Ecology of Disease

Weekly theme:	CONTACT
Lecture:	Global patterns

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Epidemiology

Study of disease distribution (temporal/spatial)
- **prevalence** (cross-sectional) point or period
- **incidence** (longitudinal) change over time
- **intensity** (burden per host)

Disease categories:
- sporadic (occasional)
- endemic (established/persistent)
- **epidemic** (outbreak)
- pandemic (global)
  - autochthonous (locally acquired)
  - introduced (imported/exotic)
  - emerging/re-emerging

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Impact of disease

MORBIDITY = incidence of illness
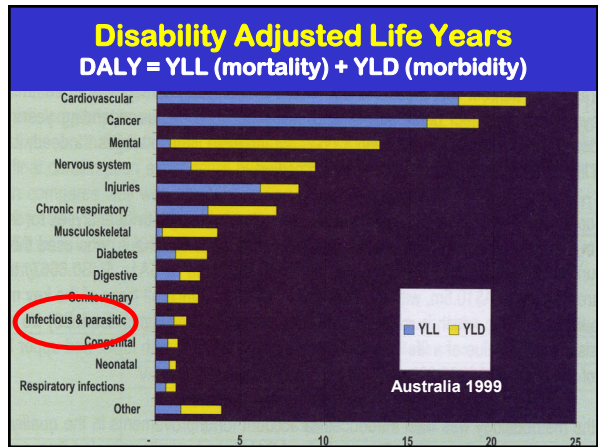MORTALITY = incidence of death

Modern economists measure it in terms of:

Disability Adjusted Life Years

DALY = YLD + YLL

where YLD = Years Life lost due to Disability
(morbidity burden)
where YLL = Years Life Lost due to premature death
(mortality burden)

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Disability Adjusted Life Years
DALY = YLL (mortality) + YLD (morbidity)

Cardiovascular, Cancer, Mental, Nervous system, Injuries, Chronic respiratory, Musculoskeletal, Diabetes, Digestive, Genitourinary, Infectious & parasitic, Congenital, Neonatal, Respiratory infections, Other

YLL YLD

Australia 1999

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Global incidence

Most common causes of mortality due to infectious diseases (2002):

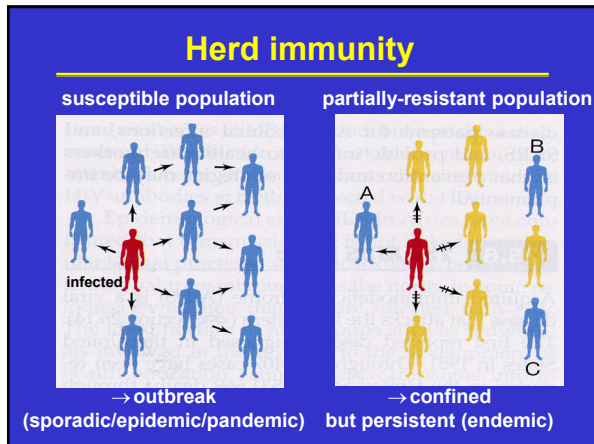|	
acute respiratory infections	4,000,000
acquired immunodeficiency syndrome	3,000,000
diarrhoeal diseases	1,800,000
tuberculosis (TB)	1,600,000
malaria	1,300,000
measles	600,000
pertussis (whooping cough)	300,000
tetanus	200,000
meningitis, bacterial	200,000
hepatitis, all types	160,000
syphilis	150,000
trypanosomiasis, all types	100,000
chlamydiasis	20,000
schistosomiasis	15,000
Japanese encephalitis	14,000
dengue	13,000
other communicable diseases	1,700,000

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Consequences of exposure

- innate resistance (do not become infected)
- susceptible (become infected)
  - latent → patent (infectious)
  - carriage (asymptomatic → subclinical)
  - disease (acute/chronic, transient/persistent)
  - resistance (immunocompetency)
    - sterile immunity (self-cure)
    - protective immunity (resist super-infection)
    - concomitant immunity (premunition)
    - herd immunity (population)
      (depends on frequency and incidence)

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Herd immunity

susceptible population

partially-resistant population

infected

→**outbreak**
(sporadic/epidemic/pandemic)

→**confined**
but persistent (endemic)

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Host susceptibility

- **age (young/old)**
- **gender (pregnant/lactating females)**
- **animal breed (innate resistance)**
- **physiological status (malnourished, stressed...)**
- **immunological status**
  - **immuno-competent**
    - **vaccination, prior exposure**
  - **immuno-incompetent**
    - **congenital immunodeficiences (genetic)**
    - **acquired immunodeficiences (infection)**
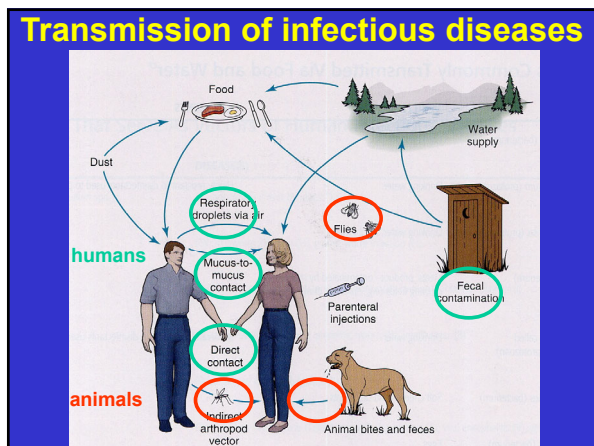   - **immunosuppression (chemotherapy/transplants)**

