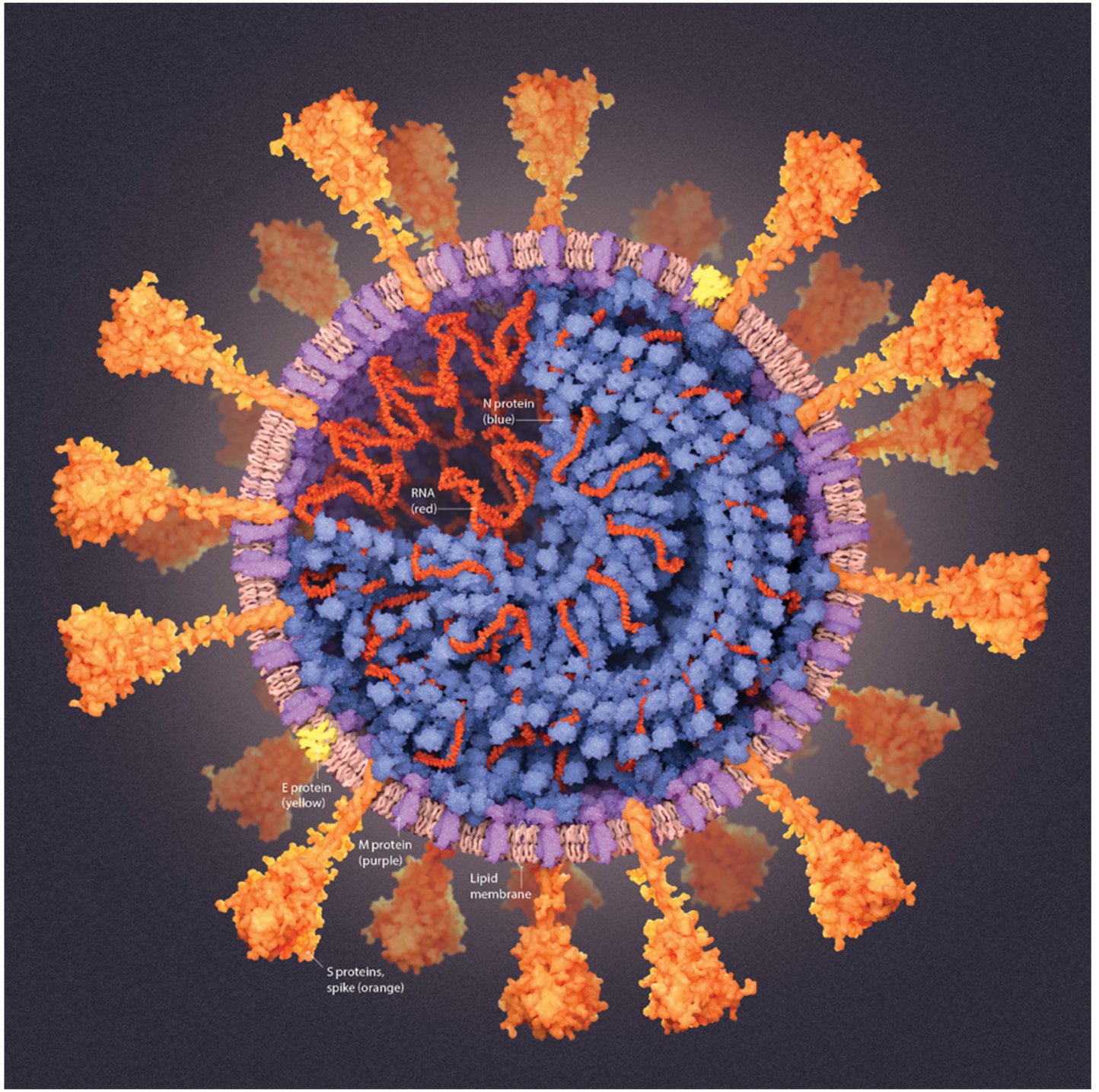
OLLI SG 492
Human Immune System

Session 1 - March 9, 2022

Coronavirus Cross Section

Gene Machine

A SARS-CoV-2 virus particle wafting into a person's nose or mouth is about 100 nanometers in diameter—visible only with an electron microscope. It is a near sphere of protein (cross section shown) inside a fatty membrane that protects a twisting strand of RNA—a molecule that holds the virus's genetic code. Proteins called "S" form spikes that extend from the surface and grab onto a human cell, hundreds of times larger, so the particle, or virion, can slip inside; the crown, or corona, appearance gives the virus its name. Structural proteins—N, M and E—move inside the cell, where they help new virions form.



