Infection, Infectious Disease & Epidemiology

NIMESH PATEL| HLSC 2400

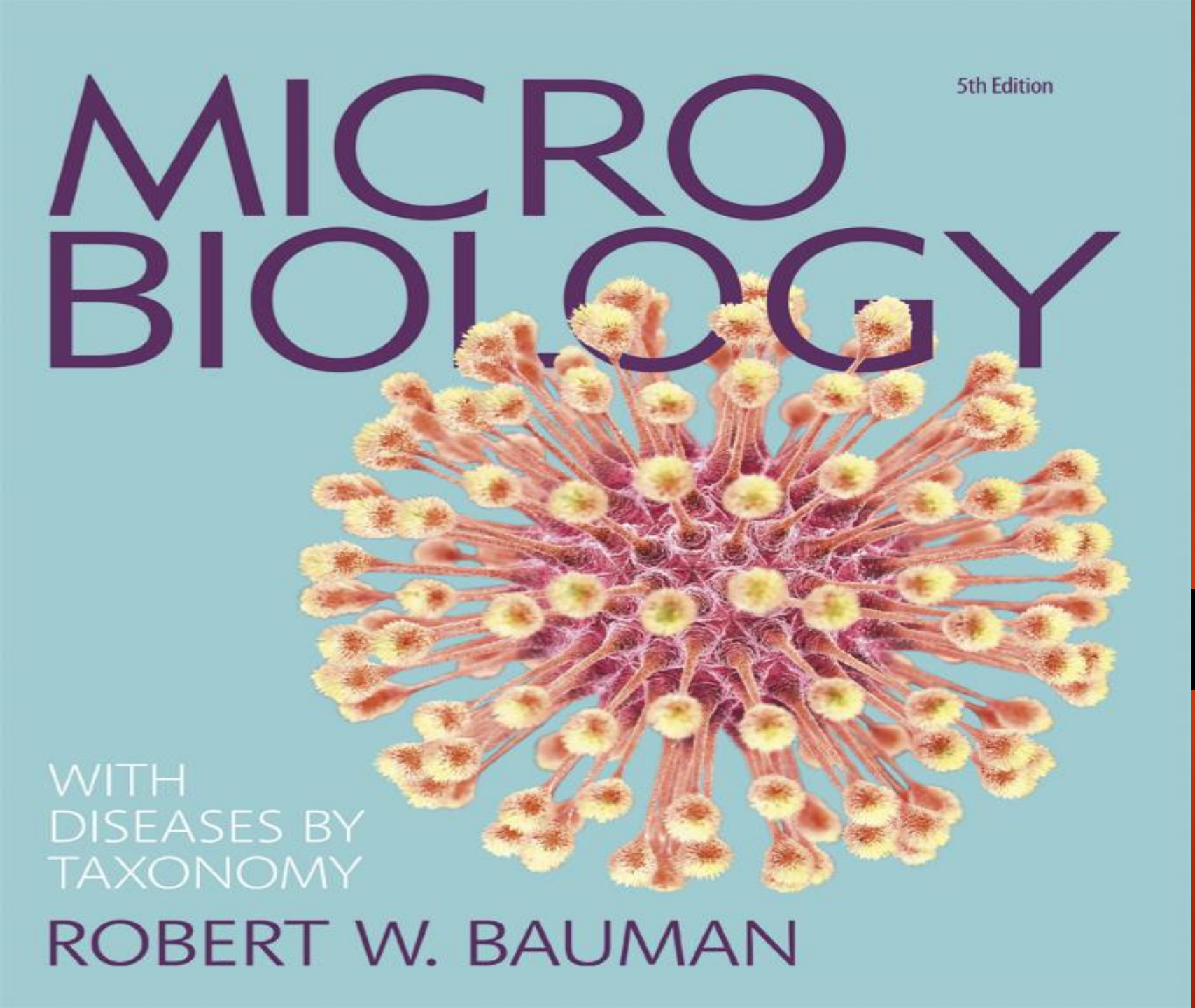
SEPTEMBER 12, 2017

Announcements

- **Exam dates:**
  - Test 1: October 3 – October 5, 2017
    - Reattempt: October 6 – October 8, 2017
  - Test 2: November 2 – November 4, 2017
    - Reattempt: November 5 – November 7, 2017
  - Test 3: December 5 – December 8, 2017
    - Reattempt: Not available
- **Location:** Testing Center
- Reattempt will be available **ONLY** if you take the first attempt in the mentioned period
- There must be min **48 hours** between the two attempts
- Check the Moodle for more info on testing center and the exam process

Oral Presentation

- Make your own group
- Each group should have five students
- Pick up an infectious disease
- One member from the group will **email** the **instructor & TA** with the name of all the group members and the infectious disease the group selected
- Topics/infectious diseases will be available to present on first come, first served basis.



