MEDICAL MICROBIOLOGY AND INFECTION

Lecture Notes

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5th Edition

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Contents

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Preface

The magnitude of recent changes in the field of medical microbiology has warranted this fifth edition of *Lecture Notes*: *Medical Microbiology and Infection*. While these changes have been encompassed in new chapters, this edition continues to maintain the well-received and user-friendly format of earlier editions, highlighting the pertinent key facts in medical microbiology and providing a sound foundation of knowledge which students can build on. The book for the first time is multi-authored, with chapters being written by recognised experts in their field.

This fifth edition is arranged into three main sections: basic microbiology, antimicrobial agents and infection. It covers all aspects of microbiology, including bacteriology, virology, mycology and parasitology. As in previous editions, the text is supported throughout with colour figures to illustrate the key points.

This book is written specifically for students in medicine, biomedicine, biology, dentistry, science and also pharmacology, who have an interest in medical microbiology at both undergraduate and postgraduate levels. In addition, this book will serve as a useful *aide memoire* for doctors sitting MRCS and MRCP examinations, as well as other healthcare professionals, for example biomedical scientists, working towards state registration.

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Part 1

Basic Microbiology

Chapter 1

Basic Bacteriology

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Bacterial Structure

Bacteria are single-celled prokaryotic microorganisms, and their DNA is not contained within a separate nucleus as in eukaryotic cells. They are approximately 0.1–10.0 μm in size (Figure 1.1) and exist in various shapes, including spheres (cocci), curves, spirals and rods (bacilli) (Figure 1.2). These characteristic shapes are used to classify and identify bacteria. The appearance of bacteria following the Gram stain is also used for identification. Bacteria which stain purple/blue are termed Gram-positive, whereas those that stain pink/red are termed Gram-negative. This difference in response to the Gram stain results from the composition of the cell envelope (wall) (Figure 1.3), which are described below.

Figure 1.1 Shape and size of some clinically important bacteria.

