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INFECTIOUS DISEASE EPIDEMIOLOGY

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OVERVIEW

1. EARLY EPIDEMIOLOGY
2. INFECTIOUS DISEASE EPIDEMIOLOGY GOALS
3. INFECTIOUS DISEASES CAUSE
4. CHAIN OF INFECTION
5. CHARACTERISTICS OF INFECTIOUS DISEASE
6. CLASSIFICATION OF INFECTIOUS DISEASES

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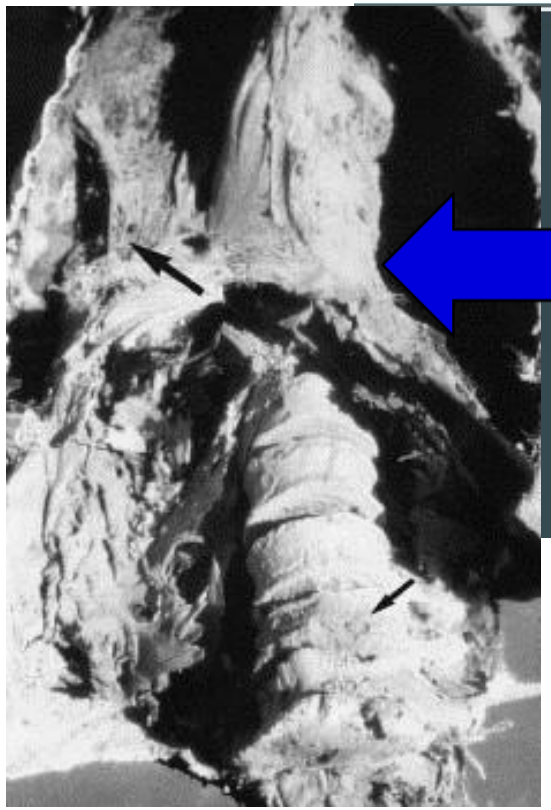
1. EARLY EPIDEMIOLOGY



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CORRESPONDENCE | VOLUME 350, ISSUE 9088, P1404, NOVEMBER 08, 1997

PDF [218 KB] Figures

Molecular evidence for tuberculosis in an ancient Egyptian mummy

Andreas G Nerlich • Christian J Haas • Albert Zink • Ulrike

Published: November 08, 1997 • DOI: https://doi.org/10.101

Traces of smallpox pustules found on the head of the 3000-year-old mummy of the Pharaoh Ramses V.

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WHEN DID THE FIRST EPIDEMICS BEGIN TO APPEAR?

- Population growth
- Explorating
- Movements of armies and big groups of people
- Expanding trade routes

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CONTAGIOSITY OF ILLNESS

WAS IT ALWAYS CLEAR?

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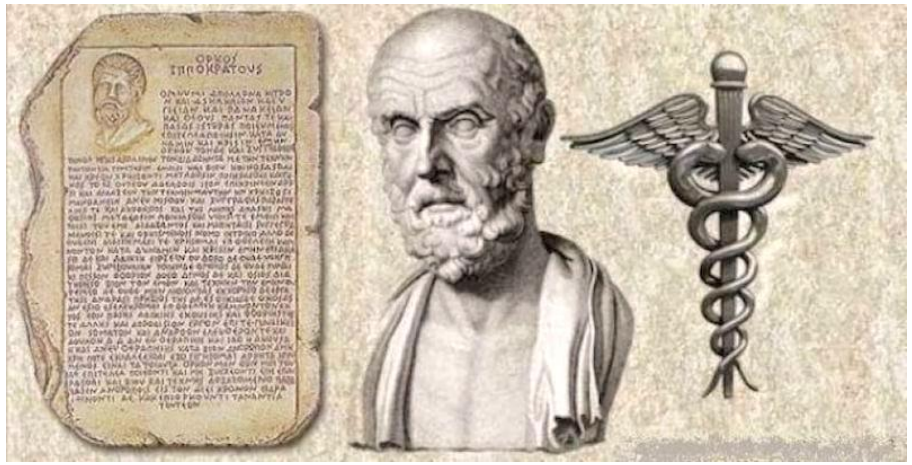
HIPPOCRATES (460-377 BC)
THE FIRST EPIDEMIOLOGIST

- First dismissed the supernatural explanation of diseases,
- attributed the illness to characteristics of the climate, water, soil, mode of life and nutrition of the patient (Epidemics, 430 BC)
- used observations to describe how diseases affected populations and how diseases spread.



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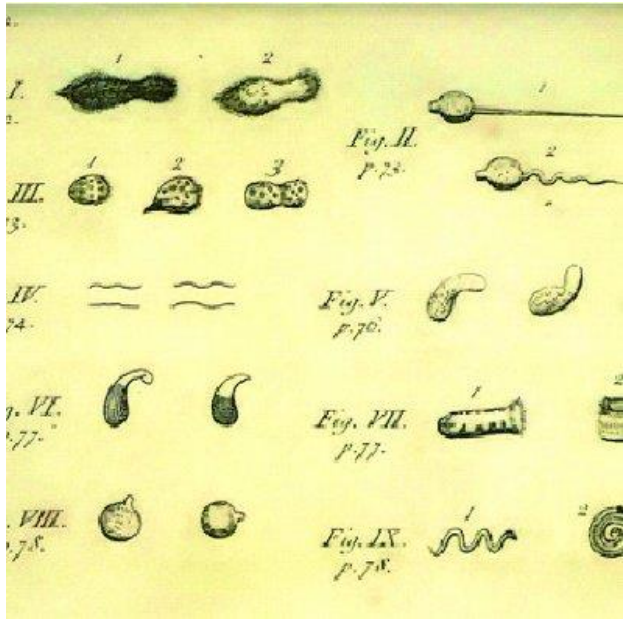
FRACASTORO (1478-1553)
THE FIRST REVOLUTIONIST IN EPIDEMIOLOGY

- book Contagious diseases, and Their Treatment (1546),
- his theory: diseases are transmitted from person to person by minute invisible particles – „seeds“ (specific and self-replicating),
- three modes of transmission of contagious diseases – by direct contact from one person to another, through contacts with fomites and through the air.

VISUALIZATION OF MICROORGANISMS

- Antoni van Leeuwenhoek – inventor of microscope
- In 1683 he described minuite forms especially in decaying or fermenting materials
- He did not evaluate these organisms as agent of diseases



The first sketch (Fig. IV) of a bacterium by Antoni van Leeuwenhoek (Delft University of Technology).

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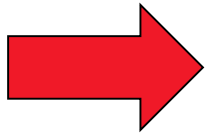
FIRST BACTERIOLOGICAL DISCOVERIES

- In 1857 Louis Paster disproved the theory about spontaneously generated microorganisms.
- In 1876 Robert Koch demonstrated the transmission of anthrax from one to another animal by inoculating him with the same microorganisms  „Henle – Koch postulates“.

