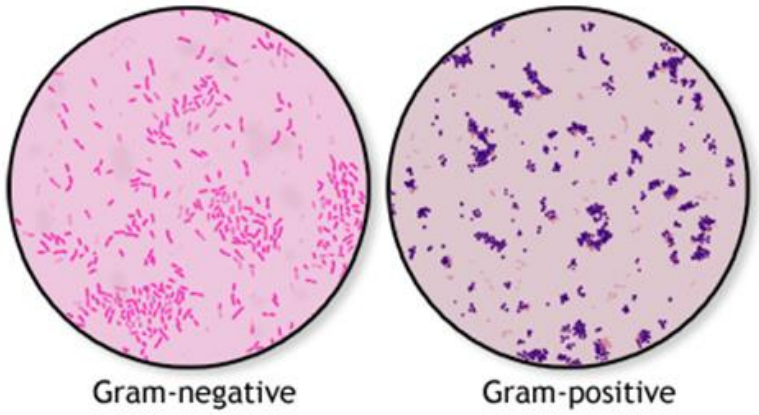
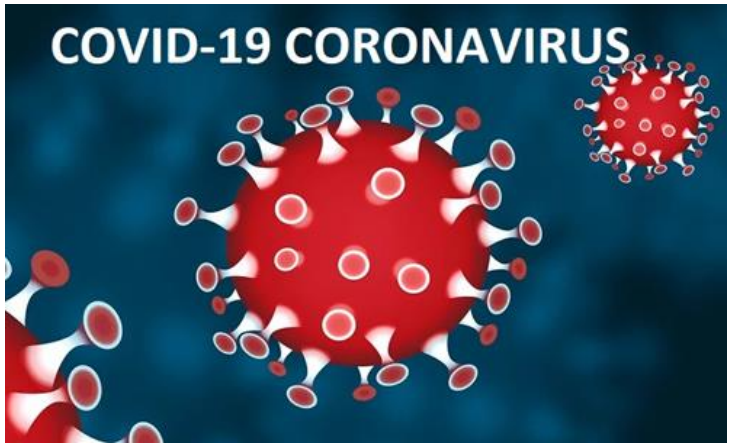
Ashur University
College of Medicine
Grade 3
Infectious Disease
Lect. 1

Introduction to infectious diseases

Ass. Professor Internal Medicine
Dr.Qasim Razzaq Radhi
21/9/2025
Reference : Davidson's principle and practice of Medicine
24th Edition





Infectious diseases – Definitions

- **Disease** – a pathological condition of body parts or tissues characterized by an identifiable group of signs and symptoms.
- **Infectious disease** – disease caused by an infectious agents such as bacterium, virus,protozoan, or fungus that can be passed to others.
- **Infection** – occurs when an infectious agent enters the body and begins to reproduce , may or may not lead to disease.
- **Pathogen** – an infectious agent that cause s disease.
- **Host** – an organism infected by another organism.
- **Virulence** – the relative ability of an agent to cause rapid and severe disease in a host.

Classification of Infectious Disease

By duration:

Acute – develops and runs its course quickly. Typically lasting days to weeks and often leading to a complete cure, such as **Flu and Common cold**.

Chronic – develops slowly, lasts for a long time (months to years), and often requires ongoing management rather than a complete cure, such as **Hepatitis B , Tuberculosis and HIV**.

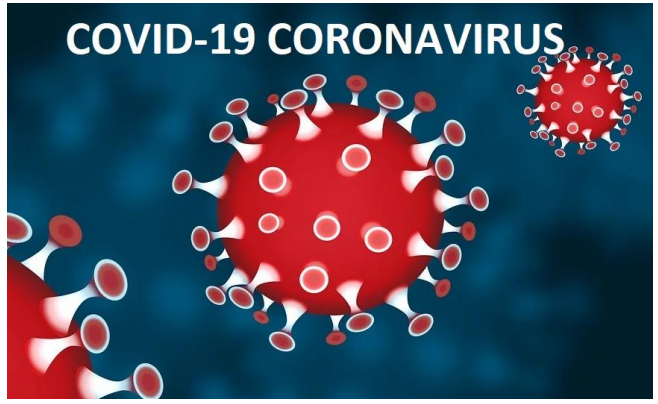
Latent – characterized by peroids of no symptoms between outbreaks of illness. Examples: **Herpes Simplex Virus (HSV) and Tuberculosis (TB).**

By location:

Local : A local infection affects a single area of the body, such as a **boil or ear infection**

Systemic : spreads throughout the entire body, potentially leading to severe complications like **sepsis and septic shock**.

Classification of Infectious Disease



Communicable infection : An infection that is transmitted from one host to another, meaning the pathogen is "communicated" or spread from person to person.

Examples : **Influenza, COVID-19, and Measles**.

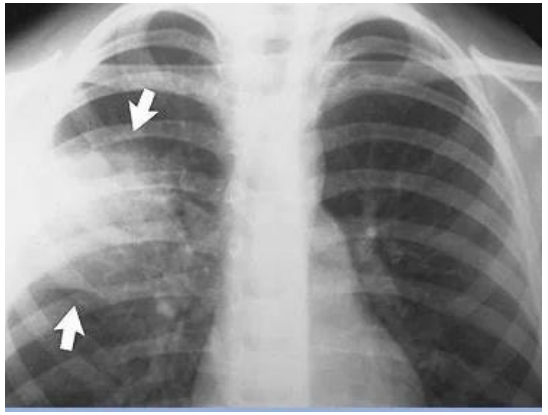
Endogenous infection: is an infection caused by microorganisms, such as bacteria, that are already present in the host's body (part of their normal microflora) and cause disease when defenses are weakened .

Example :

A **surgical site infection** → caused by the patient’sown skin bacteria.



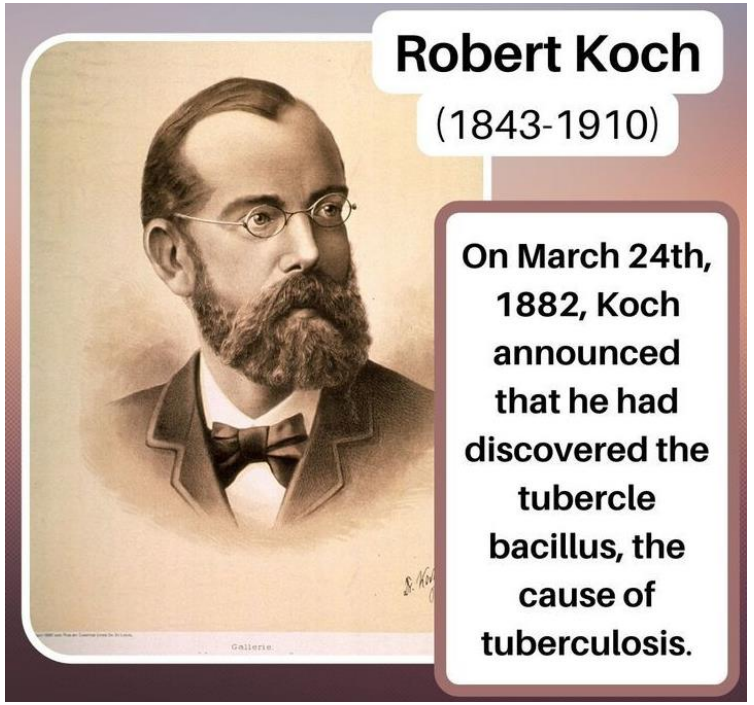
Pneumonia after aspiration of oral secretions. →