PowerPoint® Lecture Presentations prepared by
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CHAPTER 14

Infection, Infectious Diseases, and Epidemiology

Symbiotic Relationships Between Microbes and Their Hosts

- **Symbiosis** means "to live together"
- We have symbiotic relationships with countless (100 to more than 700 trillion) microorganisms
- Types of symbiosis:
  - Mutualism
  - Commensalism
  - Amensalism
  - Parasitism

Mutualism

- Both Symbionts benefit from their interaction
- Example 1: Bacteria in human colon
  - But it is not required by either
- Example 2: Termites and wood-digesting (cellulose) protozoa and bacteria living in their intestine
  - Would die without a mutualistic relationships

Mutualism - A Bioterrorist Worm

- Bioterrorism – deliberate release of viruses, bacteria, or other germs to cause illness or death
- Mutualism – Steinernema (nematode worm) + Xenorhabdus (bacteria)
- Steinernema preys on insects, including, ants, termites, worms, fleas, ticks, beetles, and gnats
- Steinernema crawls into an insect's mouth or anus – crosses intestinal walls – insect's blood – releases Xenorhabdus – insecticidal toxins to kill the insect – releases digestive enzymes to turn the insect body into slimy porridge of nutrients – the nematodes mature, mate, and reproduce within insect's liquified body – the offspring feed on gooey fluid – take their own bacterial supply to raid on new insect hosts

Commensalism

- One symbiont benefits without significantly affecting the others
- Example: Microscopic animals – hair follicle mites – live on your skin without causing measurable harm to you
- Difficult to prove because the host may experience unobserved benefits.

Amensalism

- One symbiont is harmed by a second symbiont, while the second is neither harmed nor helped by the first
- Example: Fungus penicillum produces penicillin , which inhibits nearby bacteria, but the bacteria have no effect on fungus

Parasitism

- Parasitos = "one who eats at the table of another"
- Parasites derives benefit from its host while harming it
- Damage to hosts
  - Slight damage – parasites are more like to spread, hosts are more likely to reproduce
    - Coevolution torwards commensalism or mutualism
  - Kills the host – Destroying its own home
- Pathogen: Any parasite that causes a disease
- Example: Tuberculosis in human lung
  - Monsters Inside Me: Link

Table 14.1 Types of Symbiotic Relationships

TABLE 14.1 Types of Symbiotic Relationships

	Organism 1	Organism 2	Example
Mutualism	Benefits	Benefits	Bacteria in human colon
Commensalism	Benefits	Neither benefits nor is harmed	Mites in human hair follicles
Amensalism	Neither benefits nor is harmed	Is harmed	Fungus secreting an antibiotic, inhibiting nearby bacteria
Parasitism	Benefits	Is harmed	Tuberculosis bacteria in human lung

Have We Been Too Effective in Eliminating Parasite Infections?

- Helminthic infection is a possible explanation for the **low incidence of autoimmune disease** in developing countries. link

- Helminthic therapy consists of the inoculation of the patient with specific intestinal parasites (usually hookworm or whipworm).

- Current research and therapies are available for the treatment of Crohn's disease, ulcerative colitis, inflammatory bowel disease, multiple sclerosis, asthma, eczema, dermatitis, hay fever, and food allergies.