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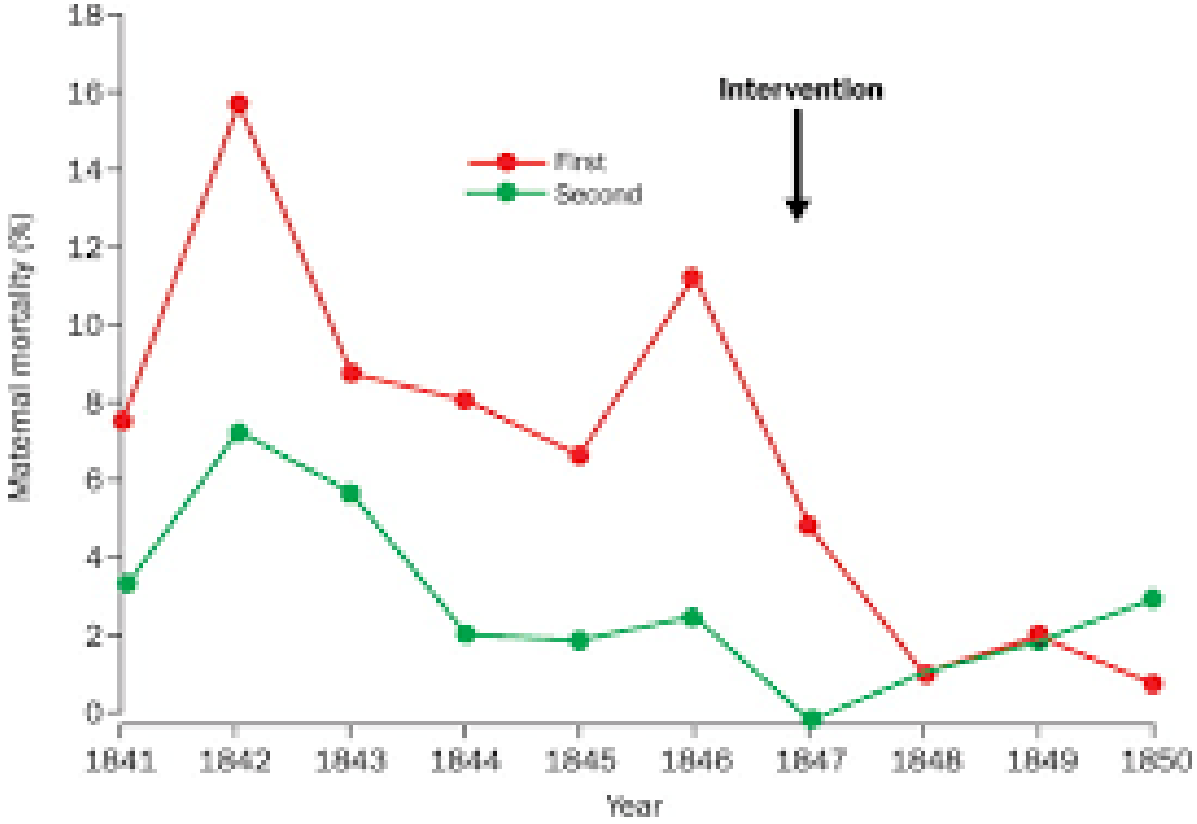
IMPACT OF HAND HYGIENE METHOD (dr. Semmelweis – Vienna 1847)



Mortality rates of puerperal sepsis in 1st and 2nd divisions at the Vienna Lying-In hospital.

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THE DISCOVERY OF IMPORTANT DISESASES

YEAR	DISEASE OR ORGANISM	SCIENTIST
1874	Leprosy	Hansen
1880	Malaria	Laveran and Eberth
1882	Tuberculosis	Koch, Loeffler, and Schutz
1884	Diphteria, Tetanus, Staphylococcus,..	Klebs and Loeffler, Rosenbach, Nicolaier
1885	E.coli	Escherich
1894	Plague	Yersin and Kitasato
1898	Disentery bacillus	Shiga

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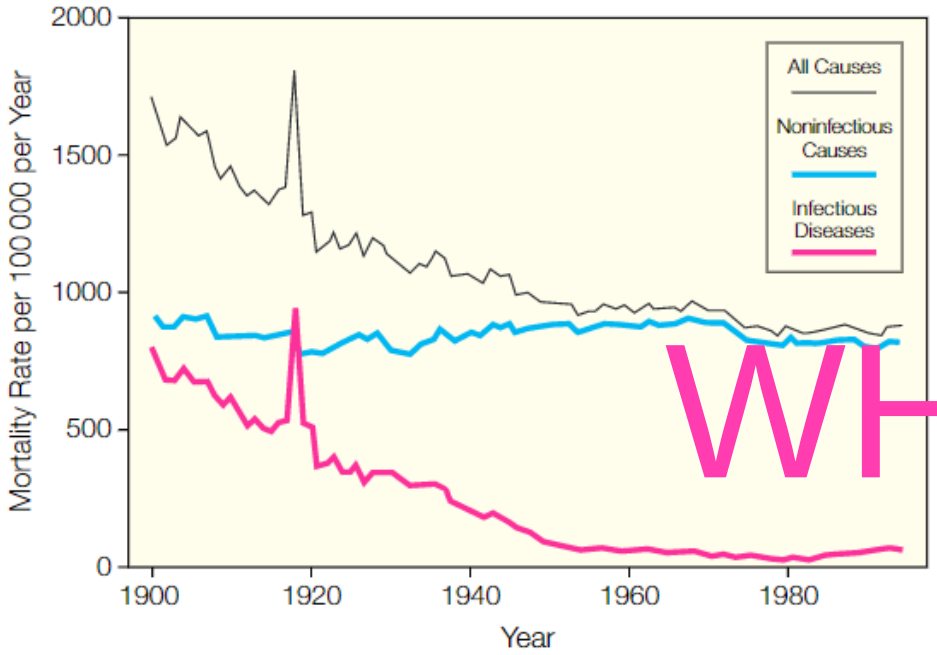
CHANGES IN INFECTIOUS DISEASE MORBIDITY AND MORTALITY

– During the first decades of 1900s - m. and m. dramatically decreased (prior the availibility of vaccines and antibotics…)



WHY?

Armstrong, G.L., 1999. Trends in Infectious Disease Mortality in the United States During the 20th Century. JAMA 281, 61.. doi:10.1001/jama.281.1.61

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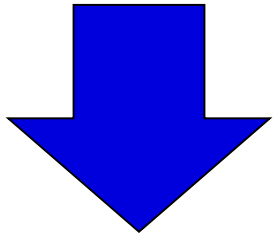
USE OF EMPIRICAL EXPERIENCES FROM EPIDEMICS

IMPROVING HYGIENE CONDITIONS

GOOD ORGANIZATION OF CARE

CHANGES IN LIFESTYLE

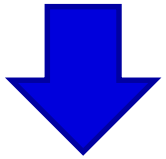
AVAILABILITY OF SAFE WATER AND FOOD



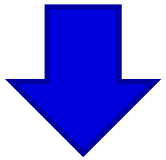
DECREASE IN INFECTIOUS DISEASE MORBIDITY AND MORTALITY DURING THE 1900S

2ND HALF OF THE 20TH CENTURY
THE END OF INFECTIONS?

- Discovery and production of antimicrobial drugs (sulfonamides, penicillin,…)
- Extensive vaccination programs (smallpox, polio, diphtheria,…)
- New technologies and techniques in treatment



Many experts believed that humanity had already dealt with the infections.



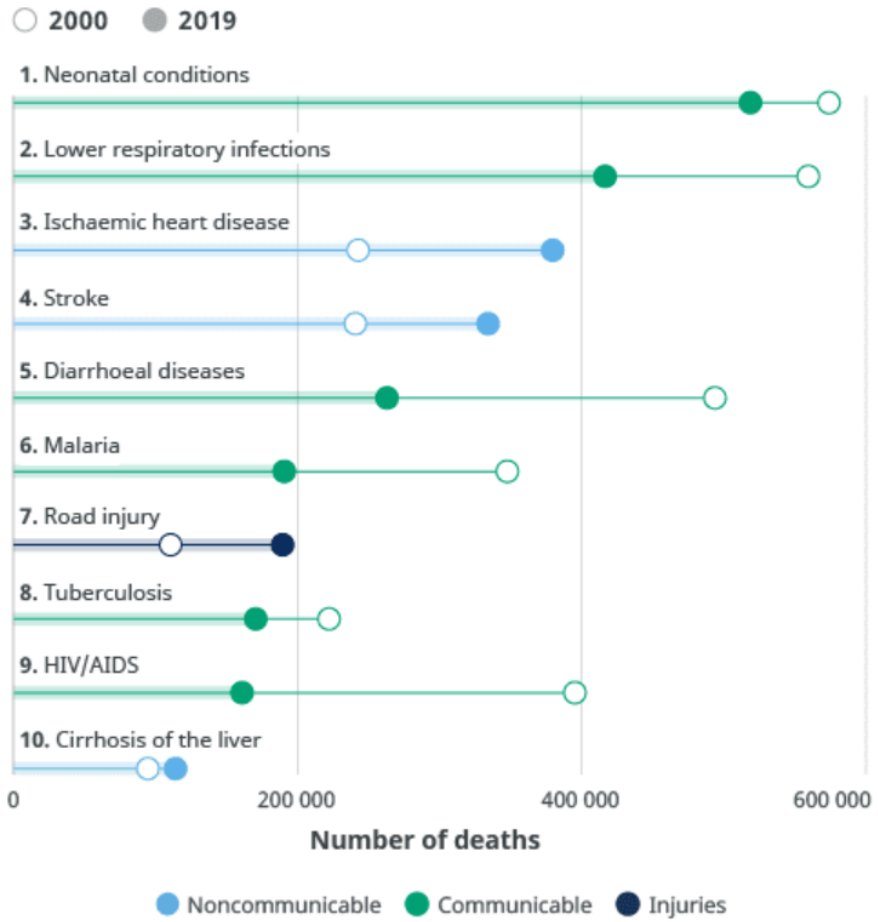
The interest and money have shifted to non-communicable diseases.