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Distribution

Infectious diseases have shaped human history
- **set zoogeographic boundaries**
- **limited agricultural/economic development**
- **defied exploration and colonization**
- **responsible for rise and fall of civilizations**
- **plagued urbanization**
- **revolutionized public health (esp. food/water)**
- **international threat through globalization**
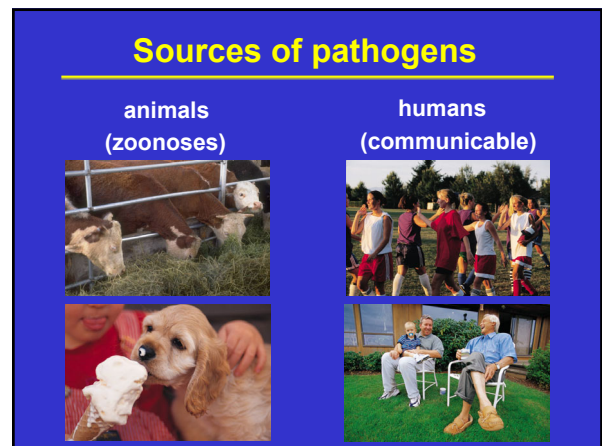
- **'Old World' and 'New World' differences**

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Chain of infection

Six links in the chain:
1. **Presence of pathogen (infectious microbe)**
2. **Reservoirs (living, non-living)**
3. **Portal of exit**
   (oral, anal, urogenital, dermal, blood)
4. **Mode of transmission**
   (contact, sex, aerosol, fomites, vectors)
5. **Portal of entry**
   (ingestion, inhalation, injection, penetration)
6. **Susceptible host**
   (age, sex, breed, physiol/immunol status)

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Transmission of infectious diseases

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Sources of pathogens

animals
(zoonoses)

humans
(communicable)

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Zoonoses

Transmission relies on close contact between humans and animals

- wildlife
- game animals
- domestic animals

- invertebrate vectors

Old World diseases

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Communicable (anthropogenic)

Transmission relies on close contact between humans

- populations
- communities
- families
- partners
- progeny
- individuals

New World crowd diseases

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Recent human history

Recognize 5 main periods:

1. Derivation (>10,000 years ago)
2. Civilization (7,000 years ago)
3. Exploration (400 years ago)
4. Colonization (200 years ago)
5. Globalization (<50 years ago)

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1. DERIVATION

Humanoid African origins > 10,000 YA (fossil records)

**hunter/gatherer societies on savanah near forests
zoonotic uptake (animal-to-human transmission)
especially vector-borne tropical diseases
"Old World" diseases**

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Old World diseases

FEVERS			
• malaria	*Plasmodium*	vector-borne	fever
• yellow fever	flavivirus	vector-borne	fever
• typhus	*Rickettsia*	vector-borne	fever
• Lassa fever	arenavirus	rodents	fever
DYSENTERY			
• amoebic	*Entamoeba*	faecal-oral	diarrhoea
• bacillary	*Shigella*	faecal-oral	diarrhoea
OTHER			
• anthrax	*Bacillus*	soil/hides/bones	lesions

⇒ ZOONOSES (animal and human correlations)
(historical zoogeography, presentation, pathology)
(transmission, vectors, molecular phylogeny)

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2. CIVILIZATION

Out-of-Africa migrations >7,000 YA

**hunters → herders → farmers → villagers → cities
civilizations in Europe, Asia, Americas
development of gregarious 'crowd' diseases
separated from Old World by deserts (Sahara)**

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New World diseases

POXES
- **smallpox**   poxvirus   contact/resp.   rash/pustules
- **syphilis**   *Treponema*   venereal   rash/lesions

PLAGUES
- **bubonic**   *Yersinia*   contact   buboes
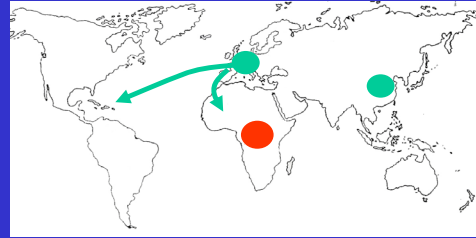- **leprosy**   *Mycobacterium*   contact   lesions

OTHER
- **measles**   paramyxovirus   respiratory   rash
- **rubella**   togavirus   contact   systemic
- **cholera**   *Vibrio*   faecal-oral   diarrhoea
- **tuberculosis** *Mycobacterium* respiratory   lesions
- **diphtheria** *Corynebacterium* respiratory   lesions
- **pertussis**   *Bordetella*   respiratory   cough