Agents causing infection

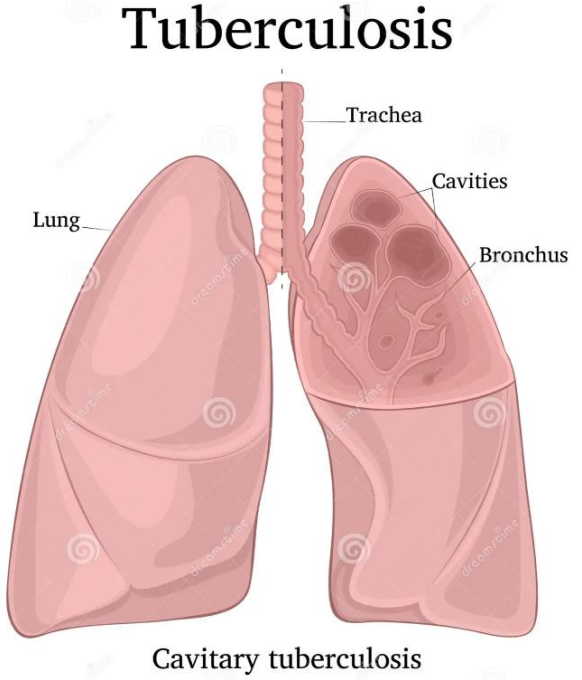
- The concept of an infectious agent was established by **Robert Koch** in the 19th century (Box 6.1). Although fulfillment of **'Koch's postulates'** became the standard for confirming the cause of an infection, many infectious agents do not fulfill Koch's postulates.



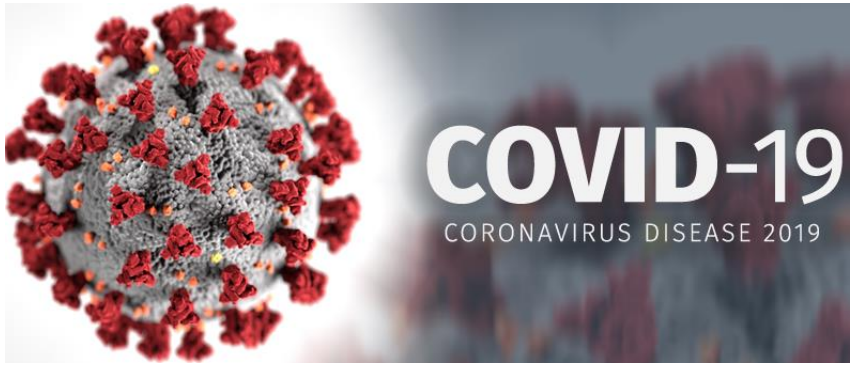


6.1 Definition of an infectious agent – Koch's postulates

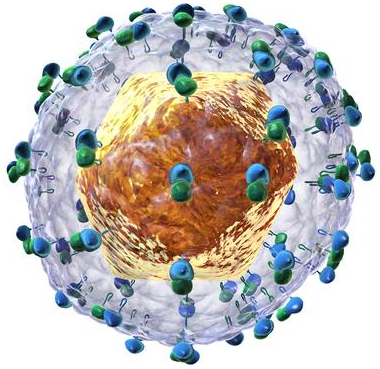
1. The same organism must be present in every case of the disease.
2. The organism must be isolated from the diseased host and grown in pure culture.
3. The isolate must cause the disease, when inoculated into a healthy, susceptible animal.
4. The organism must be re-isolated from the inoculated, diseased animal.



Viruses



- **Viruses** are incapable of independent replication. Instead, they subvert (distort , destroy) host cellular processes to ensure synthesis of their nucleic acids and proteins.
- **Viruses' genetic material (the genome)** consists of single- or double-stranded DNA or RNA.

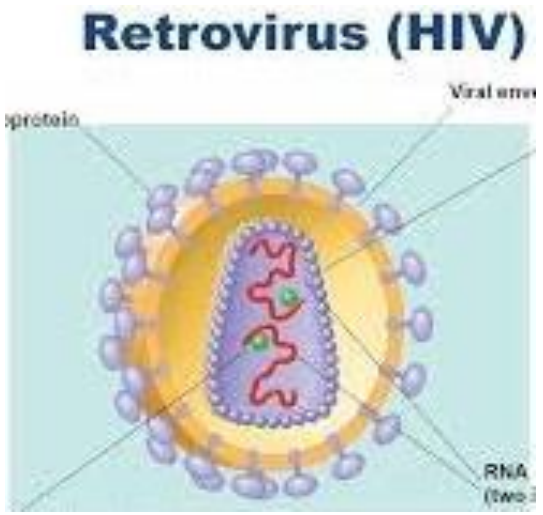


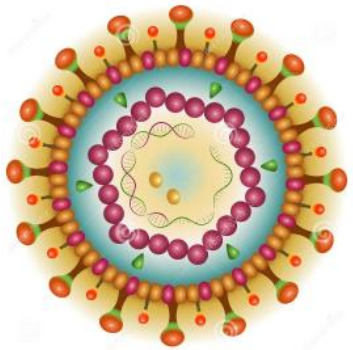
Hepatis C Virus (HCV)

Example: **HCV→RNA virus**, **HBV→DNA virus**

- **Retroviruses transcribe their RNA into DNA in the host cell by reverse transcription.**