RECENT WORLDWIDE TRENDS

- Noncommunicable diseases - leading causes of death globally but
- In low-income countries, six of the top 10 causes of death are communicable diseases (malaria, HIV, tuberculosis)
- Increasing risk of new infectious disease and reemergence of old infections!
- Vaccine hesitancy and antimicrobial resistance - two from 10 threats to global health (WHO)

[https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death]

LEADING CAUSES OF DEATH IN LOW-INCOME COUNTRIES (WHO)



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EPIDEMIC SPREAD AND MODERN LIFE

– Fast, easy and massive travel has dramatically increased the risk of spreading the infection worldwide!

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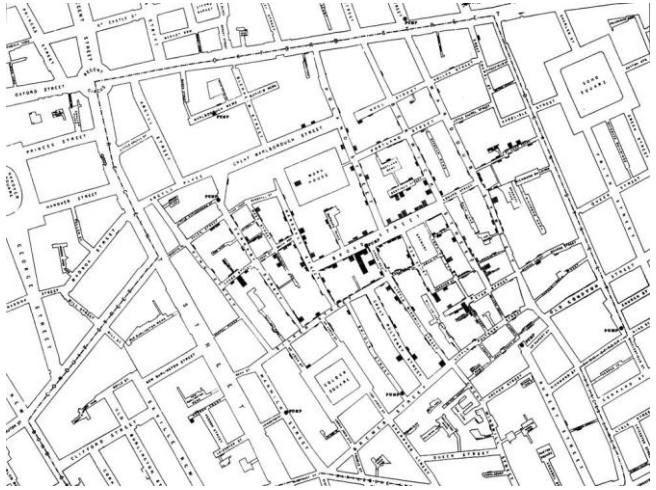
2. INFECTIOUS DISEASE EPIDEMIOLOGY GOALS

JOHN SNOW (1813-1858)
FATHER OF EPIDEMIOLOGY

- physician and the anesthesiologist for Queen Victoria.
- he studied cholera and used epidemiologic investigation for cholera outbreaks in London– descriptive and analytic studies,
- his approaches, concepts, and methods are still useful and valuable.



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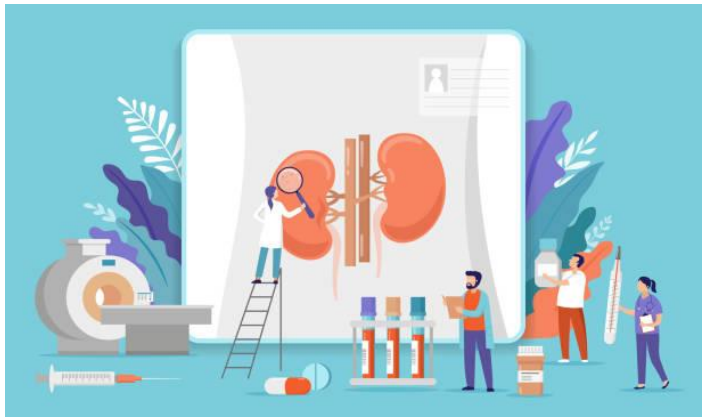
EPIDEMIOLOGY

INFECTIOUS DISEASE EPIDEMIOLOGY

NON-INFECTIOUS DISEASE EPIDEMIOLOGY



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MAIN GOALS

1. Assesing the extend of infections in a given population in terms of transmission, new reported cases (incidence), existing cases (prevalence)
2. Understanding the prognosis and natural history of infections
3. Determining the infections causing a particular disease and the risk factors that increase the frequency of infection aquisition and progression from infection to disease,..
4. Assesing the efficasy and effectiveness of preventive and curative measures
5. Outbreak investigation

USEFUL TERMS
CASE CONCEPTS IN EPIDEMIOLOGY

- PRIMARY CASE - the first disease case in the population
- INDEX CASE - the first d.c. brought to attention of epidemiologist
- SECONDARY CASES – persons who become infected after a disease have been introduced into population and who become infected from contact with the primary case.
- CASE DEFINITION

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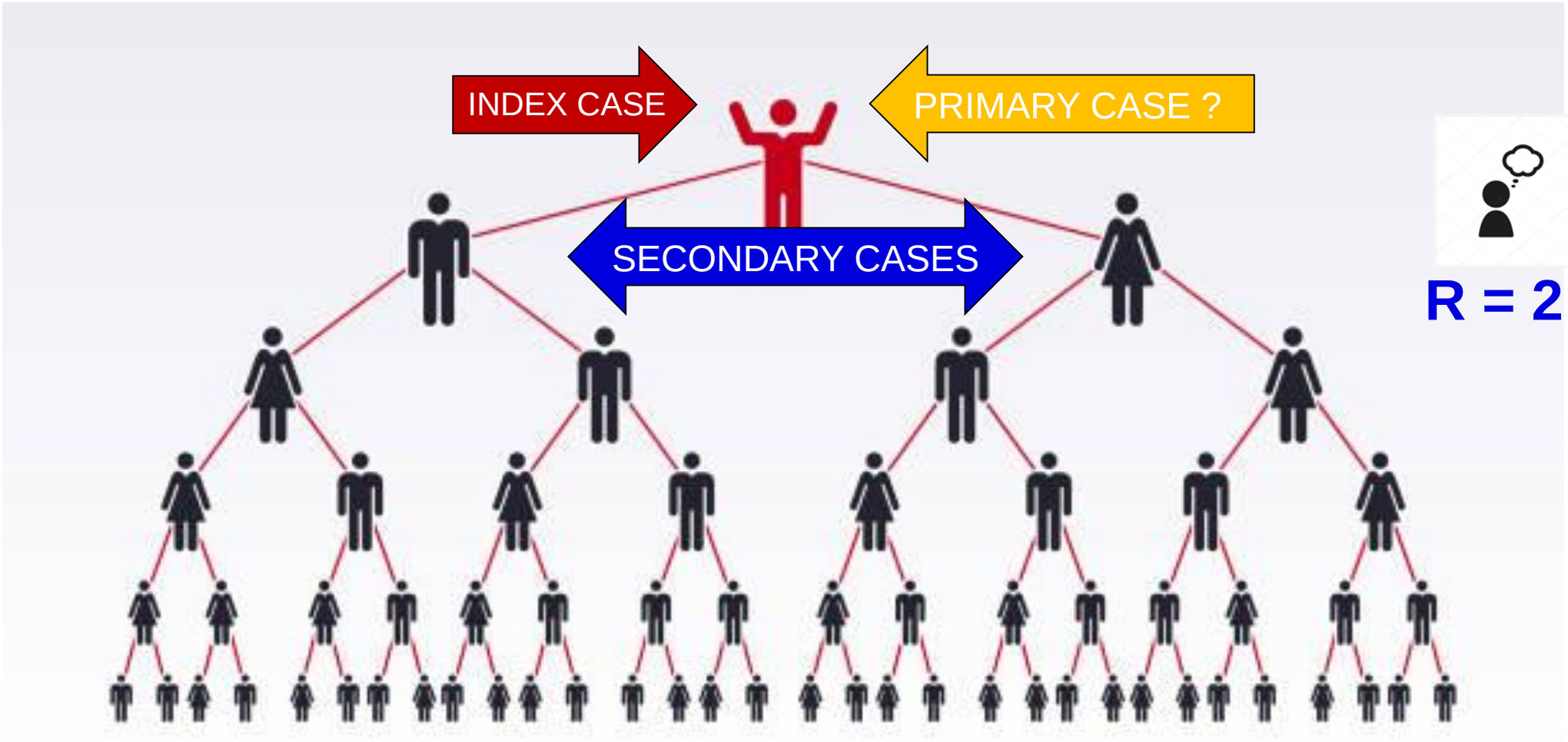
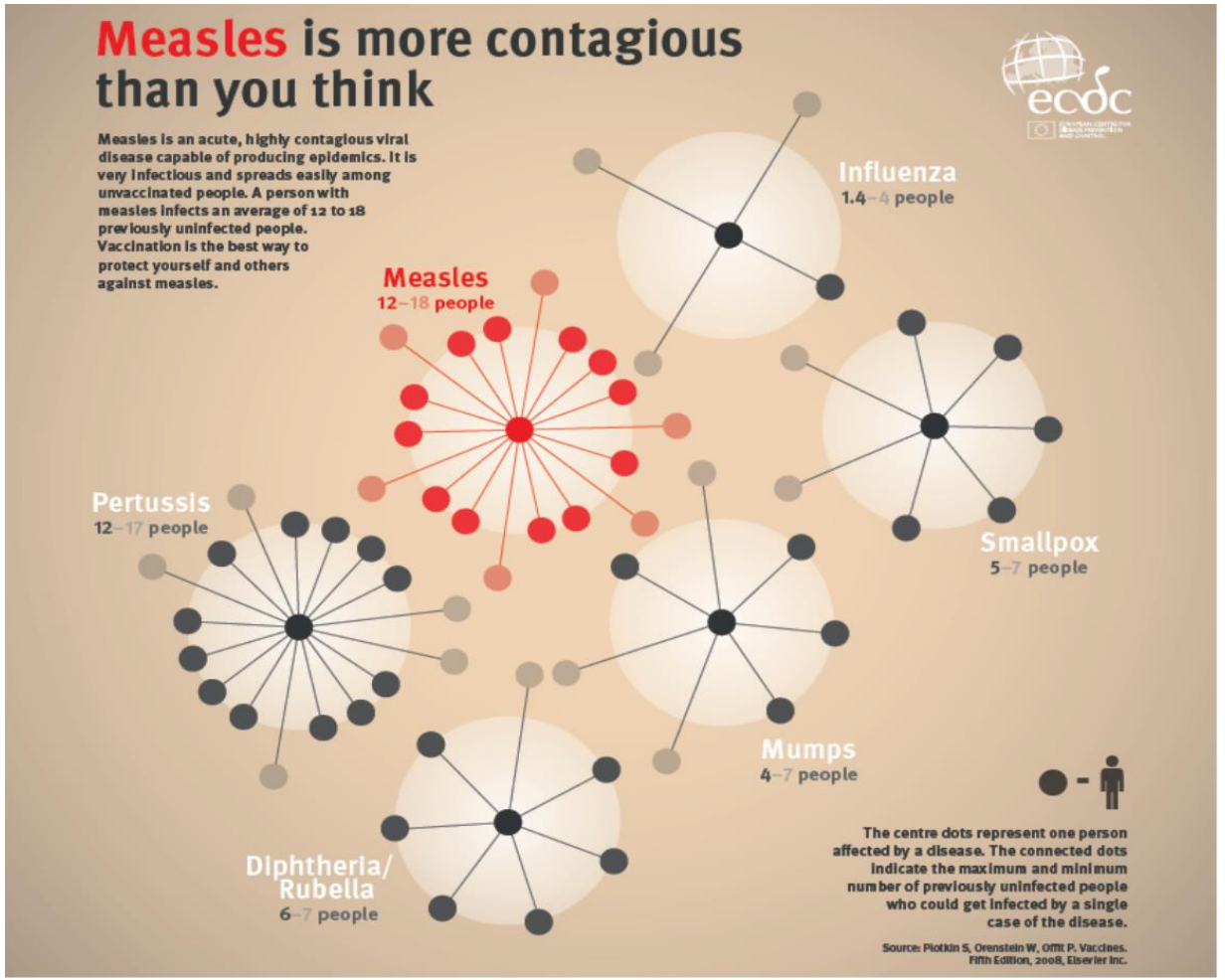
USEFUL TERMS
REPRODUCTIVE NUMBER