⇒ **COMMUNICABLE human diseases**

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3. EXPLORATION

400 YA European explorers discover Americas, etc

encounter tropical diseases
spread crowd diseases (decimation/genocide of Aztecs, Mayans, American Indians, Hawaiians, Carribean, etc)

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Spread of diseases

Susceptible populations decimated by disease
- **measles in North, Central, South American Indians (still occurring in Amazon rainforests)**
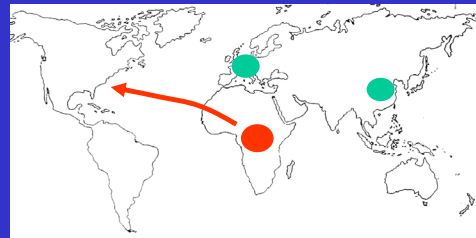- **syphilis in Hawaii (sexual hospitality)**

BUT explorers encountered tropical diseases
- **arboviral diseases worldwide**
- **malaria, sleeping sickness in Africa**
- **leishmaniasis, Chagas disease in South America**

FIRST ENCOUNTER of Old World and New World disastrous (mutually detrimental)

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4. COLONIZATION

200 YA Translocation between Old and New Worlds

European colonization
(British, German, French, Dutch empires)
needed labour force resistant to tropical diseases
imported African labour (slave trade)

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Spread of diseases

Africans with 'herd immunity' to tropical diseases
- **survived malaria, yellow fever, etc, still able to work**
But no exposure, hence immunity, to crowd diseases
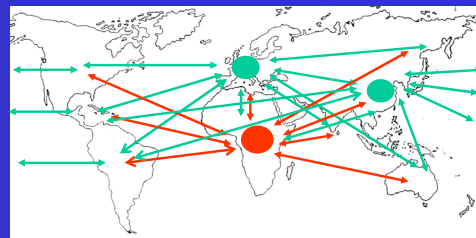- **decimated by measles, STDs, respiratory ailments**

ASSIMILATION
- **cultural/social integration slow, expatriate nationalism**
- **genetic interbreeding inevitable, but variable**
- **'mixing pot' – selection for disease resistance**

SECOND ENCOUNTER of Old World and New World slowly reconstituted gene pool

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5. GLOBALIZATION

50 YA International mixing pot

population translocations (World Wars, migration, etc)
international travel, trade, commerce, tourism, etc
technological revolution
economic globalization

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New Wave diseases

RE-EMERGING DISEASES
- influenza   orthomyxovirus   respiratory   pneumonia
- giardiasis   *Giardia*   faecal-oral   diarrhoea
- tuberculosis *Mycobacterium* respiratory   lesions

EMERGING DISEASES
- Legionnaires *Legionella*   respiratory   pneumonia
- HIV   retrovirus   sexual/blood   AIDS
- West Nile   virus   vector-borne   encephalitis
- SARS   coronavirus   respiratory   pneumonia

⇒ ZOONOSES (animal to human spread)
(contact with wildlife/vectors, extension of host range)
(field/exptl. studies, molecular phylogeny)

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Emerging Diseases

Many factors influence their emergence
- human demographics
- human behaviours
- technology
- industry
- economic development
- land use
- international travel
- commerce
- public health resources
- pathogen variation
- extraordinary events (upset stability)
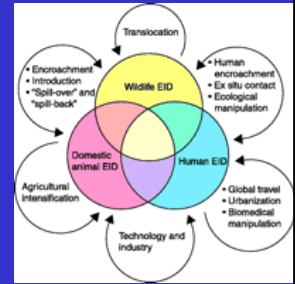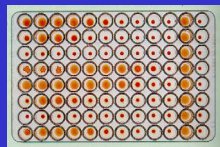

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Disease detection

Recognition of emergence
Clinic
- unique presentation
- local/focal outbreak
- sentinel populations
- syndromic surveillance

Laboratory
- diagnostic capability
- case-based
- test 'susceptibles'
- population monitoring

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Intervention

Curative treatment (therapy)
- chemotherapy (drugs)
- immunotherapy (reconstitutive)

Preventive treatment (prophylaxis)
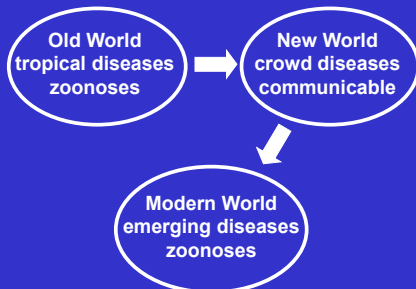- chemoprophylaxis (drugs)
- immunoprophylaxis (vaccines)

Preventive control (break transmission cycle)
- limit contamination (food/water)
- control vectors (kill/repel, barriers)
- modify behaviours (spitting, sex)

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History repeats!

Old World tropical diseases zoonoses → New World crowd diseases communicable → Modern World emerging diseases zoonoses

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