cause disease in a plant, animal or insect. Pathogenicity is the ability to produce disease in a host organism. Microbes express their pathogenicity by means of their virulence, a term which refers to the degree of pathogenicity of the microbe. Hence, the determinants of virulence of a pathogen are any of its genetic or biochemical or structural features that enable it to produce disease in a host. The relationship between a host and a pathogen is dynamic. The outcome of such a relationship depends on the virulence of the pathogen and the degree of resistance and susceptibility of the host, due to the effectiveness of the host defense mechanisms.
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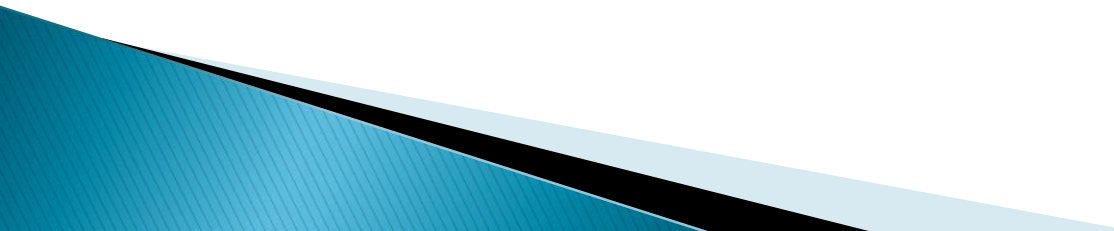
- ▶ **Two qualities of pathogenic microbes by which they cause disease to the host:**
 - ▶ **١. Invasiveness is the ability to invade tissues.** It consists of colonization, production of extracellular substances which facilitate invasion and ability to bypass or overcome host defense mechanisms.
 - ▶ **٢. Toxigenesis is the ability to produce toxins.** Bacteria may produce two types of toxins called exotoxins and endotoxins. Exotoxins are released from bacterial cells and may act at tissue sites removed from the site of bacterial growth. Endotoxins are cell-associated substance. The bacterial toxins, both soluble and cell-associated, may be transported by blood and lymph and cause cytotoxic effects at tissue sites remote from the original point of invasion or growth.
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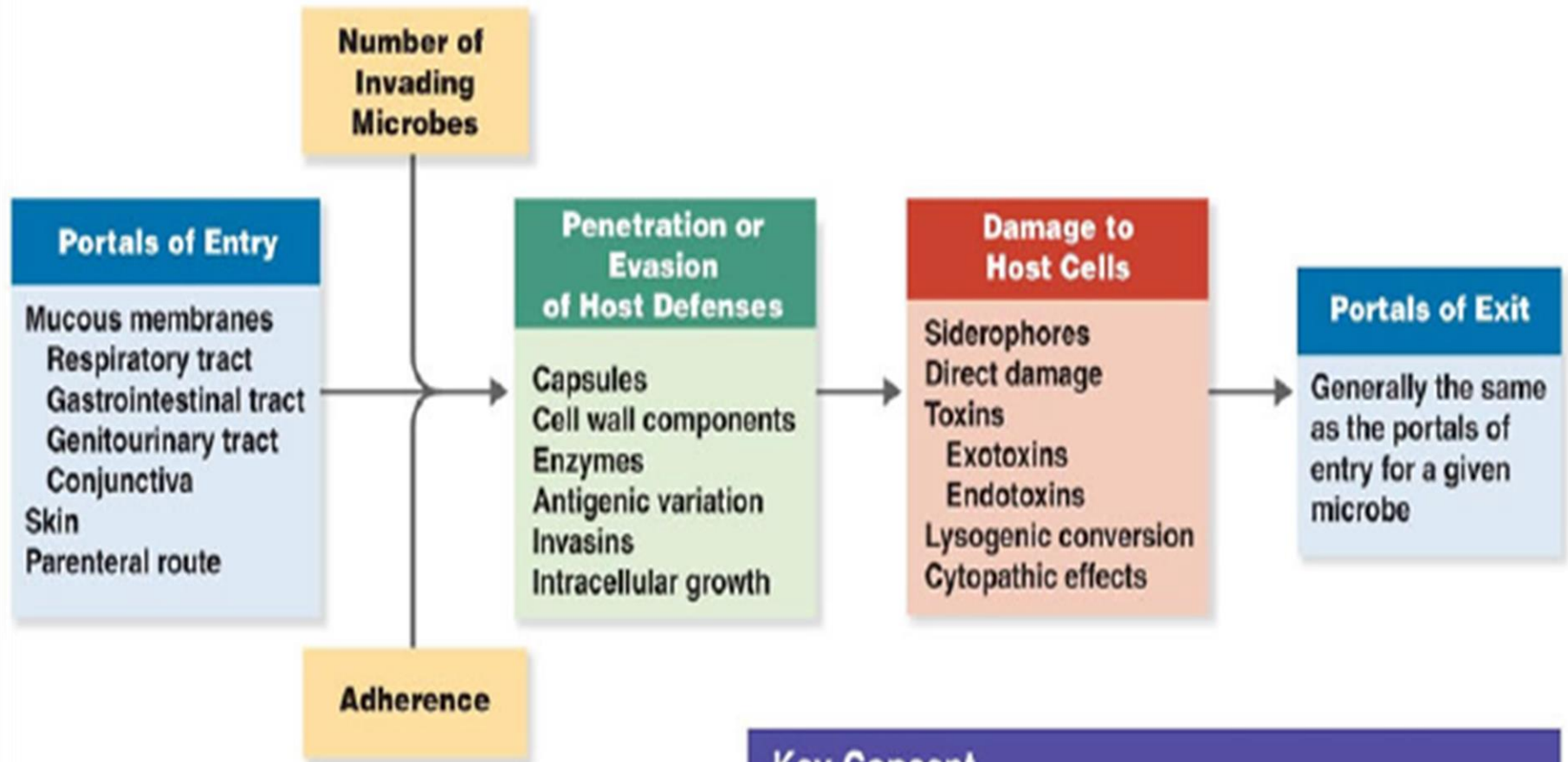
▶ The diseases can be caused by:

- ▶ **Bacteria:** - These one-cell organisms are responsible for illnesses such as strep throat, urinary tract infections and tuberculosis.
 - ▶ **Viruses:**-Even smaller than bacteria, viruses cause a multitude of diseases — ranging from the common cold to AIDS.
 - ▶ **Fungi:** - Many skin diseases, such as ringworm and athlete's foot, are caused by fungi. Other types of fungi can infect your lungs or nervous system.
 - ▶ **Parasites:** - Malaria is caused by a tiny parasite that is transmitted by a mosquito bite. Other parasites may be transmitted to humans from animal feces.
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▶ **Different infection stages**

▶ To cause disease a pathogen must:

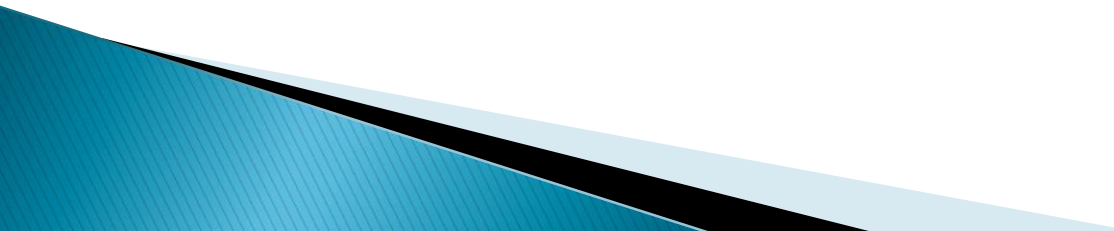
- Gain access to the host.
 - Adhere to host tissues.
 - Penetrate or evade host defenses.
 - Damage the host, either directly or accumulation of microbial wastes.
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Key Concept

Several factors are required for a microbe to cause disease. After entering the host, most pathogens adhere to host tissue, penetrate or evade host defenses, and damage host tissues. Pathogens usually leave the body via specific portals of exit, which are generally the same sites where they entered initially.