- **R** – is used to denote the number of secondary cases attributed to a single infectious individual
- **R_0** – Basic reproductive number – is R when the pathogen is introuduced to a fully susceptible population
- **$R_{effective}$** – Effective reproductive number – is R in population where some individuals can be immune


INDEX CASE
PRIMARY CASE ?
SECONDARY CASES
R = 2

R OF SOME IMPORTANT INFECTIONS



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3. INFECTIOUS DISEASES CAUSE

PATOGENS DEFINITON AND TYPES

- organisms or substances that are capable of produsing disease.
- TYPE OF PATHOGENS:

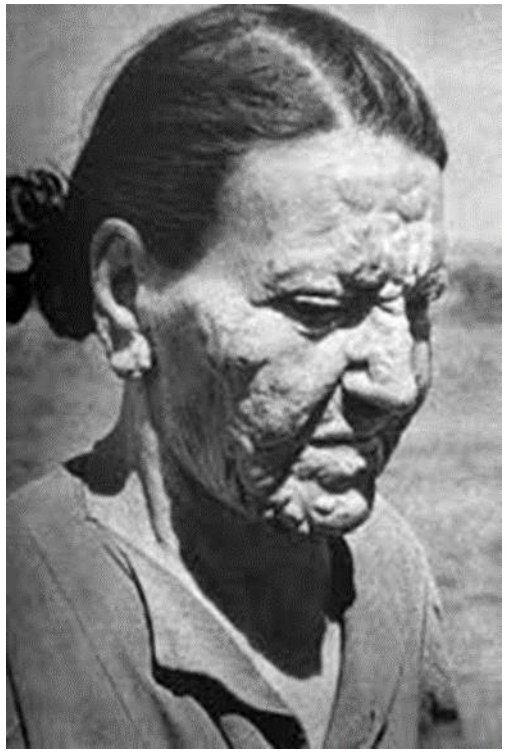
1. Bacteria (e.g. strep throat, urinary tract infections and tuberculosis)
2. Protozoa (e.g. malaria)
3. Viruses (e.g. AIDS, measles,herpes)
4. Fungi (skin diseases - athlete's foot, some infections of lung)
5. Prions
6. Parasites

BIOLOGIC CHARACTERISTICS OF PATHOGEN TERMS

- INFECTIVITY – the ability to cause infection in susceptible person.
- PATHOGENICITY – the ability to induce disease (high in measles, low in polio)
- VIRULENCE – the disease evoking power, the severity of disease after infection occurs.
- IMMUNOGENICITY – the ability to produce an immune response after an infection that is capable of providing protection against reinfection.

LEPROSY

- a human chronic infectious disease caused by *Mycobacterium leprae,*
-
- only a small percentage (less than 1%) of the population that comes into contact with M. leprae will develop the disease.



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LEPROSY IN THE MIDLE AGES

- was believed highly contagious,
- lepers were separated from society as leprosy became increasingly equated with a sin,
- lepers were forced to live in the isolated area or houses „the leprosarium“,
- some requirements looked like the current isolation measures but more drastic („Mass of Separation“)….

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SMALLPOX

- Human, highly contagious disease
- Caused by the variola virus (poxvirus – DNA virus)
- Often a serious course of disease (fever, rash) followed by secondary infections
- 3 out of every 10 people who got it died
- During the 1700s smallpox caused more than 60 million deaths

RANKING OF INFECTIONS

SEVERITY	INFECTIVITY	PATHOGENICITY	VIRULENCE
HIGH	Smallpox, Measles	Smallpox, Rabies, Measles, Common cold, Chicken pox	Rabies, Smallpox, Tuberculosis, Leprosy
INTERMEDIATE	Rubella, Mumps, Common cold	Rubella, Mumps	Poliomyelitis, Measles
LOW	Tuberculosis	Poliomyelitis, Tuberculosis	Measles, Chicken pox
VERY LOW	Leprosy	Leprosy	Rubella, Common cold

