**Lecture 22: Genetics (cont.) & Epidemiology**

**Table 8.3. Summary of last lecture**

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Main Function</th>
<th>Size of DNA Segment</th>
<th>Polarity to Vector?</th>
<th>Sensitivity to Other Additions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformation</td>
<td>Moved DNA inserted</td>
<td>Large, various</td>
<td>Both</td>
<td>No</td>
</tr>
<tr>
<td>Transduction</td>
<td>DNA injected into a bacterial cell</td>
<td>Small fraction of chromosome</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Conjugation</td>
<td>Conjugation of DNA</td>
<td>Small fraction of chromosome</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>F plasmid</td>
<td>Gene transfer</td>
<td>Entire F plasmid</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Movement of DNA within cells**

**Transposition** involves small segments of DNA (transposons, "jumping genes") that can move around chromosomes or plasmids.

- e.g. F-plasmids have insertion sequences that allow the plasmid to integrate into the chromosome => Hfr cell.

**Insertion sequences** are very simple and typically contain only the information needed for insertion (see figure 8.24). Also used in experiments to disrupt specific genes.

**Transposons** (Composite Transposon in Figure 8.24) are more complex and may contain a number of genes that confer e.g. antibiotic resistance and/or toxin production (see next slide).

---

**Epidemiology** - the study of the factors influencing the frequency and distribution of diseases.

Combines:
- microbiology
- ecology
- sociology
- statistics
- psychology

---

**Major goal of epidemiology:**

When a disease breaks out, epidemiologists try to determine root cause (or etiology), and determine the most effective measures for preventing or controlling the disease.

**Transmission routes and corresponding safety measures:**

1. animal bites - control animal populations or avoid contact
2. personal contact - isolation or treatment of infected persons, immunization
3. Ingestion - water quality and food regulations
4. sexual contact - public education regarding "safe sex" and individual treatment

---

**Fig. 8.24** a. Insertion sequence, b. Composite transposon containing an antibiotic resistance gene....

**Fig. 8.23.** Movement of a transposon through a bacterial community.

---

**Mostly about terminology...**

---

**Table 8.1: Common Terms in Epidemiology**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence</td>
<td>The ratio of new to existing cases of a disease in a specified population at a specified time</td>
</tr>
<tr>
<td>Prevalence</td>
<td>The ratio of existing to total cases of a disease in a specified population at a specified time</td>
</tr>
<tr>
<td>Mortality</td>
<td>The ratio of deaths to the total population at a specified time</td>
</tr>
<tr>
<td>Morbidity</td>
<td>The ratio of cases to the total population at a specified time</td>
</tr>
<tr>
<td>Etiology</td>
<td>The study of the causes of disease</td>
</tr>
<tr>
<td>Epidemiology</td>
<td>The study of the distribution and determinants of health-related states or events among specified populations</td>
</tr>
<tr>
<td>Public Health</td>
<td>The science and art of protecting and promoting the health of communities through the organized efforts of public and private sectors</td>
</tr>
<tr>
<td>Health Education</td>
<td>The process of facilitating voluntary changes in lifestyle or behavior to improve health outcomes</td>
</tr>
<tr>
<td>Healthy lifestyles</td>
<td>Lifestyles that promote health, well-being, and longevity</td>
</tr>
<tr>
<td>Health Promotion</td>
<td>The process of increasing the likelihood that people will adopt healthy lifestyles</td>
</tr>
<tr>
<td>Disease Prevention</td>
<td>The process of reducing the incidence of disease in a population</td>
</tr>
<tr>
<td>Health Screening</td>
<td>The early detection of disease in otherwise healthy individuals</td>
</tr>
<tr>
<td>Health Surveillance</td>
<td>The systematic collection, analysis, and interpretation of data related to health and disease in populations</td>
</tr>
<tr>
<td>Health Policy</td>
<td>The formulation of goals and objectives for health programs and systems</td>
</tr>
<tr>
<td>Health Services</td>
<td>The delivery of health-related interventions for the purpose of achieving population health outcomes</td>
</tr>
</tbody>
</table>

---

1
Communicable diseases - can be transmitted from one person to another (as opposed to genetically inherited diseases or diseases such as those caused by toxins in food)

Prevalence rate = total number of infected individuals in a population

Definitions, “rates”

Incidence = # of new cases in a population per time period
Prevalence rate = total number of infected individuals in a population

Mortality rate = number of deaths due to the disease
number of individuals with the disease

Terms to describe prevalence:
Endemic - disease is constantly present
  e.g. common cold or flu see fig. 20.2
Epidemic - unusually large number of cases in a given area
Pandemic - a worldwide epidemic e.g. AIDS

Fig. 20.2. Weekly influenza and pneumonia mortality as a % of all deaths for 121 cities in the USA. Note the normal seasonal cycles and an occasional outbreak or epidemic.