Fig. 1. Different infection stages of disease causing organisms

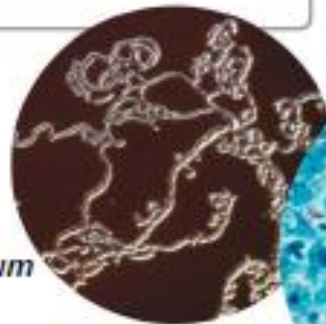
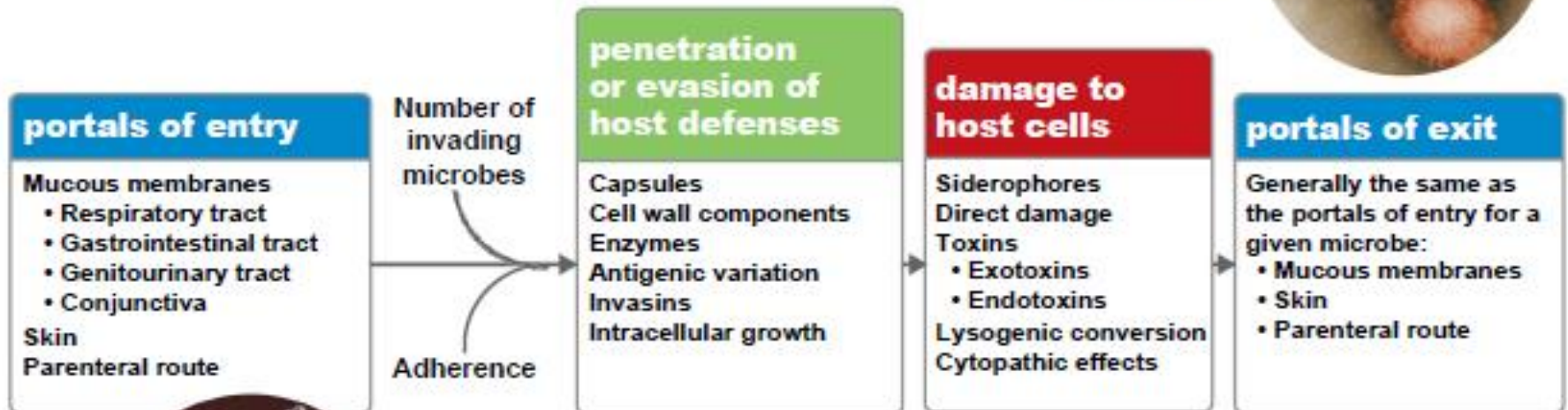
- ▶ **Mucous membrane:** - is most common route for most pathogens. The mucous membranes are respiratory tract, gastrointestinal tract, urinary/genital tracts and conjunctiva.
 - ▶ **Skin (keratinized cutaneous membrane):-** Some pathogens infect hair follicles, sweat glands and colonize surface. But unless broken, skin is usually an impermeable barrier to microbes.
 - ▶ **Parenteral route:** - penetrate skin, punctures, injections, bites, cuts, surgery and deposit organisms directly into deeper tissues.
 - ▶ The microbes must enter through preferred portal of entry in order to cause disease. But some can cause disease from many routes of entry
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Microbial Mechanisms of Pathogenicity.

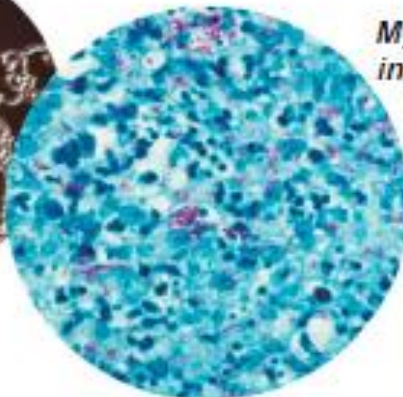
When the balance between host and microbe is tipped in favor of the microbe, an infection or disease results. Learning these mechanisms of microbial pathogenicity is fundamental to understanding how pathogens are able to overcome the host's defenses.



H1N1 flu virus



Clostridium tetani



Mycobacterium intracellulare

Micrographs are not shown to scale.