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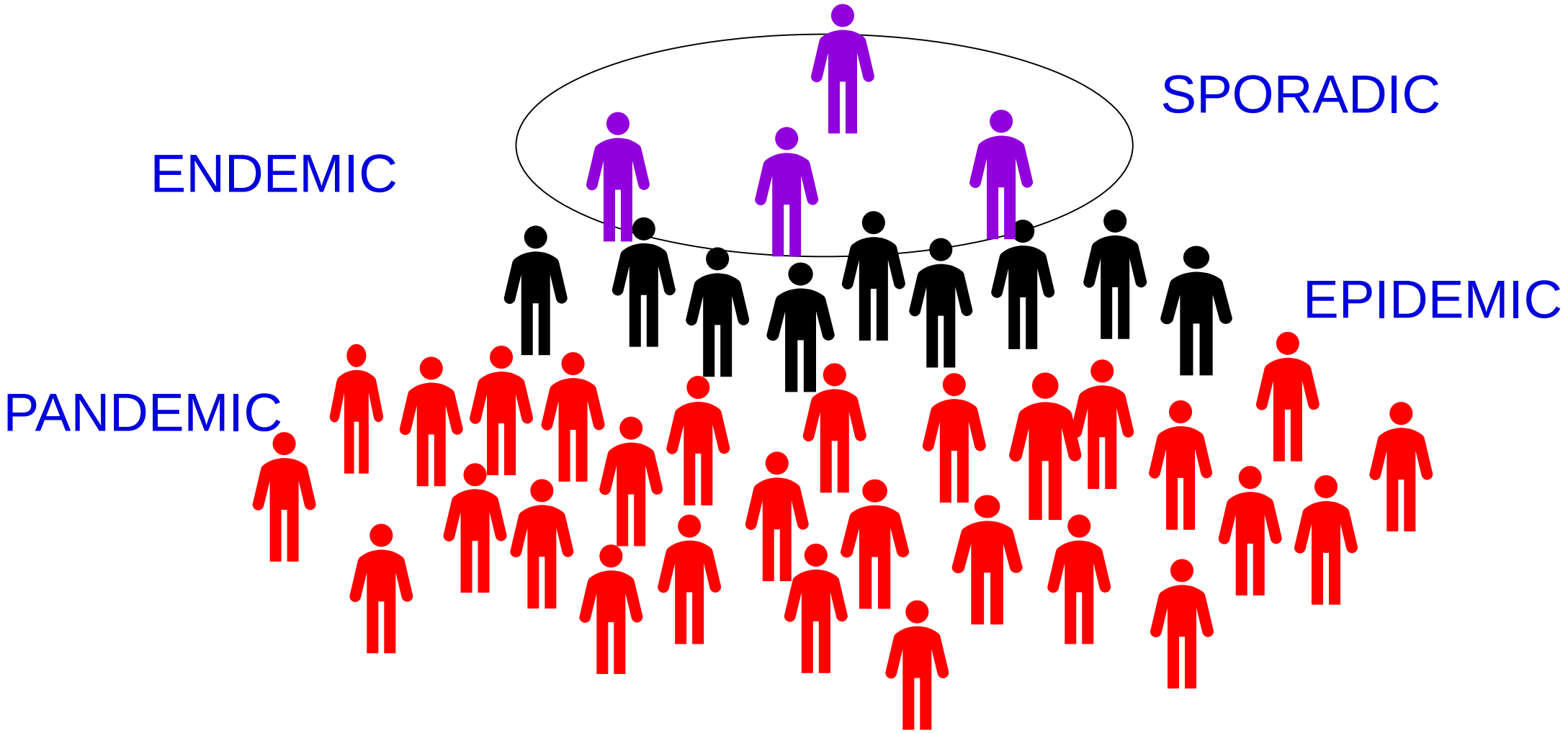
4. CHAIN OF INFECTION

LEVEL OF THE DISEASE OCCURENCE



LEVEL OF THE DISEASES OCCURENCE
OTHER TERMS

- HYPEREPIDEMIC – persistent high levels of disease occurrence
- OUTBREAK – terms often use for epidemic occurrence in a more limited geographic area
- CLUSTER - an aggregation of cases grouped in place and time that are suspected to be greater than the number expected

PLAGUE EPIDEMIC (BLACK DEATH)

- One of the most devastating diseases in the Middle Ages, especially in Europe
- E.g.1347-1351 killed 24 mill. Europeans and 40 mill. people worldwide
- Fundamentally affected the development of civilizations
- Brought specific anti epidemic measures – e.g. *quarantine*

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EPIDEMIC SPREAD WHEN

- if there are a large number of susceptible individuals in the population and
- if the infection is difficult to prevent and
- if is highly contagious.
- Other natural and social conditions - natural disasters, economic level, hygienic level (drinking water, waste), level of health care (infection therapy, vaccination), war conflicts,…

EPIDEMICS HAVE OCCURRED THROUGHOUT THE ALL HUMAN HISTORY AND HAVE INFLUENCED THAT HISTORY

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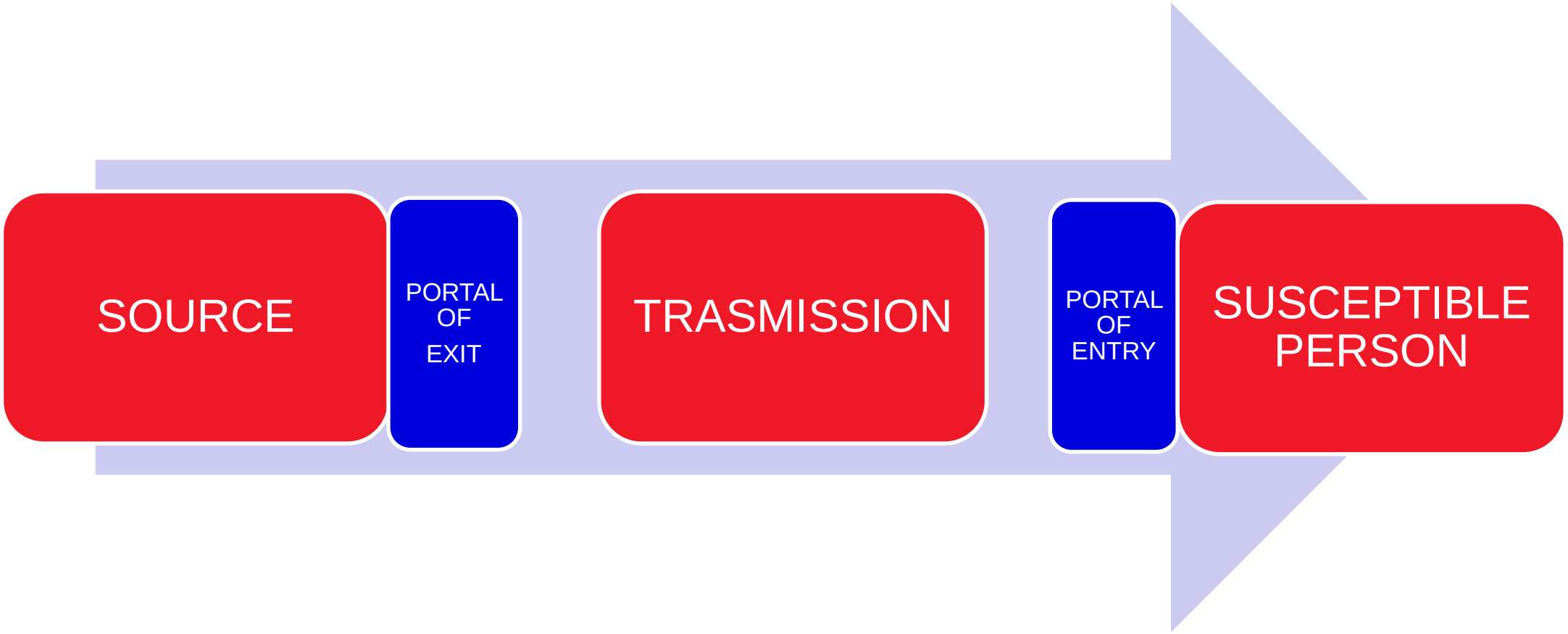
CHAIN OF INFECTION



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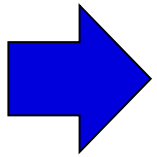
RESERVOIRE/SOURCE

RESERVOIRE/SOURCE

- Definition: Habitat (living or nonliving) in or on which an infectious agent lives, grows, multiplies and on which it depends for its survival in nature.

1. HUMAN (anthroponosis)
2. ANIMAL (zoonosis)



symptomatic, asymptomatic, carrier

3. ENVIRONMENT - water, soil (sapronosis)

STORY OF TYPHOID MARY
TYPHOID FEVER

- symptoms – fever, rose-coloured spots on the chest and abdomen, physical and mental depression, diarrhoea,..
- causative agent – bacteria *Salmonella typhi*
- transmitted by faecal contaminated food and water

STORY OF TYPHOID MARY
GOOD COOK?

- Mary Mallon, Irish cook
- worked as a cook in many houses in New York Ciry in 1900s
- chronic carrier of typhoid, without any symptoms of disease
- due to her legal escape from the health authorities' supervision, she infected the next 200 people.

