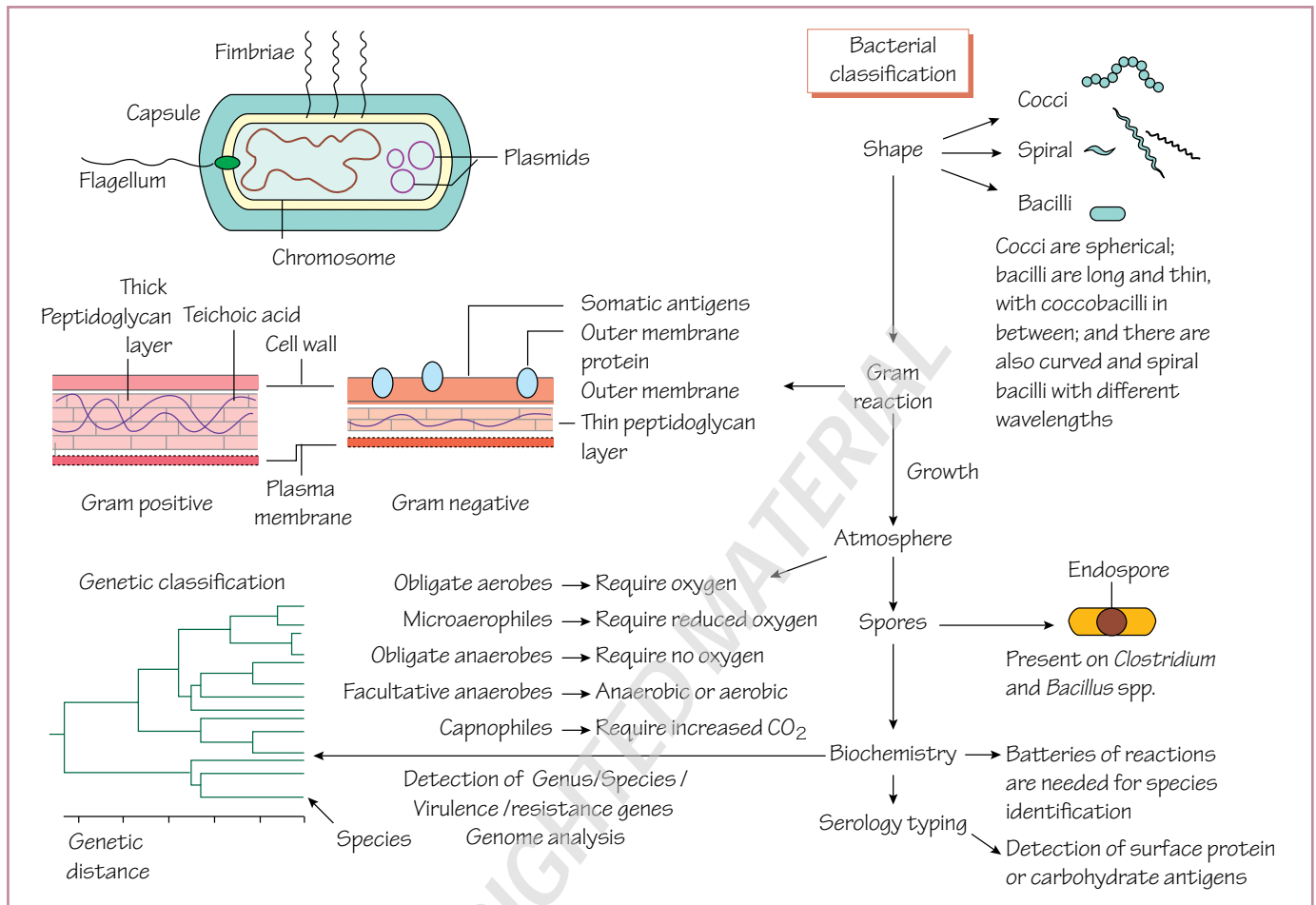


## 1

# Microbial pathogens, classification and concepts



Humans are at risk of infection by hundreds of different microorganisms: viruses, bacteria, protozoa and helminths. Understanding their biology helps us to diagnose them, classify them, to better predict their behaviour in our patients.

## Characteristics of bacteria

Describing the components of bacteria is important to help us understand how they cause disease and how we can inhibit them with antibiotics. Unlike eukaryotic cells the bacterial cell wall is rigid, to protect the organism from environmental stress. Some have a thick peptidoglycan layer and cell membrane that stains blue with Gram stain, and others have three layers: inner and outer

membranes, and a thinner peptidoglycan layer staining pink with Gram stain. Mycobacterial cells have a high proportion of lipid, including immunoreactive antigens and there are bacteria whose cell wall forms a spiral shape. Some require specialist stains.

## Bacterial structural components

- **Capsule:** a polysaccharide layer that protects the cell from phagocytosis and desiccation.
- **Slime:** polysaccharide material secreted on the surface protecting organisms against immune attack and antibiotic action. It is formed when growing in a biofilm, which may occur on medical devices such as canulae, or in lungs damaged by bronchiectasis.
- **Lipopolysaccharide:** surface antigens that strongly stimulate inflammation and protect Gram-negative bacteria from complement-mediated lysis.