The Preferred Portal of Entry

- Many organisms can cause infections only when they gain access through their specific portal of entry.
- The bacteria of typhoid fever *Salmonella typhi*
 - produce all the signs and symptoms when swallowed (preferred)
 - No reaction if the bacteria rubbed on the skin
- The bacteria, *Streptococci*
 - produce pneumonia when inhaled (preferred)
 - No sign if the bacteria swallowed
- Pathogen, (*Yersinia pestis*) cause plague from many route

Colonization (Adherence; Adhesion; Attachment)

Attachment/Adherence: Close association of bacterial cells and host cells generally characterized by receptors and target sites.

Surface Receptors/Target Sites: Receptor sites present on both hosts (Receptor) and bacterial surfaces (Adhesins).

Adhesins: Bind Specific Host Receptors often involve fimbriae as structural cell component; Host cell receptors are often sugar moieties. The lectins are adhesin specific for polysaccharide target receptor (sugar residues).

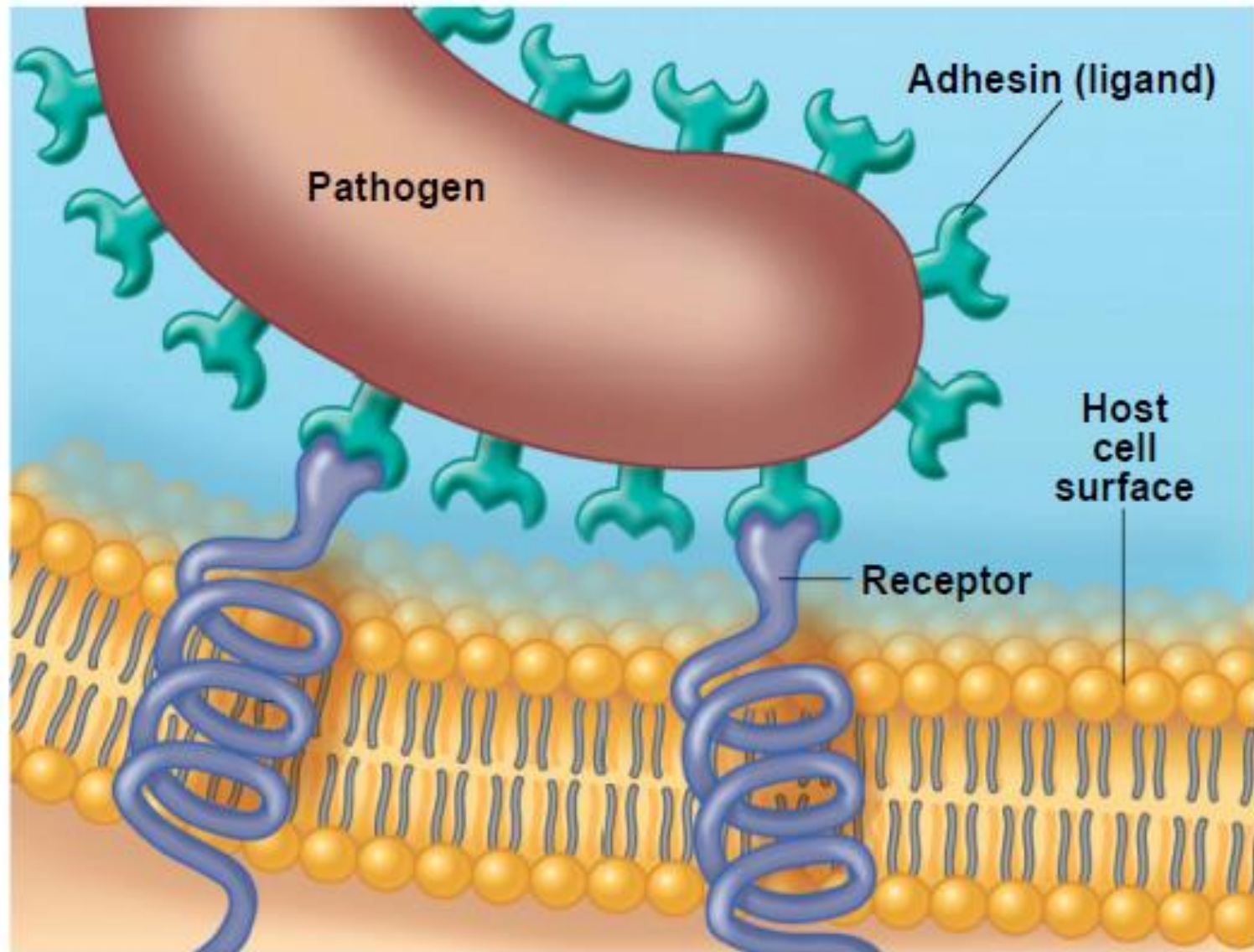
Fimbriae (plural): Short hair-like protein (pilin) appendages extending outward from the surface of certain bacteria.