Example : **HIV virus.**

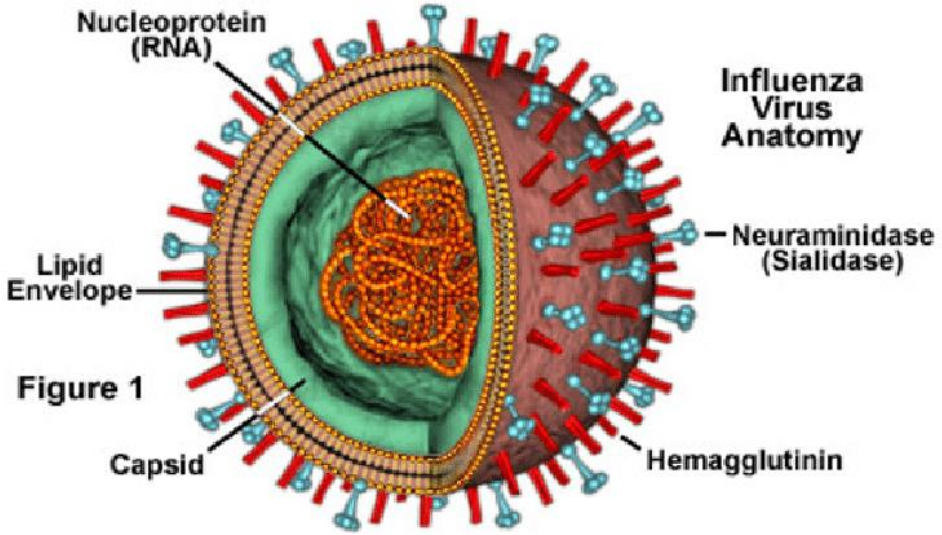


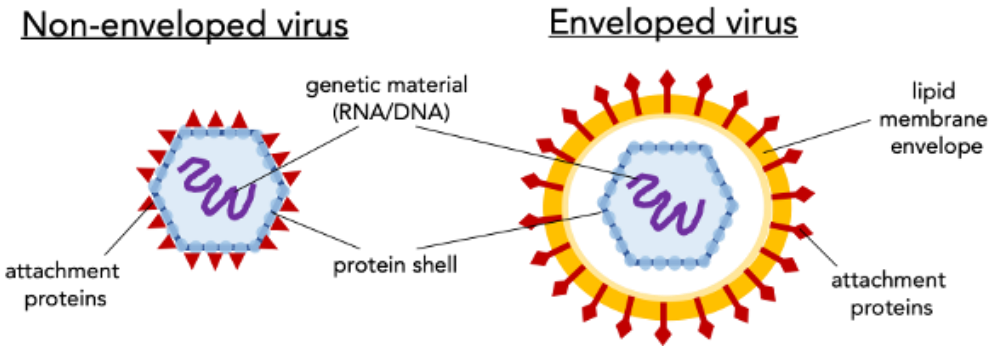


Hepatitis B Virus

Viruses ..cont.

- **An antigenically unique protein coat (Capsid)** encloses the **genome**, and together these form the **nucleocapsid**.
- **In many viruses, the nucleocapsid is packaged within a lipid envelope.**
- **Enveloped viruses** are **less able to survive** in the environment and are spread by respiratory, sexual or blood-borne routes including arthropod-based transmission.
- **Non-enveloped viruses survive better** in the environment and are predominantly transmitted by faecal–oral or, less often, respiratory routes.
- **A generic virus life cycle** is shown in Figure 6.2. A virus that infects a bacterium is a bacteriophage (phage).





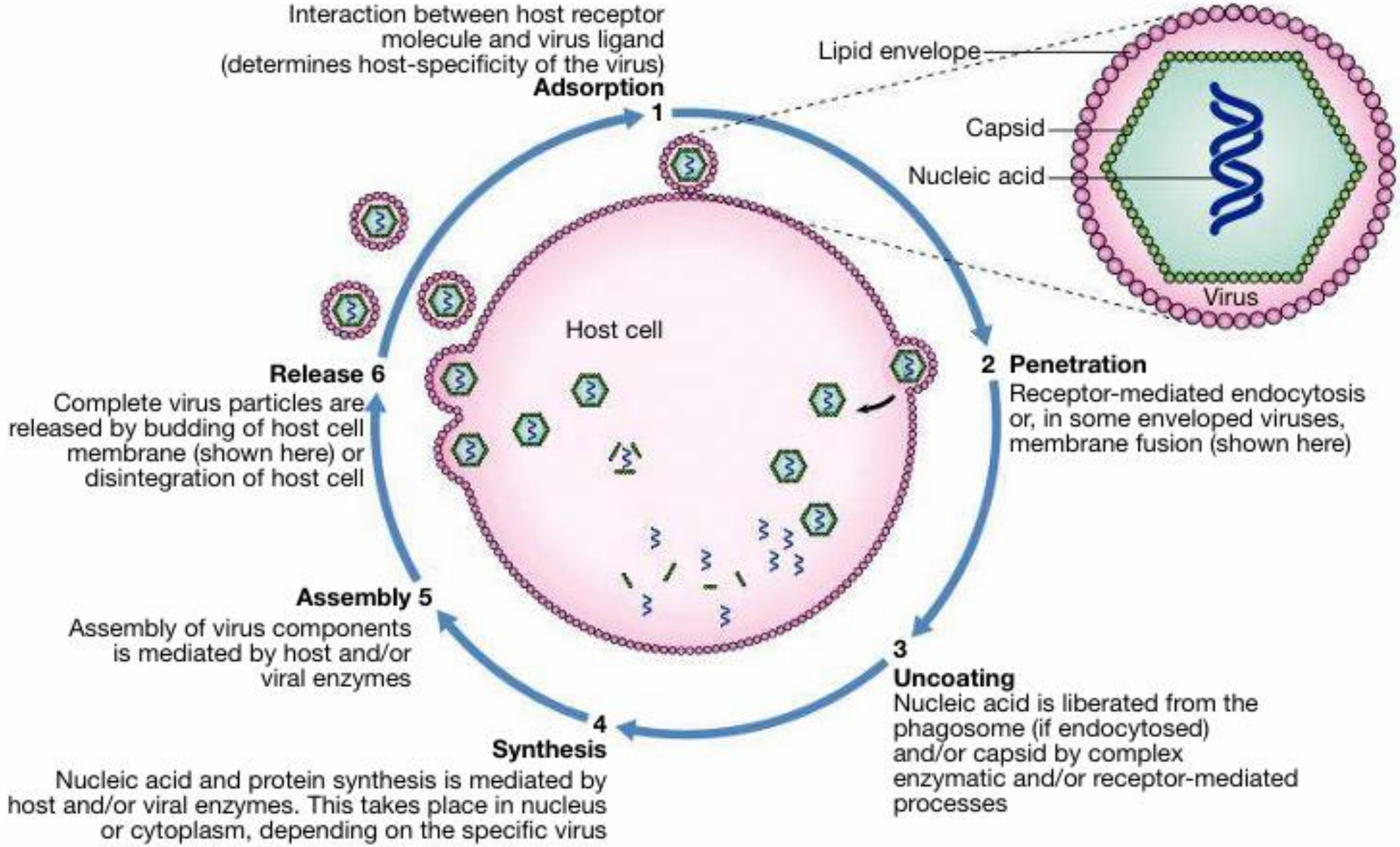
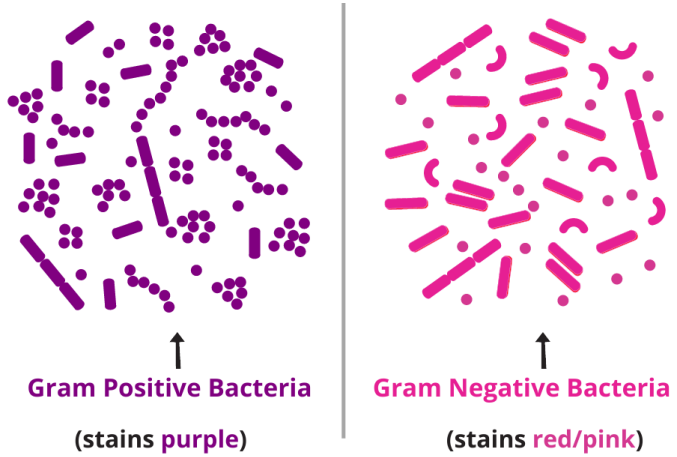