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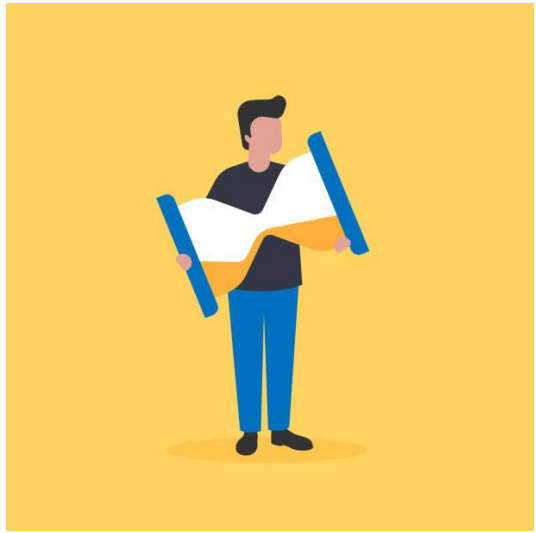
CARRIERS

- Typhoid (often s.c. Healthy carriers)
- Hepatitis B (often Intermitent carriers)
- Hepatitis C
- HIV/AIDS
- …..



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TRANSMISSION

TRANSMISSION

- HORIZONTAL - transmission of the infectious agents from an infected individual to a susceptible contemporary

- VERTICAL – transmission from an individual to its offspring, through sperm, placenta, milk, or vaginal fluids.

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MODELS OF INFECTION TRANSMISSION

DIRECT

– in physical contact between the host and susc. person:

- by droplets
- by sexual contact
- perinatal infections
- skin to skin contact

UNDIRECT

– by some intermediate item, organism, means, proces:

- air
- surfaces
- food
- water
- bites of insects, …

INFECTION WITH MORE THAN ONE MEANS OF TRANSMISSION

- Some of infections may be spread by several different means
- Often one is considered as main (the most frequent)
- E.g.: rabies (by bites, corneal transplants, aerosol?), tularemia (by vector, by contact, by inhalation),…

PLAGUE (BLACK DEATH)
WAYS OF TRANSMISSION

- causative agent – bacillus *Yersinia pestis*
- transmitted in 2 main ways:

1. by droplets from the source ➡ pneumonic plague
2. by vectors – mammals (rat,…) and their parasites

   (e.g. fleas) ➡ bubonic plague

SUSCEPTIBLE PERSON

SUSCEPTIBLE PERSON DEFINITION

- someone who is not vaccinated or otherwise immune (without specific immunity), or a person with a weakened immune system who has a way for the germs to enter the body.

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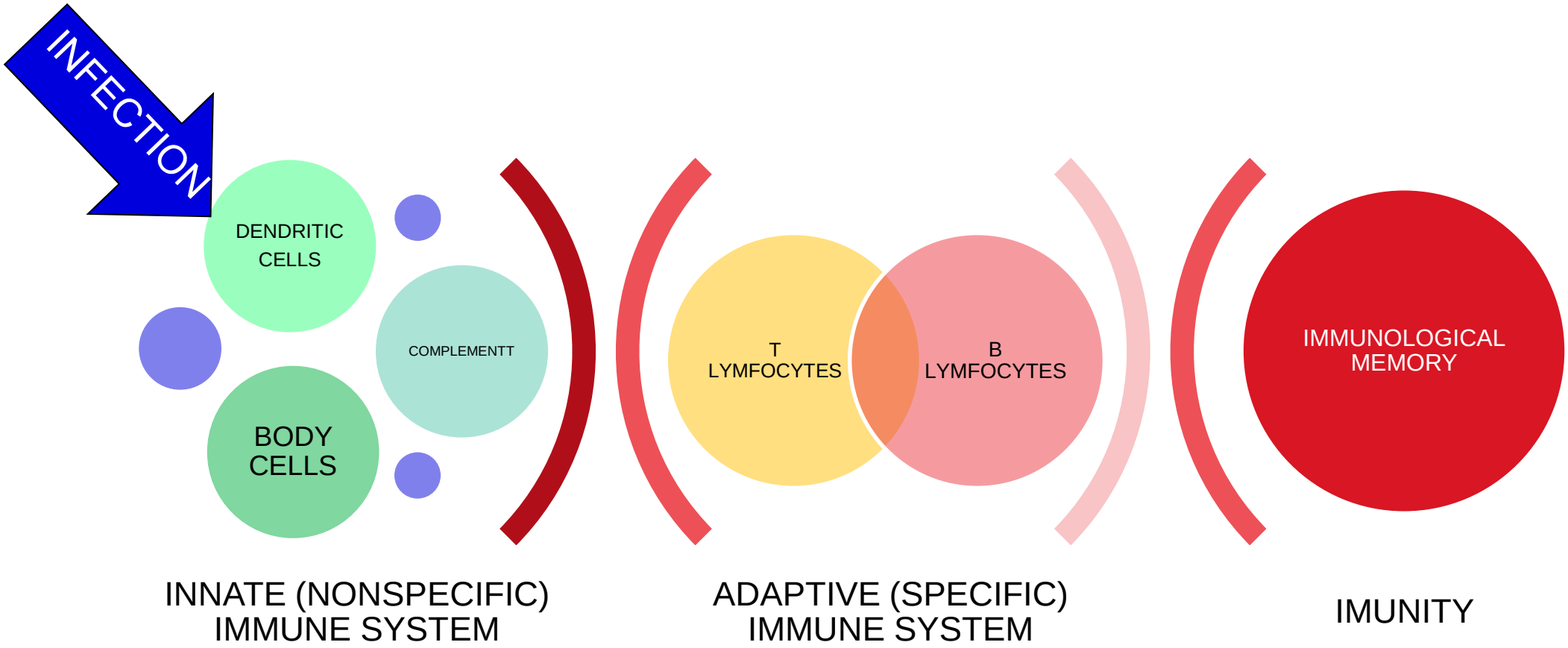
IMMUNE RESPONCES TO INFECTIONS



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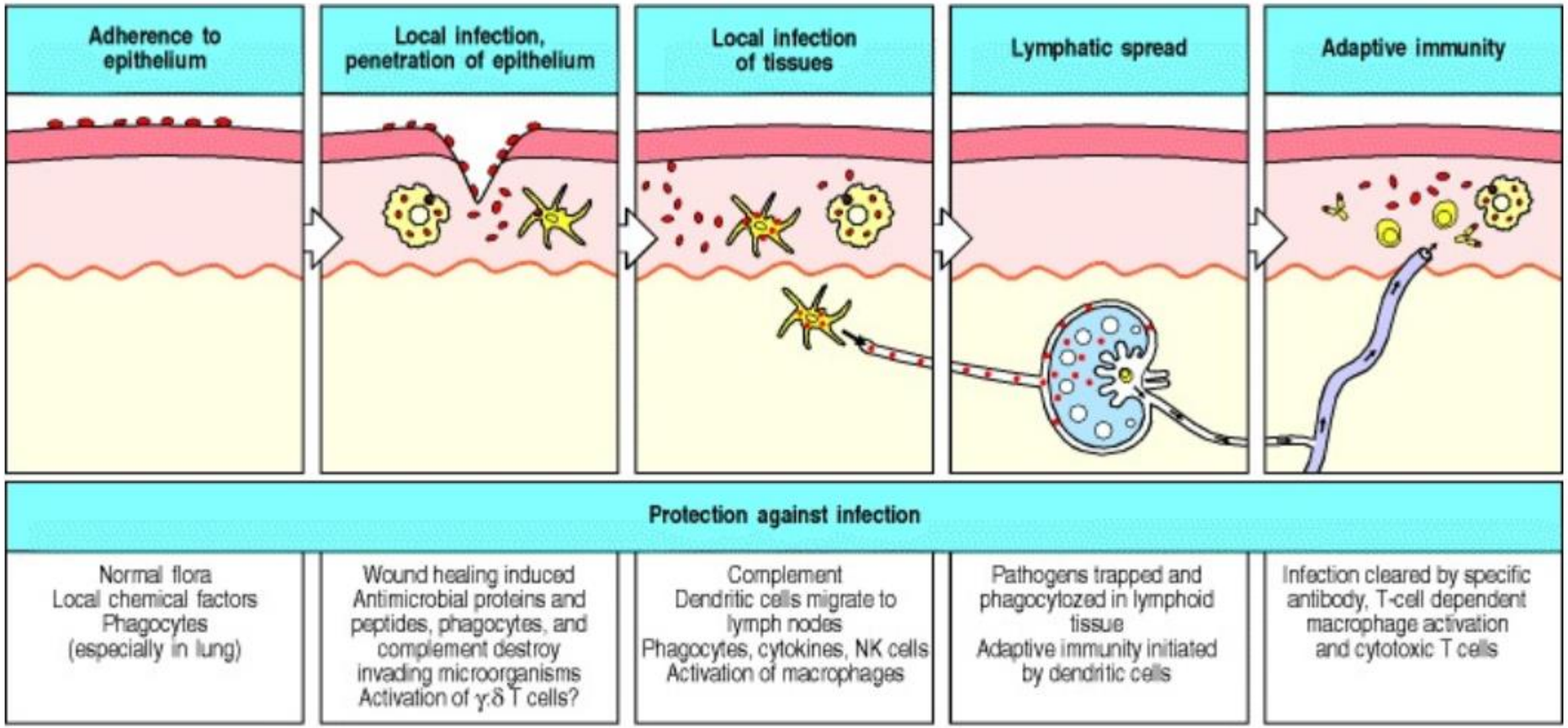
THE RESPONSES TO INFECTIONS OF EPITHELIUM