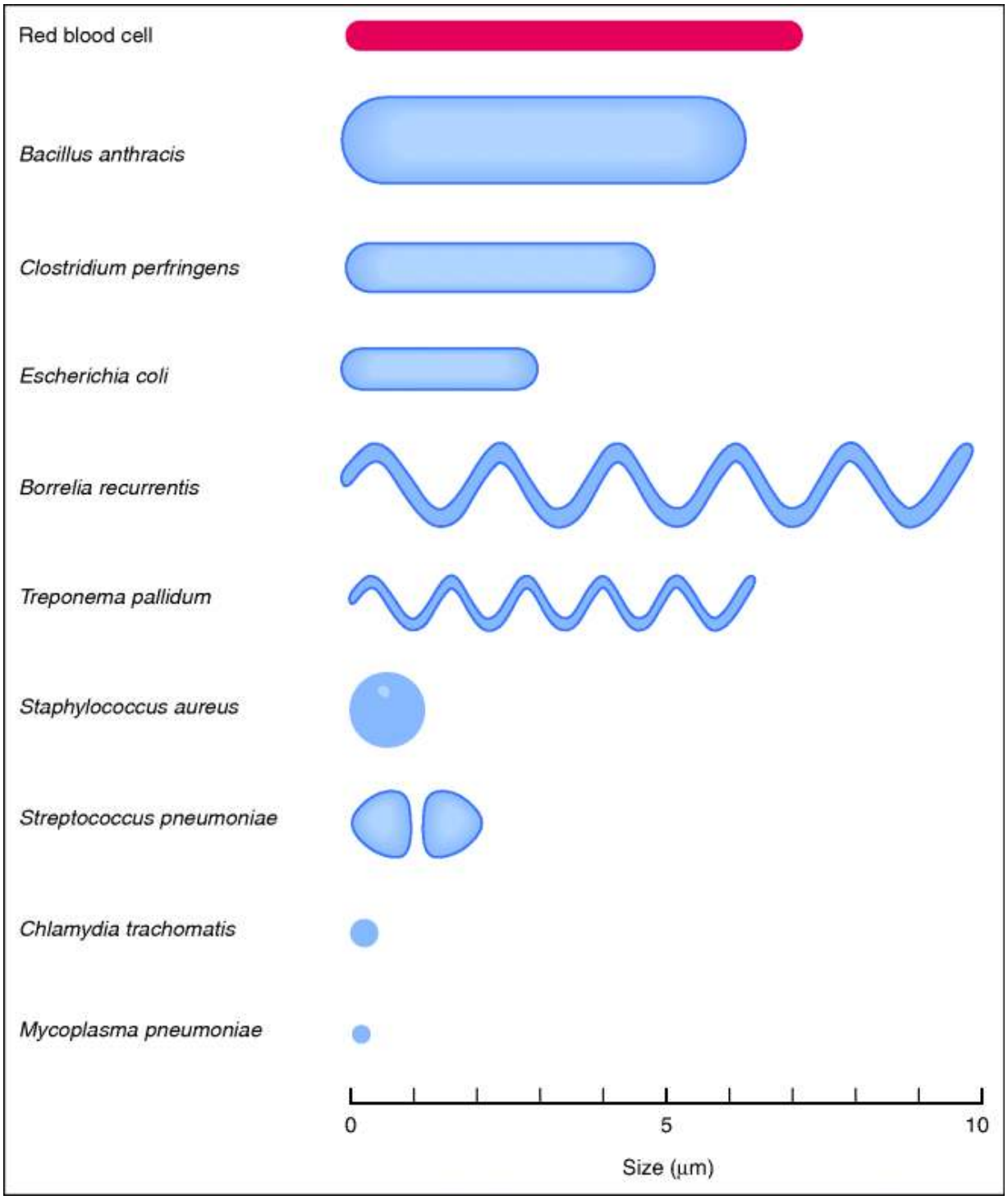


Figure 1.2 Some bacterial shapes.

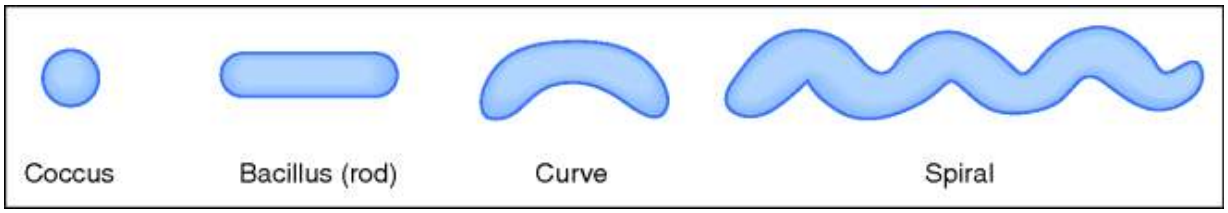
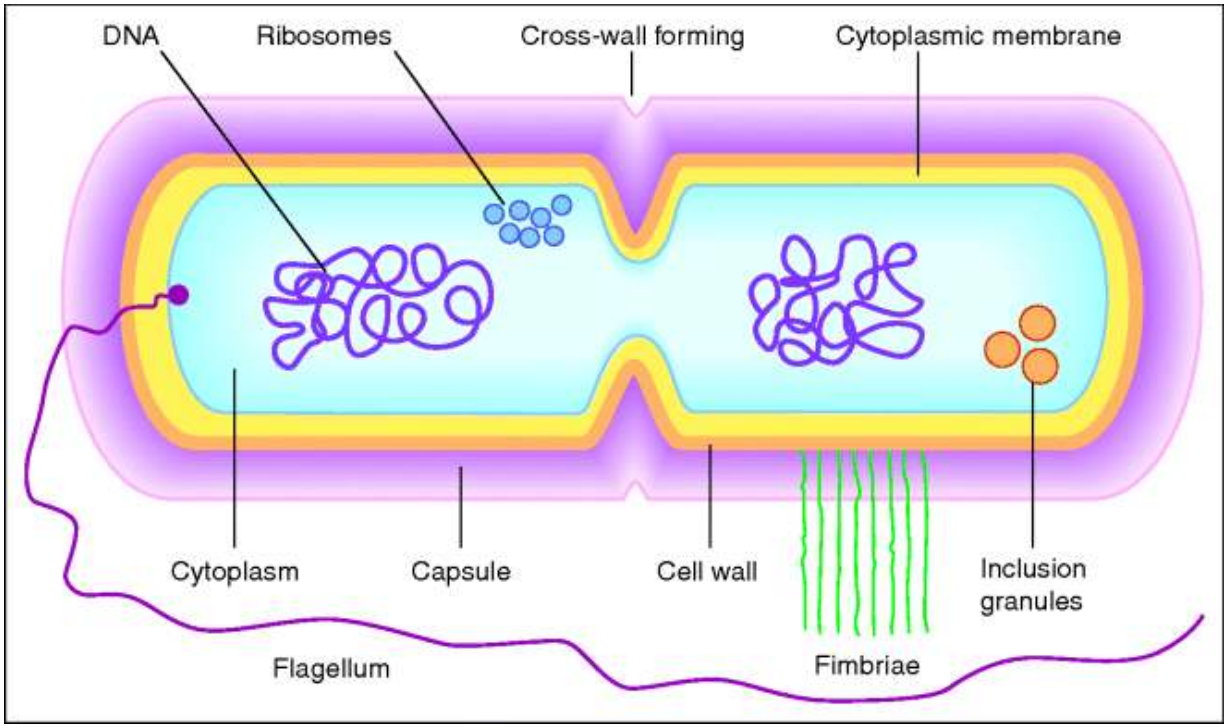


Figure 1.3 A section of a typical bacterial cell.



Cell Envelope

Cytoplasmic Membrane

A cytoplasmic membrane surrounds the cytoplasm of all bacterial cells and are composed of protein and phospholipid; they resemble the membrane surrounding mammalian (eukaryotic) cells but lack sterols. The phospholipids form a bilayer into which proteins are embedded, some spanning the membrane. The membrane carries out many functions, including the synthesis and export of cell-wall components, respiration, secretion of extracellular enzymes and toxins, and the uptake of nutrients by active transport mechanisms.