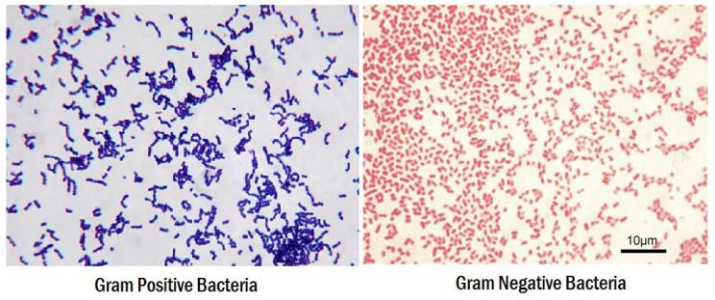
Fig. 6.2 A generic virus life cycle. Life cycle components common to most viruses are host cell attachment and penetration, virus uncoating, nucleic acid and protein synthesis, virus assembly and release. Virus release is achieved either by budding, as illustrated, or by lysis of the cell membrane. Life cycles vary between viruses.

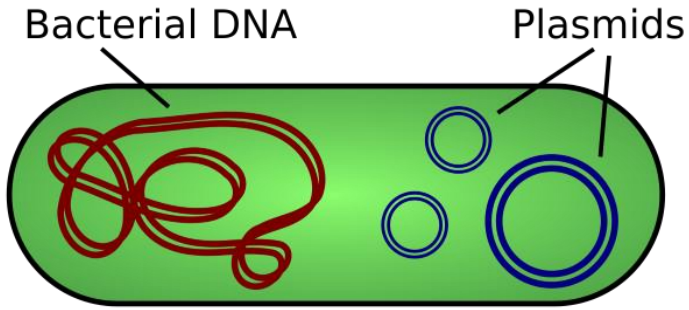
Prokaryotes: bacteria (including mycobacteria and actinomycetes)

- Prokaryotic cells can synthesise their own proteins and nucleic acids, and are able to reproduce autonomously, although they lack a nucleus.
- **The bacterial cell membrane** is bounded by a peptidoglycan cell wall, which **is thick (20–80 nm) in Gram-positive** organisms and **thin (5–10 nm) in Gram negative** ones.
- The **Gram-negative cell wall** is surrounded by an outer membrane containing lipopolysaccharide.
- **Genetic information** is contained within a chromosome but **bacteria may also contain rings of extra-chromosomal DNA, known as plasmids**.



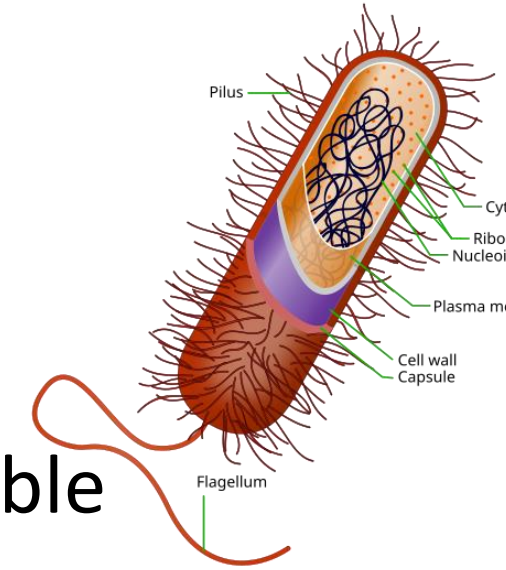
Gram Staining





Prokaryotes: bacteria

- **Bacteria** may be embedded in a polysaccharide capsule, and motile bacteria are equipped with **flagella**.





- Although many prokaryotes are capable of independent existence,

some (e.g. **Chlamydia trachomatis, Coxiella burnetii) are obligate intracellular organisms.**

- **Bacteria that can grow in artificial culture media** are classified and identified using a range of characteristics (Box 6.2).



Prokaryotes: bacteria

6.2 How bacteria are identified

Gram stain reaction (see Fig. 6.3)

- Gram-positive (thick peptidoglycan layer), Gram-negative (thin peptidoglycan) or unstainable

Microscopic morphology

- Cocci (round cells) or bacilli (elongated cells)
- Presence or absence of capsule

Cell association

- Association in clusters, chains or pairs

Colonial characteristics

- Colony size, shape or colour
- Effect on culture media (e.g. β-haemolysis of blood agar in haemolytic streptococci; see Fig. 6.4)

Atmospheric requirements

- Strictly aerobic (requires O_2), strictly anaerobic (requires absence of O_2), facultatively aerobic (grows with or without O_2) or micro-aerophilic (requires reduced O_2)

Biochemical reactions

- Expression of enzymes (oxidase, catalase, coagulase)
- Ability to ferment or hydrolyse various biochemical substrates

Motility

- Motile or non-motile

Antibiotic susceptibility

- Identifies organisms with invariable susceptibility (e.g. to optochin in *Streptococcus pneumoniae* or metronidazole in obligate anaerobes)

Matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry (MALDI-TOF-MS)

- A rapid technique that identifies bacteria and some fungi from their specific molecular composition

Sequencing bacterial 16S ribosomal RNA gene

- A highly specific test for identification of organisms in pure culture and in samples from normally sterile sites

Whole-genome sequencing

- Although not yet in routine use, whole-genome sequencing (WGS) offers the potential to provide rapid and simultaneous identification, sensitivity testing and typing of organisms from pure culture and/or directly from clinical samples. As such, WGS is likely to replace many of the technologies described above over the next few years