- **Fimbriae** or **pili**: specialized thin projections aiding adhesion to host cells. *Escherichia coli*, which causes urinary tract infections, binds to mannose receptors on ureteric epithelial cells via P fimbriae. Fimbriae are often immunogenic, varying between strains allowing repeated infections to occur (e.g. *Neisseria gonorrhoeae*).
- **Flagella**: a motility organelle that allows organisms to move to sources of nutrition and penetrate the host mucus. The number and position of flagella may help identification.
- **Spores**: metabolically inert bacterial forms adapted for long-term survival in the environment, which are able to regrow under suitable conditions.
- **Genetics**: Bacteria have a single chromosome and lack a nucleus (prokaryotes). The DNA is coiled and supercoiled by the DNA gyrase enzyme system (see Chapter 7) and bacterial ribosomes differ from eukaryotic examples. Both of these features are targets for antibacterial therapy (see Chapter 7). Bacteria have accessory DNA in the form of plasmids, integrons, transposons and bacteriophages that can transmit antimicrobial resistance (see Chapter 9) and encode for pathogenicity factors.

## Bacterial classification

Bacteria are divided into genera and species based on the sequence of their DNA. Complex computer algorithms are used to compute genomic information allowing comparison between genera, species and strains. Using these techniques, it is possible to track transmission of individual bacterial strains (see Chapter 11).

**Gram reaction:** Gram-positive and Gram-negative bacteria respond to different antibiotics. Other bacteria (e.g. mycobacteria) may require special staining techniques.

- **Cell shape:** Bacteria may be shaped as cocci, bacilli or spirals.
- **Endospore:** The presence, shape and position of the endospore within the bacterial cell are noted.
- **Fastidiousness:** Certain bacteria have specific  $O_2/CO_2$  requirements, need special media or grow only intracellularly.
- **Key enzymes:** Presence or absence of certain enzymes, for example, lack of lactose fermentation helps distinguish salmonellae from *E. coli*.
- **Serological reactions:** Interaction of antibodies with surface structures may for example help to distinguish subtypes of salmonellae, *Haemophilus* and meningococcus.
- **DNA sequences:** DNA sequencing of key genes (e.g., 16S ribosomal RNA or DNA gyrase) can identify the organism precisely.

## Medically important groups of bacteria

**Gram-positive cocci** are divided into two main groups: the staphylococci (catalase-positive), the major pathogen being *S. aureus*;

and the streptococci (catalase-negative), the major pathogens being *Streptococcus pyogenes*, which causes sore throat and rheumatic fever, and *S. agalactiae*, which causes neonatal meningitis and pneumonia (see Chapters 18 and 19).

**Gram-negative cocci** include the pathogens *N. meningitidis*, an important cause of meningitis and septicaemia, and *N. gonorrhoeae*, the agent of urethritis (gonorrhoea).

**Gram-negative coccobacilli** include the respiratory pathogens *Haemophilus* and *Bordetella* and zoonotic agents, such as *Brucella* and *Pasteurella* (see Chapter 27).

**Gram-positive bacilli** are divided into sporing and non-sporing. The sporing types are subdivided into those that are aerobic (*Bacillus*; see Chapter 16) and those that are anaerobic (*Clostridium*; see Chapter 24). Pathogens include *Bacillus anthracis*, which causes anthrax; and clostridia, which cause pseudomembranous colitis, tetanus and, more rarely, gas gangrene and botulism. The non-sporing pathogens include *Listeria* and corynebacteria (see Chapter 20).

**Gram-negative bacilli** (including the family Enterobacteriaceae) can be part of the normal flora of humans and animals, and in the environment. They include many pathogenic genera: *Salmonella*, *Shigella*, *Escherichia*, *Proteus* and *Yersinia* (see Chapters 28 and 29). *Pseudomonas* and *Burkholderia* are environmental saprophytes that are naturally resistant to antibiotics and are important healthcare associated pathogens (see Chapter 31). *Legionella* lives in the environment in water but can cause human infection if conditions in the built environment allow it to gain a foothold (see Chapter 31).

**Spiral bacteria** include the small gastrointestinal *Helicobacter* that colonizes the stomach, and may lead to gastric ulcers, duodenal ulcers and gastric cancer. *Campylobacter* spp. can cause acute diarrhoea (see Chapter 33). The *Borrelia* may cause a chronic disease of the skin joints and central nervous system, Lyme disease (*Borrelia burgdorferi*), or rarely relapsing fever (*Borrelia duttoni* and *Borrelia recurrentis*). The *Leptospira* are zoonotic agents that cause an acute meningitis syndrome that may be accompanied by renal failure and hepatitis. The *Treponema* include the causative agent of syphilis (*Treponema pallidum*) (Chapter 33).

*Mycoplasma* and *Chlamydia* are responsible for common respiratory and sexually transmitted infections (Chapter 33).

*Rickettsia* are the agents of typhus and rarer severe infections (see Chapter 32).