Slide Credit: Currie, Cheryl

Parasitic Treatments

Maggots have been shown to:

- Remove dead tissue
- Secrete enzymes that break down proteins in the diseased tissue, which the maggots ingest
- Improve oxygen supply to the wound
- Kill bacteria — In one German study5, maggot secretion was as deadly as antiseptic
- Attack biofilms that protect bacteria from immune and antibiotic attack, 6 allowing antibiotics to kill the bacteria. link

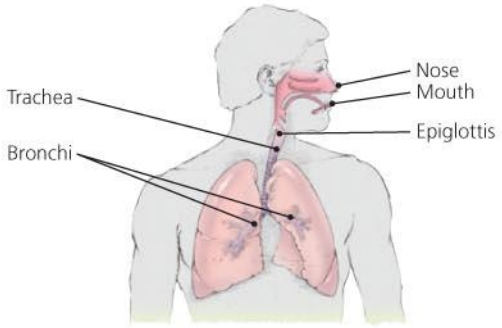
Slide Credit: Currie, Cheryl

Symbiotic Relationships Between Microbes and Their Hosts

- **Normal Microbiota in Hosts**
  - Organisms that colonize the body's surfaces without normally causing disease
  - Also termed normal flora and indigenous microbiota
  - Two types:
    - **Resident microbiota**
      - Are a part of the normal microbiota throughout life
      - Are mostly commensal
    - **Transient microbiota**

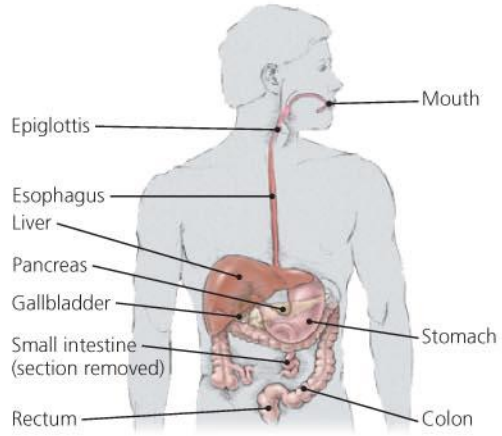
Table 14.2 Some Resident Microbiotaa (1 of 4)

TABLE 14.2 Some Resident Microbiota[a]



Upper Respiratory Tract	
Genera	**Notes**
Fusobacterium, Haemophilus, Lactobacillus, Moraxella, Staphylococcus, Streptococcus, Veillonella, Candida (fungus)	The nose is cooler than the rest of the respiratory system and has some unique microbiota. The microbiota of the trachea and bronchi are sparse compared to those of the nose and mouth. The alveoli of the lungs, which are too small to depict in this illustration, have no natural microbiota—they are axenic.

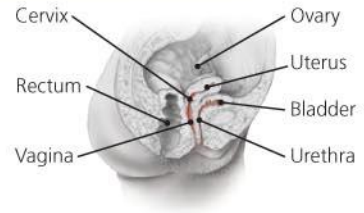
TABLE 14.2 Some Resident Microbiota[a] *(Continued)*

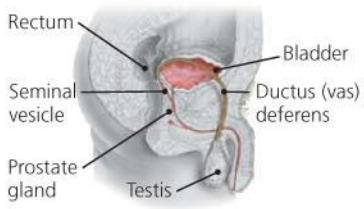


Upper Digestive Tract	
Genera	**Notes**
Actinomyces, Bacteroides, Corynebacterium, Haemophilus, Lactobacillus, Neisseria, Staphylococcus, Treponema, Entamoeba (protozoan), *Trichomonas* (protozoan)	Microbes colonize surfaces of teeth, gingiva, lining of cheeks, and pharynx, and they are found in saliva in large numbers. Dozens of species have never been identified.
Lower Digestive Tract	
Genera	**Notes**
Bacteroides, Bifidobacterium, Clostridium, Enterococcus, Escherichia, Fusobacterium, Lactobacillus, Proteus, Shigella, Candida (fungus), *Entamoeba* (protozoan), *Trichomonas* (protozoan)	The bacteria are mostly strict anaerobes, though some facultative anaerobes are also resident.

Table 14.2 Some Resident Microbiotaa (2 of 4)

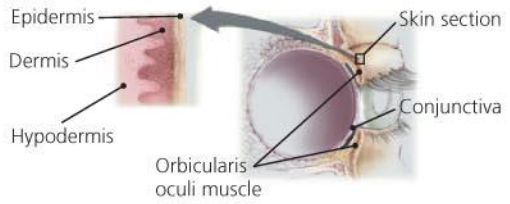
TABLE 14.2 Some Resident Microbiota[a] *(Continued)*





Female Urinary and Reproductive Systems	
Genera	**Notes**
Bacteroides, Clostridium, Lactobacillus, Staphylococcus, Streptococcus, Candida (fungus), *Trichomonas* (protozoan)	Microbiota change as acidity in the vagina changes during menstrual cycle. The flow of urine prevents extensive colonization of the urinary bladder or urethra.
Male Urinary and Reproductive Systems	
Genera	**Notes**
Bacteroides, Fusobacterium, Lactobacillus, Mycobacterium, Peptostreptococcus, Staphylococcus, Streptococcus	The flow of urine prevents extensive colonization of the urinary bladder or urethra.