Prokaryotes: bacteria



Gram stain

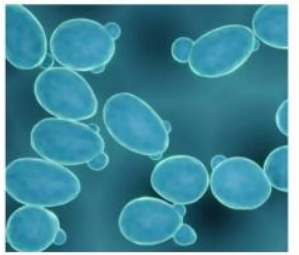
Gram-positive cocci	Gram-positive bacilli	Gram-negative cocci	Gram-negative bacilli
Colony morphology (e.g. haemolysis), Gram stain appearance, agglutination reactions, coagulase test, catalase	Colony morphology, growth characteristics (e.g. growth in anaerobic atmosphere), Gram stain appearance, MALDI-TOF-MS identification	Colony morphology, growth characteristics, oxidase reaction, sugar fermentation/MALDI-TOF-MS identification	Colony morphology, growth characteristics, lactose fermentation, oxidase reaction, MALDI-TOF-MS identification
Gram-positive cocci–clusters **Examples** *Staphylococcus aureus* Coagulase-negative staphylococci **or** Gram-positive cocci–chains **Examples** Oral streptococci *Streptococcus pneumoniae* (often pairs) β-haemolytic streptococci Enterococci (short chains)	**Examples** Actinomycetes *Arcanobacterium haemolyticum* *Bacillus* spp. *Corynebacterium diphtheriae* *Lactobacillus* spp. *Listeria monocytogenes* *Nocardia* spp. *Clostridium* spp.	**Examples** *Neisseria meningitidis* *Neisseria gonorrhoeae* *Moraxella catarrhalis*	**Examples** *Escherichia coli* *Klebsiella pneumoniae* *Proteus* spp. *Enterobacter* spp. *Serratia* spp. *Salmonella* spp. *Shigella* spp. *Yersinia* spp. *Vibrio* spp. *Pseudomonas aeruginosa*

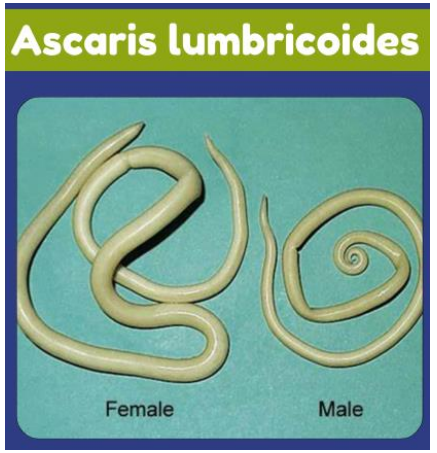
Fig. 6.3 Flow chart for bacterial identification, including Gram film appearances on light microscopy (×100). (MALDI-TOF-MS = matrix-assisted laser desorption/ionisation time-of-flight mass spectroscopy).

Eukaryotes: Fungi, Protozoa and Helminths

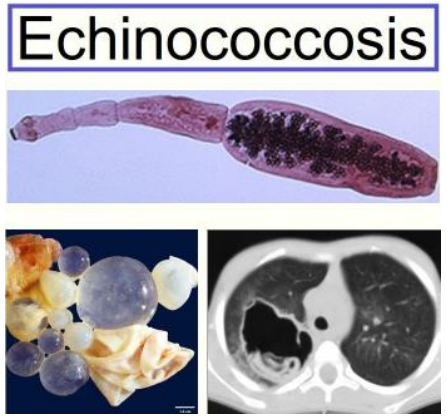
- **Eukaryotic cell**s contain membrane-bound organelles, including nuclei, mitochondria and Golgi apparatus.
- **Pathogenic eukaryotes are unicellular** (e.g. **yeasts, protozoa**) or **complex multicellular organisms** (e.g. **nematodes(Roundworms), trematodes(flukes) and cestodes (tapeworms)**).
- Fungi exist as either moulds (filamentous fungi) or yeasts. Dimorphic fungi exist in either form, depending on environmental conditions (see Fig. 13.62).

The fungal plasma membrane differs from the human cell membrane in that it contains the sterol, ergosterol. Fungi have a cell wall made up of polysaccharides, chitin and mannoproteins.


YEASTS

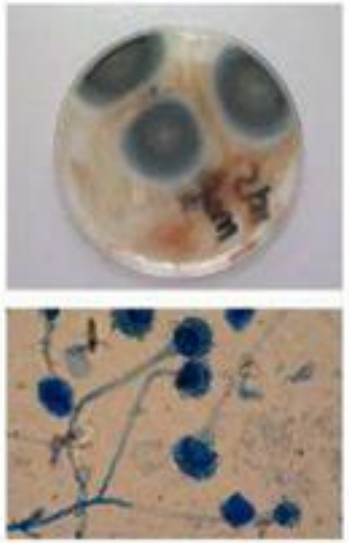






Eukaryotes: Fungi

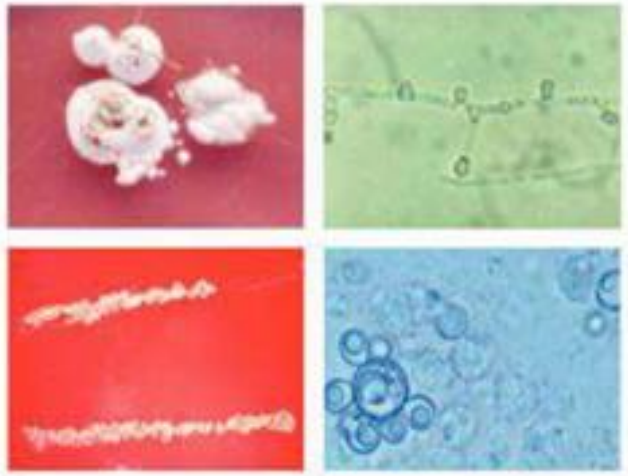
Filamentous fungi (moulds)



Characterised by the production of elongated, cylindrical, often septate cells (hyphae) and conidia (spores)

Examples:
- *Aspergillus* spp. (*A. fumigatus* shown here)
- *Fusarium* spp.
- Dermatophyte fungi (*Tricophyton* spp., *Microsporum* spp. etc.)
- Mucorales

Dimorphic fungi



Exist in filamentous (top) or yeast (bottom) form, depending on environmental conditions

Examples:
- *Histoplasma capsulatum*, *Coccidioides immitis*, *Paracoccidioides brasiliensis* (shown here), *Blastomyces dermatidis*
- *Sporothrix schenkii*
- *Talaromyces marneffei*
- *Malassezia* spp.

Yeasts



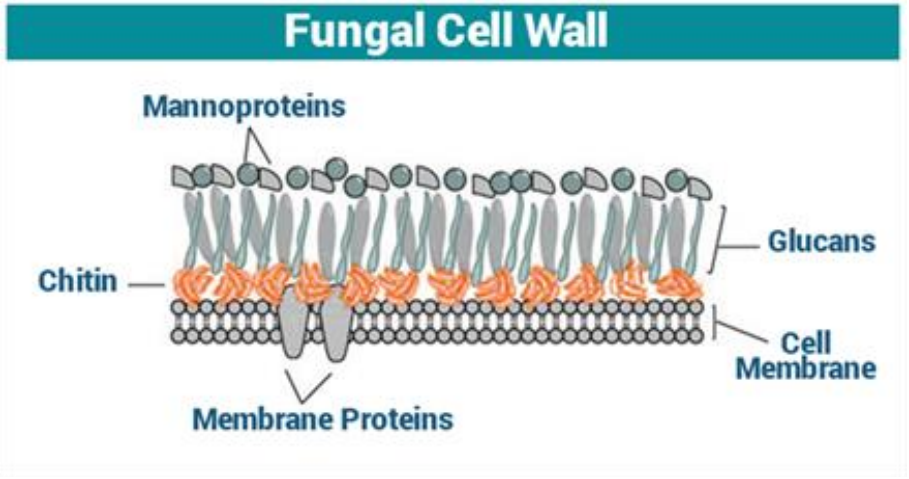
Characterised by the production of oval or round cells, which reproduce by binary fission (budding)