Pili (plural); Pilus (singular): Short hair-like protein (pilin) appendages extending outward from the surface of certain bacteria and responsible for bacterial conjugation.

Adhesins/ligands of pathogen bind to receptors on host cells and/or help to penetrate

Adhesin Pathogen _ ٢٠..Glycocalyx *Streptococcus mutans* -Fimbriae *Escherichia coli* -M protein *Streptococcus pyogenes* -Opa protein *Neisseria gonorrhoeae* -Wax *Mycobacterium tuberculosis* -Tapered end *Treponema pallidum*

Adherence



Surface molecules on a pathogen, called adhesins or ligands, bind specifically to complementary surface receptors on cells of certain host tissues.

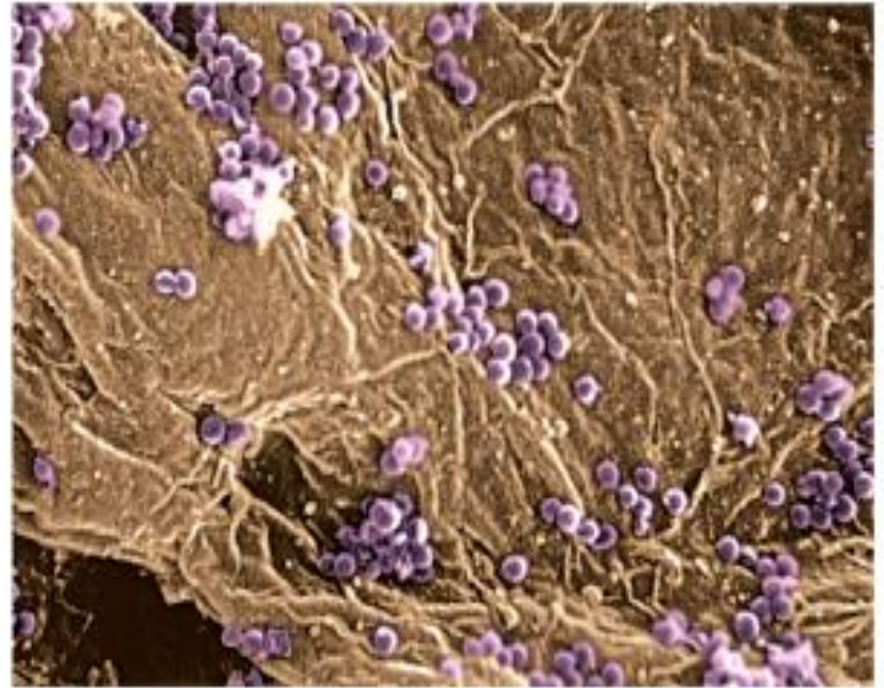
More Examples of Adherence



(b) *E. coli* bacteria (yellow-green) on human urinary bladder cells

SEM

1 μm



(c) Bacteria (purple) adhering to human skin

SEM

9 μm

- ▶ **Numbers of Invading Microbes:** - The chances of causing diseases increase as the numbers of invading pathogens increases. This is expressed by infectious dose (ID_{50}) and lethal dose (LD_{50}). The ID_{50} (Infectious Dose) is the number of microbes required to produce infection in 50% of the population. The ID_{50} is different for different pathogens i.e. different ID_{50} for different portals of entry for the same pathogen. The LD_{50} (Lethal Dose) amount of toxin or pathogen necessary to kill 50% of the population in a particular
- ▶ **Biofilms:** - are formed when microbes adhere to a surface which is usually moist and contains organic matter. The microbe secretes glycocalyx allowing other microbes to adhere a large mass is formed. The biofilms are resistant to disinfectants and antibiotics.

End