TABLE 14.2 Some Resident Microbiota[a] *(Continued)*



Eyes and Skin	
Genera	**Notes**
Skin: *Corynebacterium, Micrococcus, Propionibacterium, Staphylococcus, Candida* (fungus), *Malassezia* (fungus)	Microbiota live on the outer, dead layers of the skin and in hair follicles and pores of glands. The deeper layers (dermis and hypodermis) are axenic.
Conjunctiva: *Staphylococcus*	Tears wash most microbiota from the eyes, so there are few compared to the skin.

[a]Genera are bacteria unless noted.

Symbiotic Relationships Between Microbes and Their Hosts

- **Normal Microbiota in Hosts**
  - Transient Microbiota
    - Remain in the body for short period
    - Found in the same regions as resident microbiota
    - Cannot persist in the body
      - Competition from other microorganisms
      - Elimination by the body's defense cells
      - Chemical or physical changes in the body

Symbiotic Relationships Between Microbes and Their Hosts

- **Normal Microbiota in Hosts**
  - Acquisition of Normal Microbiota
    - Development in womb free of microorganisms
    - Microbiota begin to develop during birthing process
    - Much of one's resident microbiota established during first months of life

Symbiotic Relationships Between Microbes and Their Hosts

- **How Normal Microbiota Become Opportunistic Pathogens**
  - Opportunistic pathogens
    - Normal microbiota that cause disease under certain circumstances
  - Conditions that provide opportunities for pathogens
    - Introduction of normal microbiota into unusual site in body
    - Immune suppression
    - Changes in the relative abundance of normal microbiota
    - Stressful conditions

Reservoirs of Infectious Diseases of Humans

- Most pathogens cannot survive for long outside of their host
- Reservoirs of infection
  - Sites where pathogens are maintained as a source of infection
- Three types of reservoirs:
  - Animal reservoir
  - Human carriers
  - Nonliving reservoir

Reservoirs of Infectious Diseases of Humans

- **Animal Reservoirs**
  - Zoonoses
    - Diseases naturally spread from animal host to humans
  - Acquire zoonoses through various routes
    - Direct contact with animal or its waste
    - Eating animals
    - Bloodsucking arthropods
  - Humans are usually dead-end host to zoonotic pathogens
  - Difficult to eradicate

Reservoirs of Infectious Diseases of Humans

- **Human Carriers**
  - Asymptomatic infected individuals can be infective to others
  - Some individuals eventually develop illness while others never get sick
  - Healthy carriers may have defensive systems that protect them
- **Nonliving Reservoirs**
  - Soil, water, and food can be reservoirs of infection
    - Presence of microorganisms often due to contamination by feces or urine