Examples:
- *Candida* spp.*
- *Cryptococcus* spp. (*C. neoformans* shown here)

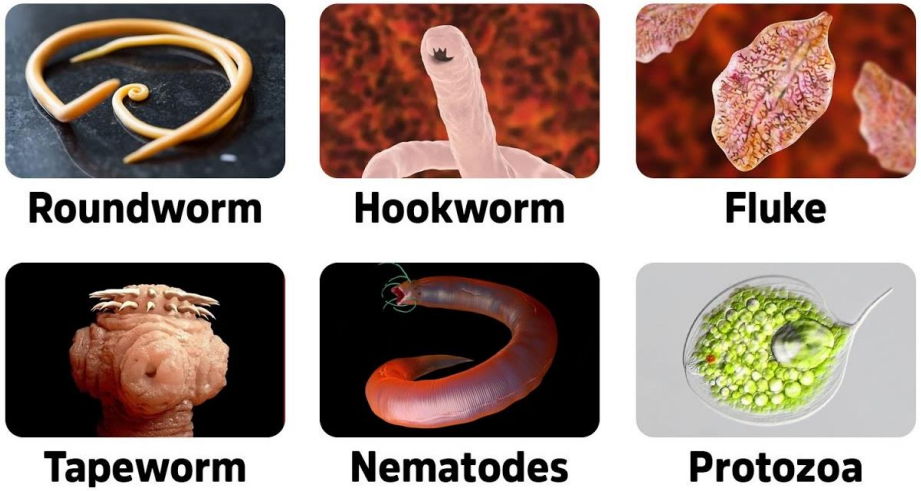
Fig. 13.62 Classification of medically important fungi. Fungal classification is based on simple morphological characteristics. *Pneumocystis jirovecii* is morphologically distinct from other fungi and does not fit into this classification. *Although *Candida albicans* exists in a number of forms, including filamentous (hyphae and pseudohyphae), it is generally encountered in its yeast form so is classified in this category. *Insets (dimorphic fungi) Courtesy of Beatriz Gomez and Angela Restrepo, CIB, Medellín, Colombia.*

Eukaryotes: fungi, protozoa and helminths

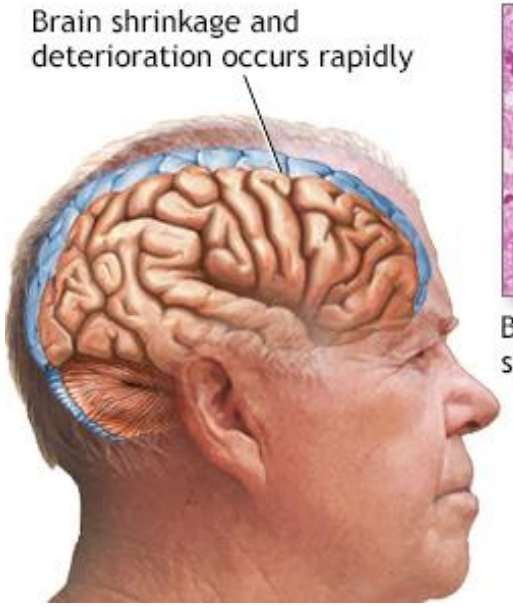
- **In most fungi, the main structural component of the cell wall is β-1,3 D-glucan, a polysaccharide**. These differences from mammalian cells are important because they offer useful therapeutic targets.

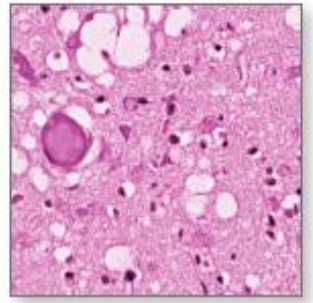


- **Protozoa and helminthes are often referred to as parasites**. Many parasites have complex multistage life cycles, which involve animal and/or plant hosts in addition to humans.



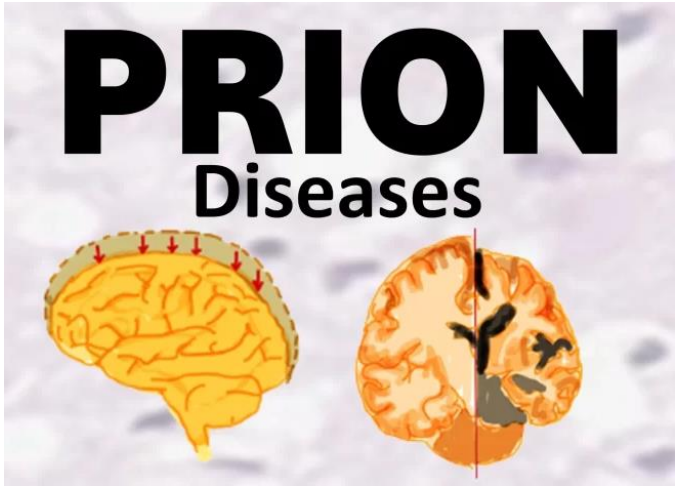
Prions





Brain section showing spongiform pathology characteristic of Creutzfeldt-Jakob

- Although prions are transmissible and have some of the characteristics of infectious agents, they are not microorganisms.
- **Prion diseases are rare, fatal, neurodegenerative brain disorders caused by misfolded proteins called prions that accumulate in the brain**, damaging nerve cells and leading to a range of neurological symptoms.
- **These diseases, also known Transmissible Spongiform Encephalopathies (TSEs), also known as Prion Disease** ,
  can affect humans and animals.
- **Creutzfeldt-Jakob disease (CJD): A common and fatal prion disease in humans.**



Normal microbial flora

- The human body is colonised by large numbers of microorganisms (**collectively termed the Human Microbiota**).
- Colonising bacteria, also referred to as the **'Normal Bacterial Flora' ,** are able to survive and replicate on epithelial surfaces, e.g. skin and mucosal surfaces.
- **The gastrointestinal tract and the mouth are the two most heavily colonised sites in the body** and they have distinct microbiota, in both composition and function.
- Knowledge of non-sterile body sites and their normal bacterial flora is required to inform microbiological sampling strategies and interpret culture results.

Host–pathogen interactions

- A ‘pathogen’ is a microorganism that can cause infection.
- Virulence is determined by the number and type of disease – causing proteins and other factors that it can produce (‘virulence factors’).
- Primary pathogens cause disease in a proportion of individuals to whom they are exposed, regardless of the host’s immunological status.
- Opportunistic pathogens cause disease only in individuals whose host defences are compromised, e.g. by an intravascular catheter, or when the immune system is compromised, by genetic susceptibility or immunosuppressive therapy.