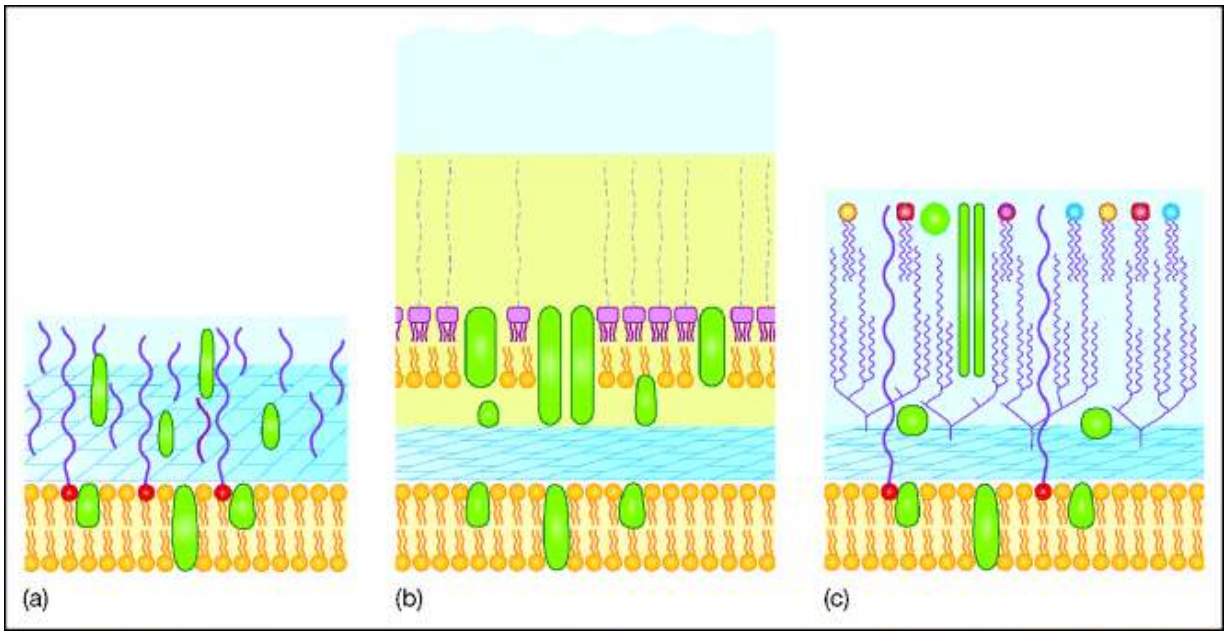
Mesosomes are intracellular membrane structures, formed by folding of the cytoplasmic membrane. They occur more frequently in Gram-positive than in Gram-negative bacteria. Mesosomes present at the point of cell division of Gram-positive bacteria are involved in chromosomal separation; at other sites they may be associated with cellular respiration and metabolism.

Cell Wall

Bacteria maintain their shape by a strong rigid outer cover, the cell wall (Figure 1.3).

Gram-positive bacteria have a relatively thick, uniform cell wall, largely composed of peptidoglycan, a complex molecule consisting of linear repeating sugar subunits cross-linked by peptide side chains (Figure 1.4a). Other cell-wall polymers, including teichoic acids, teichuronic acids and proteins, are also present.

Figure 1.4 Cell wall and cytoplasmic membrane of (a) Gram-positive bacteria, (b) Gram-negative bacteria and (c) mycobacteria. The Gram-positive bacterial cell wall has a thick peptidoglycan layer with associated molecules (teichoic acids, teichuronic acids and proteins). The Gram-negative bacterial cell wall contains lipopolysaccharides, phospholipids and proteins in an outer membrane linked to a thin inner peptidoglycan layer. The mycobacterial cell wall contains long chain length fatty acids (mycolic acids).



Gram-negative bacteria have a thinner peptidoglycan layer and an additional outer membrane that differs in structure from the cytoplasmic membrane (Figure 1.4b). The outer membrane contains lipopolysaccharides on its outer face, phospholipids on its inner face, proteins and lipoproteins which anchor it to the peptidoglycan. Porins are a group of proteins that form channels through which small hydrophilic molecules, including nutrients, can cross the outer membrane. Lipopolysaccharides are a characteristic feature of Gram-negative bacteria and are also termed ‘endotoxins’ or ‘pyrogen’. Endotoxins are released on cell lysis and have important biological activities involved in the pathogenesis of Gram-negative infections; they activate macrophages, clotting factors and complement, leading to disseminated intravascular coagulation and septic shock (Chapter 33).

Mycobacteria have a distinctive cell wall structure and composition that differs from that of Gram-positive and Gram-negative bacteria. It contains peptidoglycan but has large amounts of high molecular weight lipids in the form of long chain length fatty acids (mycolic acids) attached to polysaccharides and proteins. This high lipid content gives