Immunobiology: The Immune System in Health and Disease. *5th edition.Janeway CA Jr, Travers P, Walport M, et al.*
New York: Garland Science; 2001.

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HOW TO GET THE SPECIFIC IMMUNITY?

POSSIBILITIES OF IMMUNIZATION		
IMMUNIZATION	NATURALLY ACQUIRED	ARTIFICIALLY ACQUIRED
ACTIVE	AFTER INFECTION	AFTER VACCINATION
PASSIVE	TRANSPLACENTAL TRANSFER OF IG	IG PREPARATIONS TRANSFER

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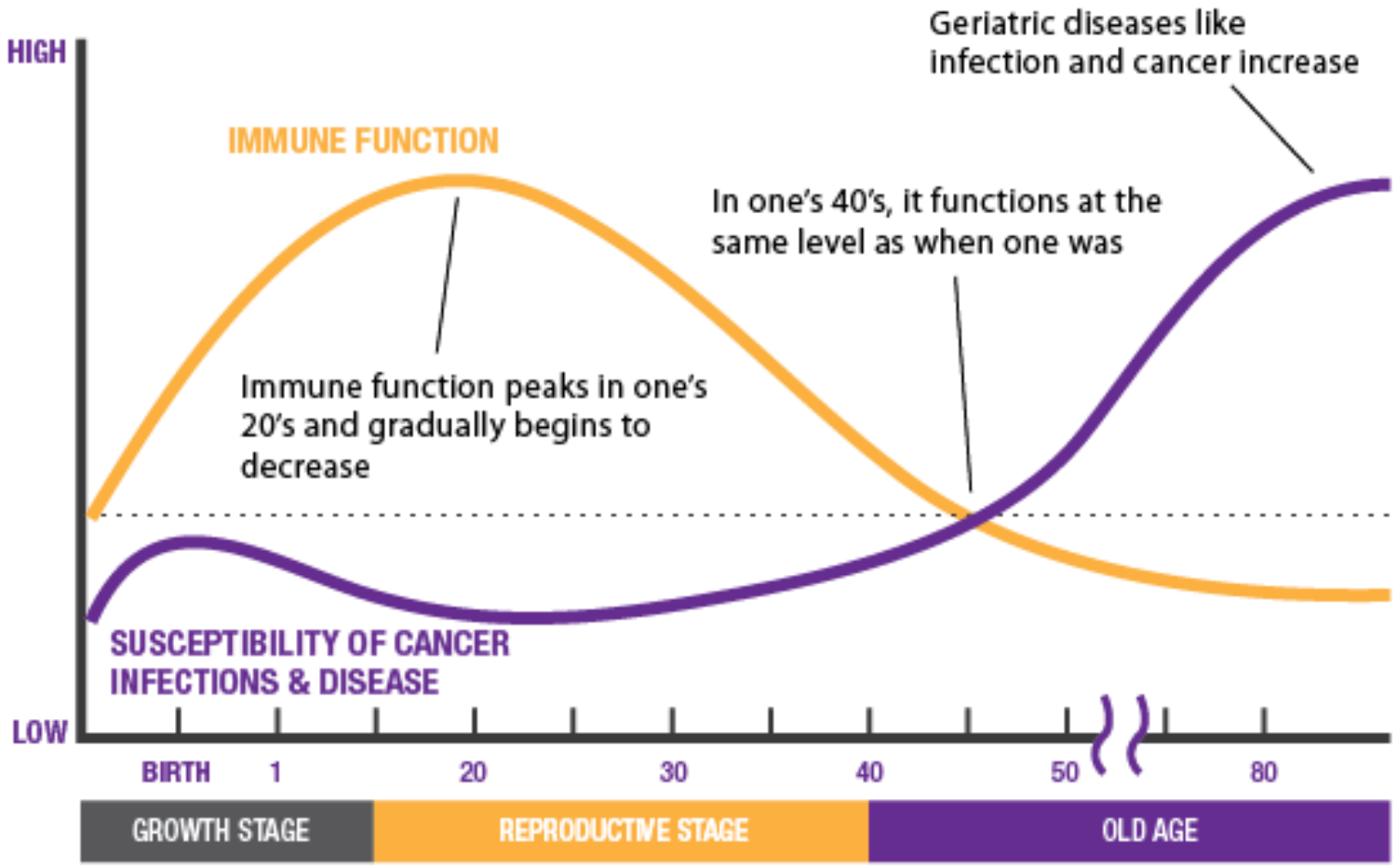
IMMUNE SYSTEM AND AGE



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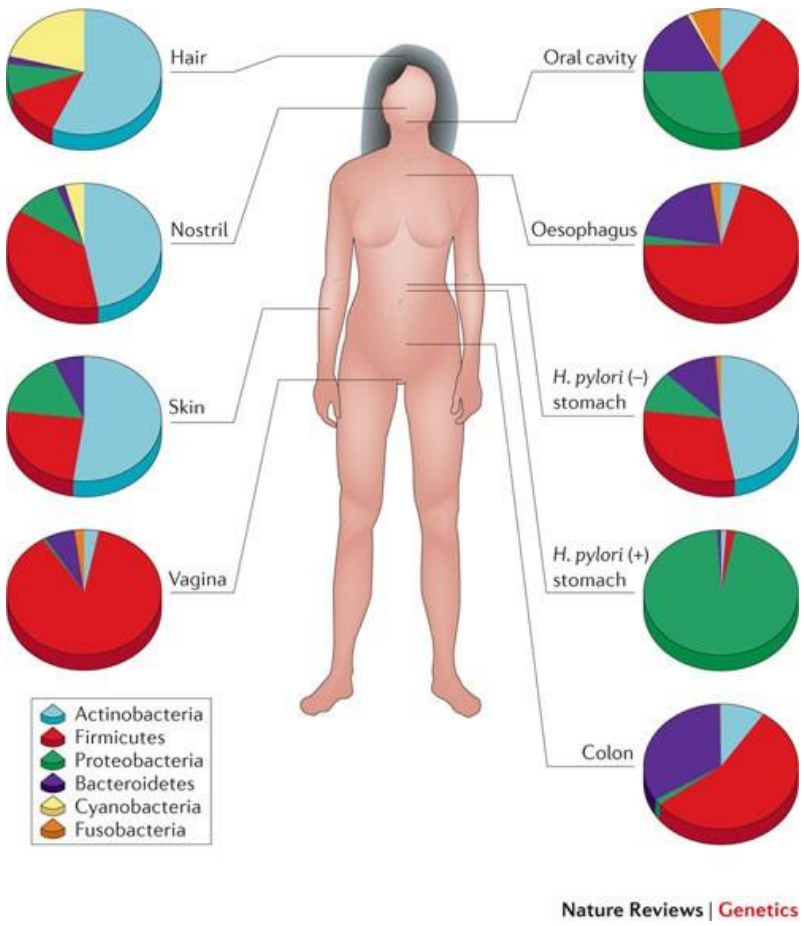
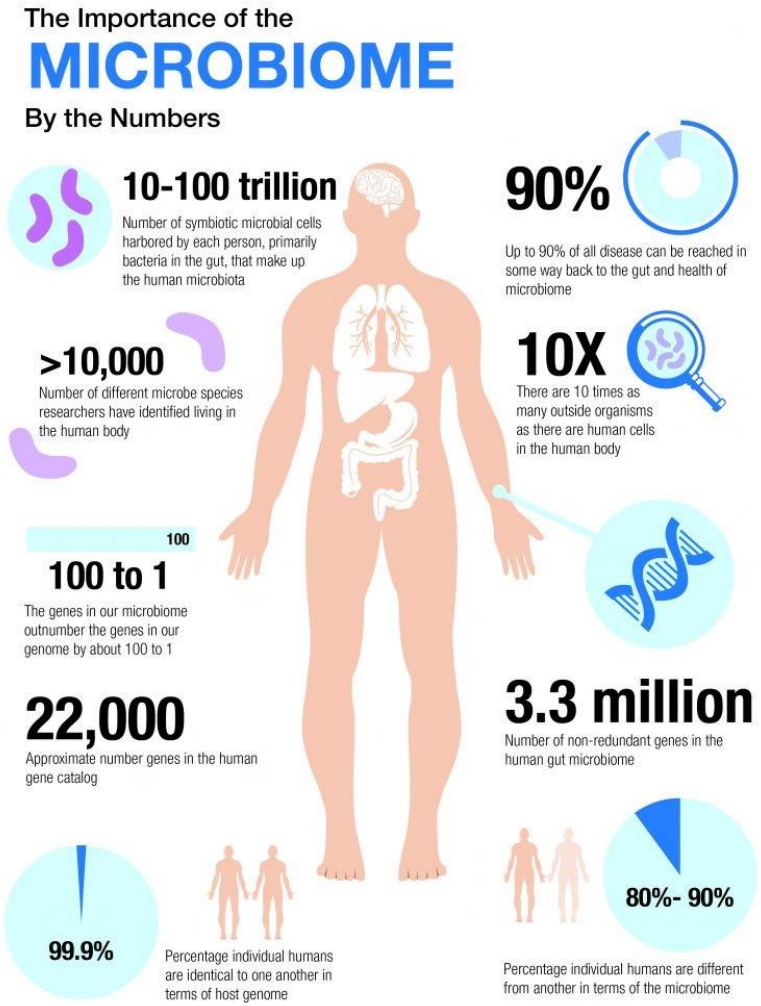
ROLE OF MICROBIOM!