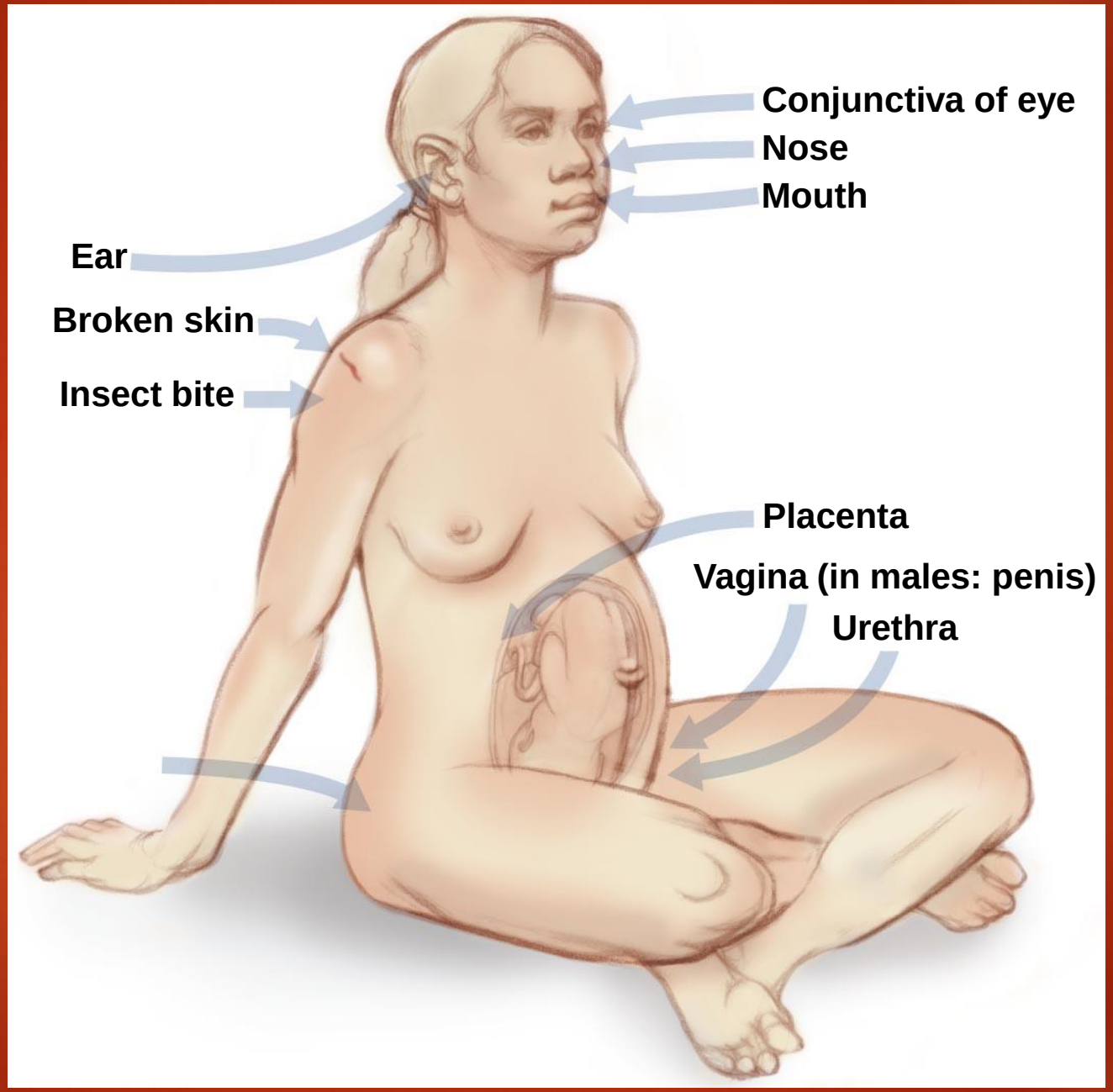
The Invasion and Establishment of Microbes in Hosts: Infection

- **Exposure to Microbes: Contamination and Infection**
  - Contamination
    - The mere presence of microbes in or on the body
  - Infection
    - When organism evades body's external defenses, multiplies, and becomes established in the body

The Invasion and Establishment of Microbes in Hosts: Infection

- **Portals of Entry**
  - Sites through which pathogens enter the body
  - Three major pathways:
    - Skin
    - Mucous membranes
    - Placenta
  - Entry via the parenteral route circumvents the usual portals