Investigation of infection

The aims of investigating a patient with suspected infection are:

- To confirm the presence of infection
- To identify the specific pathogen (s)
- To identify its susceptibility to specific antimicrobial agents in order to optimize therapy.

Investigation of infection

6.4 Tests used to diagnose infection

Non-specific markers of inflammation/infection

- e.g. White cell count in blood sample (WCC), plasma C-reactive protein (CRP), procalcitonin (PCT)*, serum lactate, cell counts in urine or cerebrospinal fluid (CSF), CSF protein and glucose

Direct detection of organisms or organism components

- Microscopy
- Detection of organism components (e.g. antigen, toxin)
- Nucleic acid amplification tests (e.g. polymerase chain reaction)

Culture of organisms

- ± Antimicrobial susceptibility testing

Tests of the host's specific immune response

- Antibody detection
- Interferon-gamma release assays (IGRA)

*Although PCT is used increasingly in clinical practice, further evidence is required to establish its precise role in distinguishing bacterial infections from other causes of inflammation.

Direct detection of pathogens



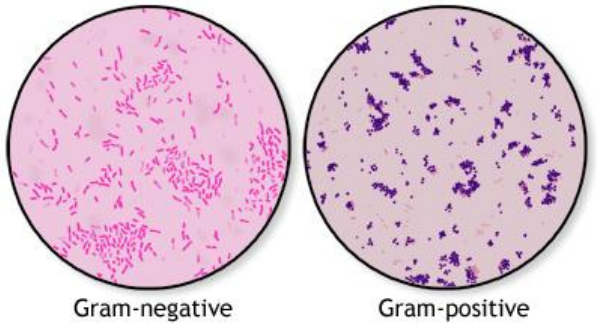
- Whole organisms are detected by examination of biological fluids or tissue using a microscope.
- **Bright Field microscopy:** → →

  uses stains to enhance the vision of organism.

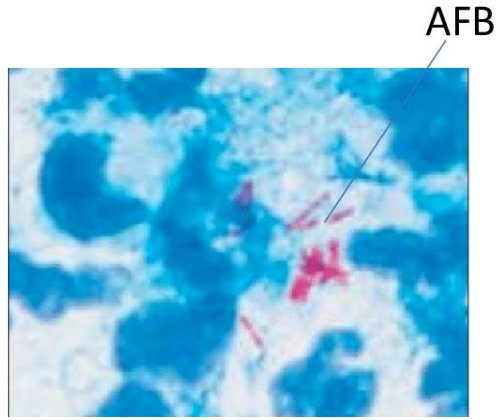
Examples include :

1-Gram staining of bacteria → →

2- Ziehl–Neelsen or auramine staining of **acid- and alcohol-fast bacilli (AAFB) in tuberculosis (T.B.). →**



In **histopathological examination** of tissue samples, stains are used to demonstrate the presence of microorganisms and features of disease pathology.

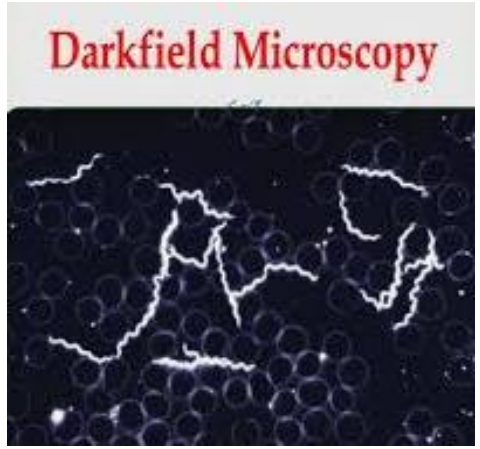


Direct detection of pathogens .. cont.



- **Dark field microscopy**: → →

  (in which light is scattered to make organisms appear bright on a dark background) is used, for **example,** to examine genital chancre fluid in **suspected syphilis**. → →



- **Flow cytometry** can be used to analyse liquid samples (e.g. urine) for the presence of particles based on properties such as size, impedance and light scatter. This technique can detect bacteria but may misidentify other particles as bacteria too



Detection of components of organisms

- Components of microorganisms detected for diagnostic purposes include **nucleic acids**, **cell wall molecules**, **toxins** and **other antigens**. Commonly used examples include

SARS-CoV-2 antigen in respiratory secretions, →

Legionella pneumophila serogroup 1 antigen in urine and →

Cryptococcal polysaccharide antigen in cerebrospinal fluid (CSF). →







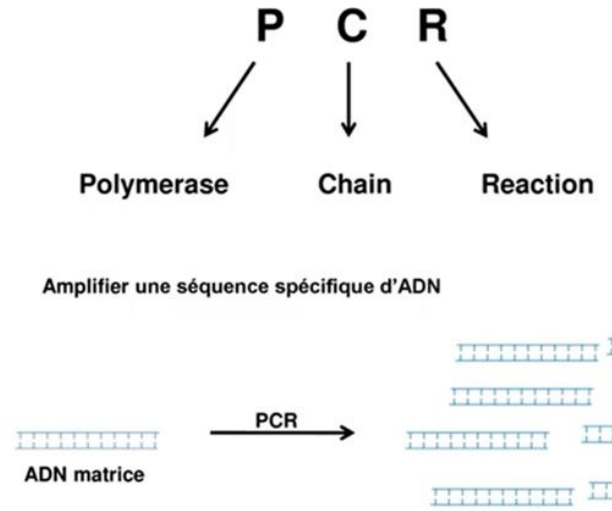
Detection of components of organisms .. cont.

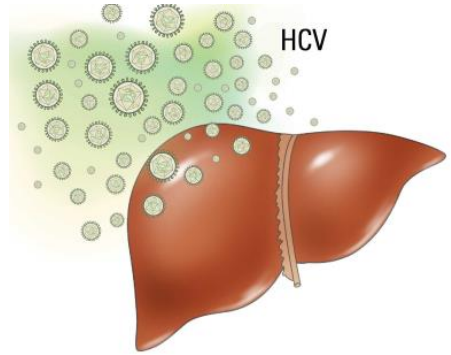
- **Nucleic acid amplification test (NAAT):** specific sequences of microbial DNA or RNA are identifed using a nucleic acid primer that is amplified.