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5. CHARACTERISTICS OF INFECTIOUS DISEASE

INFECTIOUS DISEASES
DEFINITIONS

- INFECTION - the invasion and multiplication of microorganisms that are not normally present within the body.
- INFECTIOUS DISEASE – disease caused by pathogen, contagious or not.
- COMMUNICABLE DISEASE – i.d. contagious, or capable to being transmitted (Tuberculosis, Influenza, Polio,..)
- NONCOMMUNICABLE DISEASE - unable to being trasmitted from the host to susceptible person (mostly zoonosis, sapronosisi - Tetanus, Anthrax, Legionellosis,..)

INFECTIOUS DOSE

- the number of cells (particles) required to cause disease of the host
- Typical for most of the pathogens, e.g.:
  - Enterohemorrhagic E. coli: 10 bacteria cells
  - Hepatitis A: 10-100 virus particles
  - Rotavirus (severe diarrhea, can be fatal): 10-100 virus particles
  - *Mycobacterium tuberculosis*. 10-100 cells
  - Salmonella: varies by strain, 100-1 billion bacteria cells
  - *Vibrio cholerae* (Cholera): 1000-100,000,000 bacteria cells

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NATURAL COURSE OF COMMUNICABLE DISEASES

DISEASE COURSE IN TIME

– ACUTE – relatively severe disorder with sudden onset and short duration of sympoms

– CHRONIC – less severe but continous duration, lasting over long time periods if not a lifetime

STAGES OF ACUTE COURSE

1. INCUBATION PERIOD
2. PRODROMAL PERIOD
3. CLINICAL DISEASE PERIOD
4. CONVALESCENT (RECOVERY) PERIOD X Disability or Death

INCUBATION PERIOD

- The time between exposure to an infectious agent and the onset of symptoms or signs of infections
- The time required for multiplication of the agent to a treshold neccesary to produce symptoms or laboratory evidence of infection
- Typical for each infectious disease (e.g. Hep.A – 15-60 days)

PRODROMAL PERIOD

- The period in which signs of a disease first appear
- Mostly non-specific symptoms - headache, weakness, upset stomach, higher temperature, …
- High risk of disease transmission!

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INFECTIOUS PERIOD

- the time interval during which a host is infectious, i.e. capable of directly or indirectly transmitting pathogenic infectious agents or pathogens to another susceptible host.
- can start before, during or after the onset of symptoms, and it may stop before or after the symptoms stop showing.
- The degree of infectiousness is not constant but varies through the infectious period.
- Typical for some diseases (Hep. A - 14 days before and 7 days after onset of symptoms)

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6. CLASSIFICATION OF INFECTIOUS DISEASES

ACCORDING THE RECERVOIR/SOURCE

1. ANTHROPONOSIS – e.g. measles, typhoid, HIV, hep.B,…
2. ZOONOSIS – e.g. rabies, salmonellosis, …)
3. SAPRONOSIS – e.g. tetanus, legionellosis

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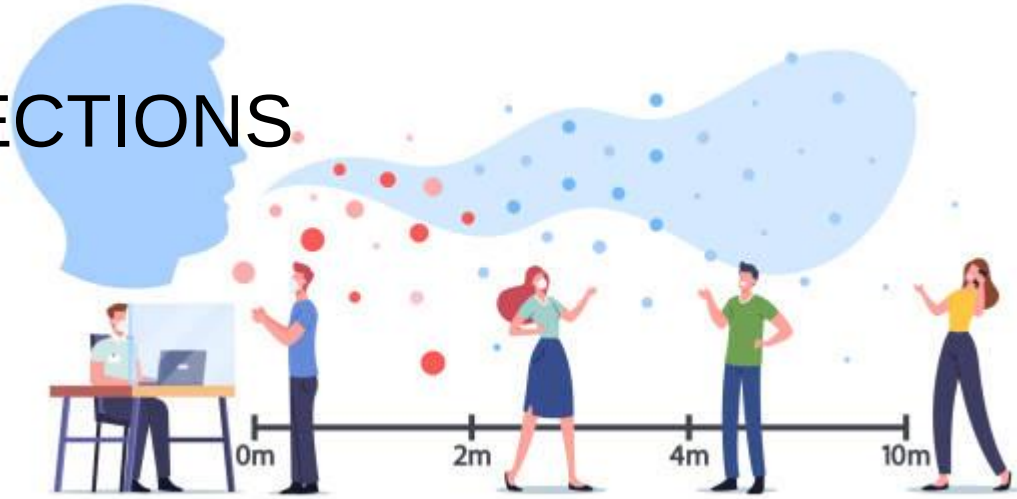
ACCORDING THE MEANS OF TRANSMISSION

- AIRBORNE INFECTIONS
- FOOD- OR WATER-BORNE INFECTIONS
- VECTOR-BORNE INFECTIONS
- BLOOD-BORNE INFECTIONS
- CONTACT INFECTIONS



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ACCORDING TO THE PORTAL OF ENTRY

1. RESPIRATORY INFECTIONS
2. ALIMENTARY INFECTIONS
3. INOCULATED INFECTIONS (directly to the tissues or blood)
4. SKIN TO SKIN OR MUCOUSE INFECTIONS

ACCORDING TO THE CAUSATIVE AGENTS

- BACTERIAL - Gram neg. or Gram pos.
- VIRAL – DNA or RNA viruses, enveloped or nonenveloped
- FUNGAL – dissesminated or localized
- PARASITIC – Protozoa, Helminths, Trematodes, Cestodes
- PRION

ACCORDING TO THE PRESENCE OF CLINICAL SIGNS

1. Manifest (symptomatic) - with symptoms
2. Inaparent (asymptomatic) - without symptoms, demonstrable only by laboratory tests

SPECIFIC TERMS

- RELAPSE - a new outbreak of the disease at the stage of symptom remission (endogenous infection).
- REINFECTION - the recurrence of infection with the same microorganism that caused the original disease but originating from a different source (exogenous infection).
- SUPERINFECTION - an infection that "seeds" onto an existing infectious disease caused by another agent.
- CO-INFECTION - the simultaneous infection with two different agents (e.g. VHD and VHB, influenza virus and SARS-CoV-2).

THANK YOU FOR YOUR ATTENTION

MUNI MED