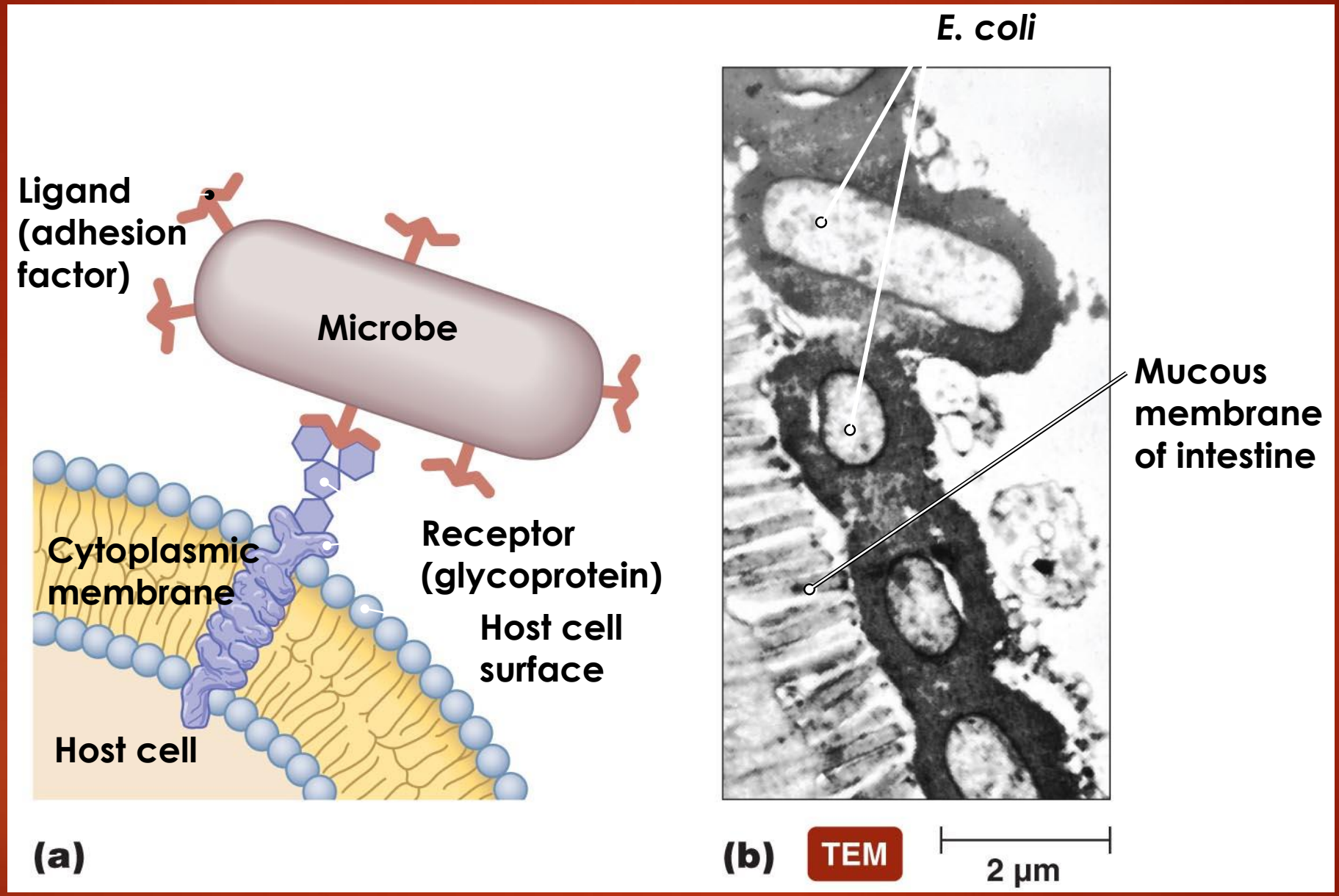
Figure 14.3 Routes of entry for invading pathogens.



The Invasion and Establishment of Microbes in Hosts: Infection

- **The Role of Adhesion in Infection**
  - Adhesion
    - Process by which microorganisms attach themselves to cells
    - Required to successfully establish colonies within the host
    - Uses **adhesion factors**
      - Specialized structures
      - Attachment molecules

Figure 14.5 The adhesion of pathogens to host cells.



The Invasion and Establishment of Microbes in Hosts: Infection

- **The Role of Adhesion in Infection**
  - *Attachment proteins* help in adhesion
    - Found on viruses and many bacteria
    - Viral or bacterial ligands bind host cell receptors
      - Interaction can determine host cell specificity
  - **Changing/blocking a ligand or its receptor can prevent infection**
  - Inability to make attachment proteins or adhesins renders microorganisms avirulent
  - Some bacterial pathogens attach to each other to form a biofilm

The Nature of Infectious Disease

- Infection is the invasion of the host by a pathogen
- **Disease** results if the invading pathogen alters normal body functions
- Disease is also referred to as **morbidity**

The Nature of Infectious Disease

- **Manifestations of Disease: Symptoms, Signs, and Syndromes**
  - Symptoms
    - **Subjective** characteristics of disease felt only by the patient
  - Signs
    - **Objective** manifestations of disease observed or measured by others
  - Syndrome
    - Symptoms and signs that characterize a disease or abnormal condition
  - **Asymptomatic**, or **subclinical**, infections lack symptoms but may still have signs of infection