Morbidity rate = number of cases per unit time
number of individuals in the population at risk

Reservoir - source of disease-producing organism
Affects extent & distribution of disease
Can be humans, animals, or environmental.
Infected humans are most significant reservoirs of communicable diseases.

- **symptomatic** - show obvious signs of the disease
- **asymptomatic carrier** - an infected individual who is a potential source of infection.

Asymptomatic carriers,

e.g. 50% of women infected with *Neisseria gonorrhoeae* have no symptoms.

60% of the population carry *Staphylococcus aureus* during some part of their lives. 20% are chronic carriers.

The Most (in)famous Carrier:

Mary Mallon - "Typhoid Mary"

She was a **chronic carrier** of *Salmonella typhi* in the early 1900s and worked as a cook all over NYC. She was arrested and imprisoned until she promised not to ever handle the food of others again. She broke that promise and escaped authorities for 5 more years, causing numerous deaths. She was re-captured and imprisoned for life!

2-5% of typhoid victims are **chronic, asymptomatic carriers**.

Animal reservoirs

- **Poultry** - *Salmonella, Campylobacter*
- **Rodents** - *plague, hantavirus*
- **Raccoons, bats, skunks** - *rabies*
- **Zoonoses** - diseases that primarily exist in other animals, but can be transmitted to humans.

**Environmental Reservoir**

Some pathogens, e.g. *C. tetani* and *C. botulinum* are widespread in soils.

**Vector** - an organism that spreads a disease from one host to another.

e.g. Mosquitos, Ticks, Fleas, Lice

An example using some of these terms: (read pages 723-726)

Plague (black death): *Yersinia pestis* (Gamma Proteobacteria, Enterobacteriaceae) infection is **endemic** in prairie dogs and other wild rodents (reservoirs). Fleas (vectors) on the wild rodents can transfer plague to the occasional human. This results in sporadic occurrence of "wild" plague or "sylvatic" plague ("cat case" in Colorado). Of greater threat is when fleas pass *Y. pestis* on to domestic rats, that can then pass (via fleas) *Y. pestis* on to large numbers of humans. This can result in an **epidemic** (India, 1994) or even a **pandemic** (middle ages). *Y. pestis* infects lymph nodes to make bubos, hence "bubonic" plague. Subcutaneous hemorrhaging makes dark areas, hence "Black Death". Because bubonic plague originates in a rodent, bubonic plague is considered a **zoonosis**.

*Yersinia pestis* in lungs results in **pneumonic plague** (pneumon=Gk. for "lung"). Pneumonic plague can spread through the **air or via direct contact**.

**Mortality rate** = 50 - 80%, almost always fatal in a few days if left untreated.
Fig. 28.6. Cells of *Yersinia pestis* have safety pin appearance when isolated from lymph nodes.

Fig. 28.7. Fleas after a blood meal

a. Healthy Flea

b. Flea infected with *Y. pestis.*

Note intestinal blockage,……

Results in very hungry flea (therefore bites over and over) and flea that vomits *Y. pestis* cells.

Table 28.4. Plasmid and chromosomally borne *virulence factors* of *Y. pestis.* Note that F1 is only expressed in mammals (37°C) and not in fleas (26°C).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Code by</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pai (peptide)</td>
<td>9.5 kDa plasmid</td>
<td>Activates pathogenic adhesion, phagocytic Clq, C3a</td>
</tr>
<tr>
<td>Not (peptide)</td>
<td>32 kDa plasmid</td>
<td>Inhibits phagocytic and the immune response by inhibiting invasiveness</td>
</tr>
<tr>
<td>F1</td>
<td>130 kDa plasmid</td>
<td>Forms epithelial capsule at 29°C</td>
</tr>
<tr>
<td>Pest (nuclein)</td>
<td>Chromosome</td>
<td>Reassociation to host cells</td>
</tr>
<tr>
<td>Complement exotoxin</td>
<td>Chromosome</td>
<td>Produces anti-thrombin and anti-complement</td>
</tr>
<tr>
<td>Iron acquisition</td>
<td>Chromosome</td>
<td>Enhances and other iron-containing substances, metal ion compounds intracellularly</td>
</tr>
</tbody>
</table>

Indirect Contact - transfer of a pathogen via an object or fomite.

Droplet transmission - respiratory droplets with microbes can spread from person to person in close proximity

AIR

> Mucus droplets are emitted when people talk, laugh, or sneeze

Food & Water

> Many pathogens that infect the gastrointestinal tract use this mode.