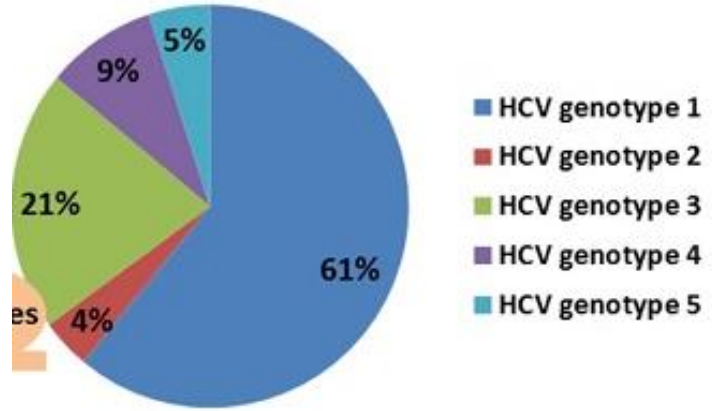
The most commonly used NAAT is **Polymerase Chain Reaction (PCR)**. →

Reverse transcription PCR (RT-PCR) is used to detect RNA from RNA viruses.

- **Determination of nucleotide sequences in a target gene(s)** can be used to assign microorganisms to specific strains, which may be relevant to treatment and/or prognosis (e.g. in **hepatitis C infection**). →







Detection of components of organisms

6.5 How to provide samples for microbiological sampling

Communicate with the laboratory

- Discuss samples that require processing urgently or that may contain hazardous or unusual pathogens with laboratory staff *before* collection
- Communication is key to optimising microbiological diagnosis. If there is doubt about any aspect of sampling, it is far better to discuss it with laboratory staff beforehand than to risk diagnostic delay by inappropriate sampling or sample handling

Take samples based on a clinical diagnosis

- Sampling in the absence of clinical evidence of infection is rarely appropriate (e.g. collecting urine, or sputum for culture)

Use the correct container

- Certain tests (e.g. nucleic acid and antigen detection tests) require proprietary sample collection equipment

Follow sample collection procedures

- Failure to follow sample collection instructions precisely can result in false-positive (e.g. contamination of blood culture samples) or false-negative (e.g. collection of insufficient blood for culture) results

Label sample and request form correctly

- Label sample containers and request forms according to local policies, with demographic identifiers, specimen type and time/date collected
- Include clinical details on request forms
- Identify samples carrying a high risk of infection (e.g. blood liable to contain a blood-borne virus) with a hazard label

Use appropriate packaging

- Close sample containers tightly and package securely (usually in sealed plastic bags)
- Attach request forms to samples but not in the same compartment (to avoid contamination, should leakage occur)

Manage storage and transport

- Transport samples to the microbiology laboratory quickly
- Consider pre-transport storage, conditions (e.g. refrigeration, incubation, storage at room temperature) vary with sample type
- Notify the receiving laboratory prior to arrival of unusual or urgent samples, to ensure timely processing

Detection of components of organisms

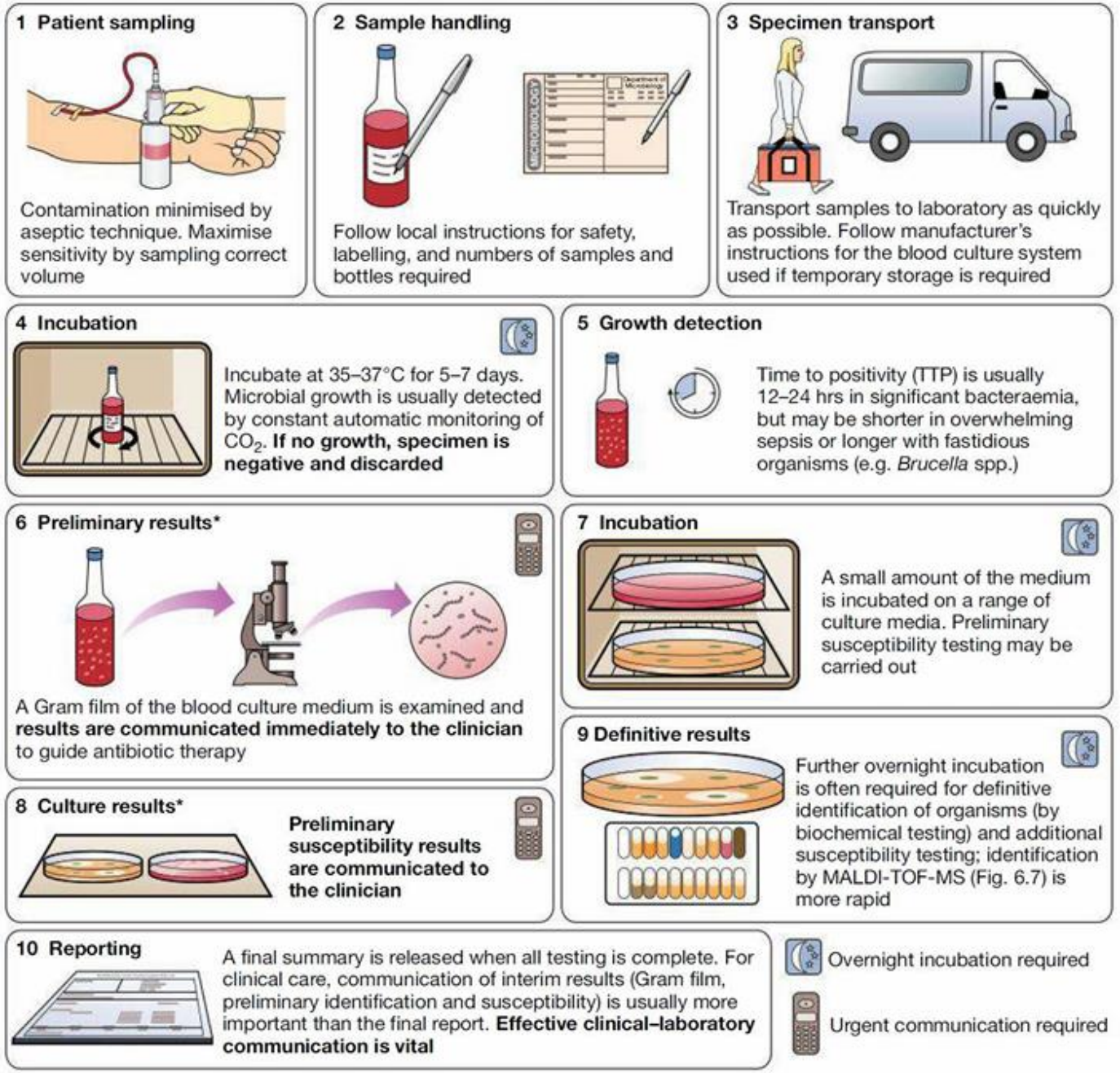


Fig. 6.6 An overview of the processing of blood cultures. *In laboratories equipped with MALDI-TOF-MS (see Fig. 6.7), rapid definitive organism identification may be achieved at stage 6 and/or stage 8.

Indirect detection of pathogens

- Antibody detection
- Enzyme-linked immunosorbent assay
- Immunoblot (Western blot)
- Immunofluorescence assays
- Complement fixation test (CFT)
- Agglutination tests
- Immunodiffusion
- Lateral flow immunochromatography
- Interferon-gamma release assays (IGRA)


Thank you!