TABLE 14.5 Typical Manifestations of Disease

Symptoms (Sensed by the Patient)	Signs (Detected or Measured by an Observer)
Pain, nausea, headache, chills, sore throat, fatigue or lethargy (sluggishness, tiredness), malaise (discomfort), itching, abdominal cramps	Swelling, rash or redness, vomiting, diarrhea, fever, pus formation, anemia, leukocytosis/leukopenia (increase/decrease in the number of circulating white blood cells), bubo (swollen lymph node), tachycardia/bradycardia (increase/decrease in heart rate)

TABLE 14.6 Terminology of Disease

Prefix/Suffix	Meaning	Example
carcino-	Cancer	Carcinogenic: giving rise to cancer
col-, colo-	Colon	Colitis: inflammation of the colon
dermato-	Skin	Dermatitis: inflammation of the skin
-emia	Pertaining to the blood	Viremia: viruses in the blood
endo-	Inside	Endocarditis: inflammation of lining of heart
-gen, gen-	Give rise to	Pathogen: giving rise to disease
hepat-	Liver	Hepatitis: inflammation of the liver
idio-	Unknown	Idiopathic: pertaining to a disease of unknown cause
-itis	Inflammation of a structure	Meningitis: inflammation of the meninges (covering of the brain)
-oma	Tumor or swelling	Papilloma: wart
-osis	Condition of	Toxoplasmosis: being infected with *Toxoplasma*
-patho, patho-	Abnormal	Pathology: study of disease
septi-	Literally, *rotting*; refers to presence of pathogens	Septicemia: pathogens in the blood
terato-	Defects	Teratogenic: causing birth defects
tox-	Poison	Toxin: harmful compound

The Nature of Infectious Disease

- **Causation of Disease: Etiology**
  - Etiology
    - Study of the cause of disease
    - Diseases have various causes

TABLE 14.7 Categories of Diseases[a]