> Foods can become contaminated:

> Directly in the food

> During food preparation

   Cross-contamination - one food to another

> Improper storage

Other modes of disease transmission:

Contact

Direct contact - one person touches another

- handshake
- sexual intercourse
- fecal-oral transmission

Most pathogens transmitted this way cannot survive for long in the environment.

Population Characteristics that affect epidemiology

1. Immunity - a disease needs a population of susceptible people

   Herd immunity - a critical concentration of immune hosts prevents the spread of a disease

2. General Health

   Malnutrition and crowding can make people more susceptible to disease.

3. Age, gender, genetic background etc.
Epidemiological Studies

Descriptive studies - characteristics of people involved and place and time of outbreak

- place - may give clues about reservoirs, vectors, etc.
- time - how fast it spread, time of year

Fig. 20.6 Seasonal Occurrence of Respiratory Infections
Fig. 20.7 Seasonal Occurrence of Gastrointestinal Diseases

Variation in timing of Epidemics

- common-source epidemic - a peak level in a short period of time. Usually results from a single contaminated source.
- propagated epidemic - slow and prolonged rise in number of cases. Usually from the introduction of an infected individual into a susceptible population.

Give examples of AIDS for propagated and food-borne for common source

Fig. 29.9. Percentage of AIDS cases in women in the USA.

Infectious Disease Surveillance

- National Centers for Disease Control and Prevention - CDC
  Publishes:
  
  Morbidity and Mortality Weekly Report

Notifiable Infectious Diseases see Table 20.2

Trends in Disease

Reduction & Eradication

Smallpox - last natural case occurred in 1977. Declared eradicated in 1979

Other diseases slated for eradication:
1. Polio

Nosocomial Infections

Hospital-acquired infections

Fig. 20.11
Reservoirs of Infectious Agents in Hospitals

- Other patients
- The hospital environment
- Health care workers
- Patient’s normal flora

Airborne diseases - may result in respiratory or skin diseases

Pertussis (whooping cough)
- Diphtheria
- Legionnaire’s Disease
- TB (see lecture 15)
- Streptococcal Diseases

Bacteria are inhaled, then attach to epithelial cells in respiratory system (see Fig. 23.1).

Release exotoxins (e.g. an A-B toxin, see fig. 23.14 ) and an endotoxin, which kill ciliated cells of the “Mucociliary Escalator” (read page 562). Thus a major defense against respiratory pathogens (and method of removing mucus) is disabled and coughing is our attempt to dislodge the pathogen……

Colonization of surface, followed by toxin production (From lecture 20)

- B. pertussis (whooping cough)
  - Attach to ciliated epith, toxin causes release of NO from goblet cells
  - also produces an endotoxin
  - Kills ciliated epithelial cells
  - Bordetella - small, aerobic, Gm- rods. Very sensitive to drying therefore transmitted in coughed-up droplets of mucous...

Fig. 23.1. B. pertussis infects the trachea, bronchi etc…

Fig. 23.13. Diagnostic picture of fluorescent antibody stain of B pertussis attached to a coughed up epithelial cell

Fig. 23.15. Reported Pertussis cases in the USA. Note recent increase……

Pertussis (whooping cough)

- Caused by Bordetella pertussis (Gram -)
- primarily affects children
- common worldwide (50 million cases and >300,000 deaths per year), but rare in U.S. because of vaccination.

Recent increase in cases in the U.S. due to lapses in vaccination, about 1000 cases per year in Colorado (several recent deaths.....)
Figure 23.14. Mode of action of the pertussis A-B toxin (Ptx). The A portion is taken into the cell where it functions as an enzyme to deactivate the G protein that decreases cAMP production. Increased cAMP causes excess mucous production, decreases blood sugar levels and depresses local immune function….

Cell death is caused by another exotoxin, an endotoxin and nitric oxide (NO) production by goblet cells.

**Three stages:**

1) Mucous membranes inflame, resembles a cold (about 5 days to a week...).

2) Prolonged coughing. 5-15 consecutive coughs followed by a “whoop” - deep inspiration

   These 2 stages last about 6 weeks.

3) Convalescent stage - may take months to recover.

**Legionnaire's Disease**

- first found at a convention of the American Legion in Pennsylvania in 1976.
- Causative agent is Legionella pneumophila - Gram - rod
- Present naturally in warm ponds, soils, lakes, etc., but can proliferate in air conditioners, cooling towers, humidifiers, and other warm, moist places.

**Diptheria**

- caused by Corynebacterium diphtheriae - Gram pos. rod
- very rare in U.S. because of vaccination
- recent outbreak in central Asia

**Evidence suggests that the bacteria may be endobionts of amoeba or other protozoa.**

Causes a pneumonia-like disease