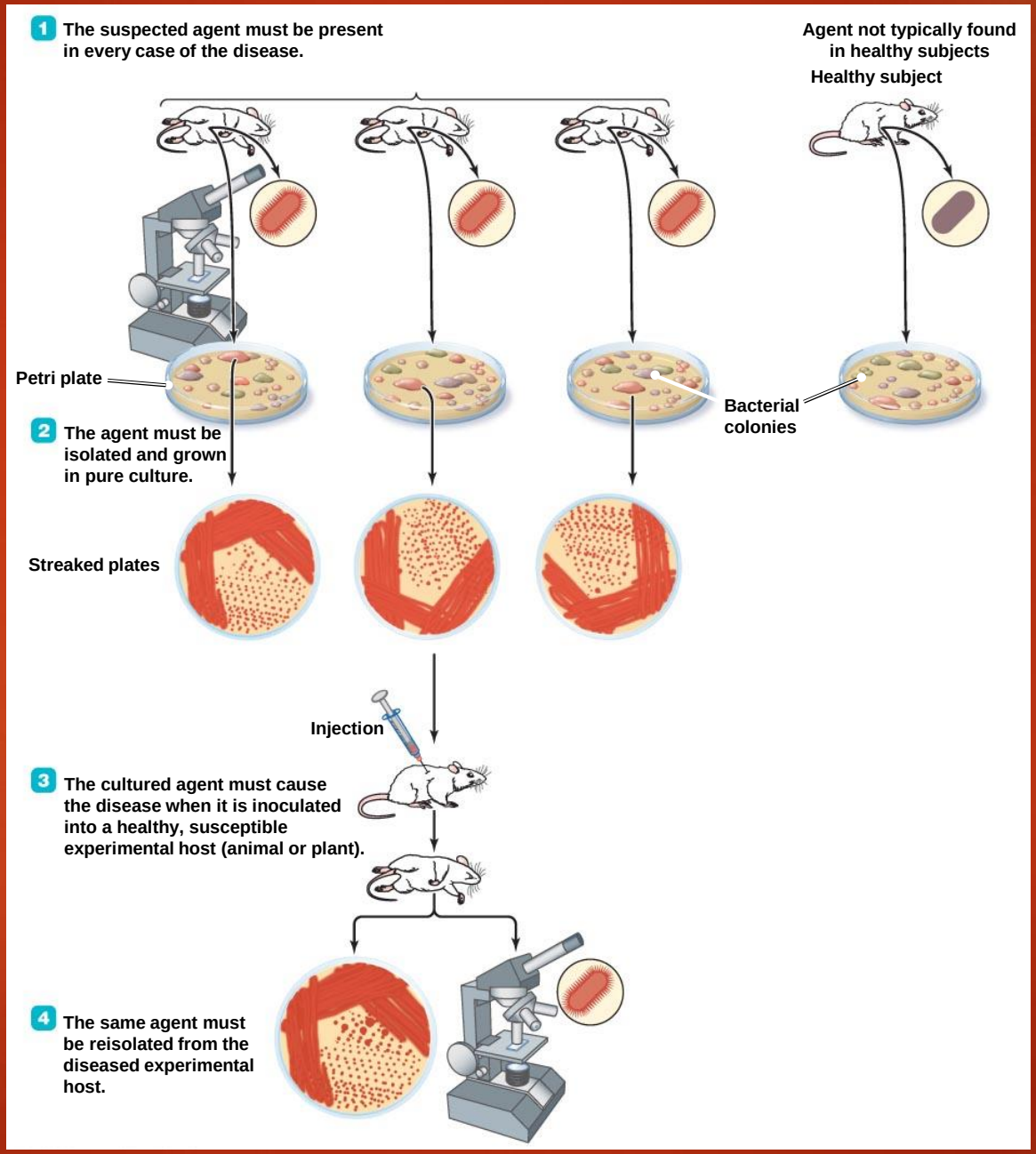
	Description	Examples
Hereditary	Caused by errors in the genetic code received from parents	Sickle-cell anemia, diabetes mellitus, Down syndrome
Congenital	Anatomical and physiological (structural and functional) defects present at birth; caused by drugs (legal and illegal), X-ray exposure, or infections	Fetal alcohol syndrome, deafness from rubella infection
Degenerative	Result from aging	Renal failure, age-related farsightedness
Nutritional	Result from lack of some essential nutrients in diet	Kwashiorkor, rickets
Endocrine (hormonal)	Due to excesses or deficiencies of hormones	Addison's disease
Mental	Emotional or psychosomatic	Skin rash, gastrointestinal distress
Immunological	Hyperactive or hypoactive immunity	Allergies, autoimmune diseases, agammaglobulinemia
Neoplastic (tumor)	Abnormal cell growth	Benign tumors, cancers
Infectious	Caused by an infectious agent	Colds, influenza, herpes infections
Iatrogenic[b]	Caused by medical treatment or procedures; are a subgroup of healthcare-associated diseases	Surgical error, yeast vaginitis resulting from antimicrobial therapy
Idiopathic[c]	Unknown cause	Alzheimer's disease, multiple sclerosis
Healthcare-Associated (nosocomial[d])	Disease acquired in health care setting	*Pseudomonas* infection in burn patient

[a]Some diseases may fall in more than one category.
[b]From Greek *iatros*, meaning "physician."
[c]From Greek *idiotes*, meaning "ignorant person," and *pathos*, meaning "disease."
[d]From Greek *nosokomeion*, meaning "hospital."

The Nature of Infectious Disease

- **Causation of Disease: Etiology**
  - Using Koch's Postulates
    - **Germ theory of disease**
      - Infections by pathogenic microorganisms cause disease
    - Robert Koch developed a set of *postulates* one must satisfy to prove a particular pathogen causes a particular disease

Figure 14.7 Koch's postulates.



The Nature of Infectious Disease

- **Causation of Disease: Etiology**
  - Exceptions to Koch's Postulates
    - Some pathogens can't be cultured in the laboratory
    - Diseases caused by a combination of pathogens and other cofactors
    - Ethical considerations prevent applying Koch's postulates to pathogens that require a human host
  - Difficulties in satisfying Koch's postulates
    - Diseases can be caused by more than one pathogen
    - Pathogens that are ignored as potential causes of disease

The Nature of Infectious Disease

- **Virulence Factors of Infectious Agents**
  - Pathogenicity
    - Ability of a microorganism to cause disease
  - Virulence
    - Degree of pathogenicity
    - Virulence factors contribute to virulence
      - Adhesion factors
      - Biofilms
      - Extracellular enzymes
      - Toxins
      - Antiphagocytic factors