Today’s Meeting

- Introductions
- My Background and Approach
- Review of Operational Procedures
- Review of the Syllabus
- Recommended Readings and Resources
- About the Author and About the Book
- General Observations on the Immune System
- Some Basics of the Immune System

Introductions

- Knowledge of Biology, Immunology - Any Biologists, Medical Professionals, Immunologists in the Group?
- Experience with Biology - High School, College?
- Your Interest in Taking This Study Group
- Did the Covid 19 Pandemic Influence Your Decision to Sign-up For This Study Group - Some, A Lot, Not At All?

My Background

- BA, Philosophy, 1972, Temple University, Philadelphia
- Teaching Fellowship in Philosophy, Graduate School, Temple Univ. (4 years)
- Career in Information Technology (Mostly Federal Govt.)
- First OLLI Study Group - Fall 2015
- Led 15 Unique Study Groups - 8 Biology, 2 Geology, 5 Philosophy
- With Repeats, Led 21 Study Groups

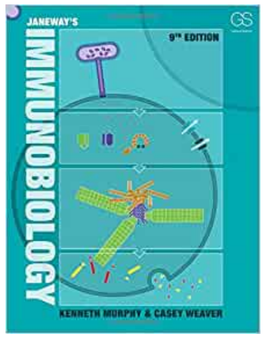
My Approach

- Not a Teacher, Not a Lecturer, Just a Study Group Leader
- Encourage Optimum Participation
- Mix of Presentation, Discussion, Comments, Q&A
- Maintain a casual atmosphere - but focused on the subject.

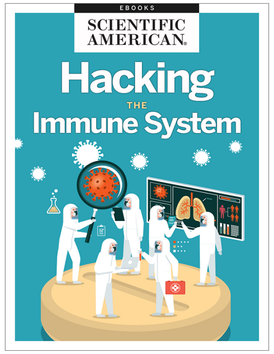
Operational Procedures

- I will prepare and email to you a summary of the assigned reading in advance of the meeting.
- I will email a PDF of the slides used in each meeting right after the meeting.
- I will also post all material used in this study group on OLLI's website.
- If needed, and if there is sufficient interest, I will set up and host Zoom meetings for questions and additional presentations.
- I will be presenting material on the basics of the immune system to complement the advances described in our book.

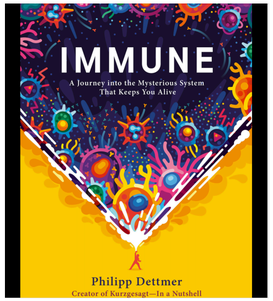
Recommended Readings and Resources



Janeway's Immunobiology, 9th Edition, Garland Science, 2017



Hacking the Immune System: From the Editors of Scientific Amrican, 2020



Immune: A Journey Into the Mysterious System That Keeps You Alive by Philipp Dettmer, Random House, 2021

Recommended Readings and Resources

- iBiology (Home Page)
- iBiology - Immune System Lectures
- Bozeman Science
- Khan Academy - Immune System
- Wikipedia
- Kurzgesagt YouTube Channel

Daniel M. Davis

Author's Background

- Born 1970
- PhD. in Physics, Strathclyde University, Scotland
- Hired into Jack Strominger's lab at Harvard to work on Immune System
- Professor of Immunology at Manchester University, U.K.
- Research Director, Manchester Collaborative Centre for Inflamm Research
- Author's Webpage, Manchester University

About the Book

- Very Good Presentation of the Advances Made In Our Understanding of the Immune System Since the 1990s
- Technical Terms Are Used Judiciously, and Explained
- Written For the Intelligent Layman
- The Narrative Keeps The Scientists Involved In a Central Role - Author Humanizes and Personalizes the Narrative of Discovery
- Roughly Divided Into Two Equal Parts - First On the Discoveries, the Science; Second On the Therapies Developed From These Discoveries
- However… Author Assumes Prior Knowledge of Many Important Aspects of the Immune System (Which I Will Attempt to Provide)

General Observations on Immune System

- It’s Complicated!
- Author Gives Plenty of Space To Those Researchers Who Look At the Immune System From a Whole-Organism Perspective
- The Amazing Persistence and Patience Of So Many Scientists At Work In This Field
- Throughout the Book, the Author Remarks On the Many, Many Gaps In Our Understanding of the Immune System; Constant Refrain - “We Don’t Know…”
- All Multi-cellular Organisms Have an Immune System Of Some Sort (Incl. Plants and Insects)

Basics of the Immune System - 1

Pathogen Size

- Viruses and Bacteria Are Incredibly Small
- Viruses Cannot Be Seen Under a Light Microscope; Require Electron Microscopes
- Viruses Are Measured in Nanometers - 0.000000001 (1 Billionth of a Meter)
- Bacteria Are Measured in Micrometers - 0.0000001 (1 Millionth of a Meter)
- Parasites Are Measured in Centimeters - 0.01 (1 Hundredth of a Meter)
- T Cells Are Measured in Micrometers - 0.0000007
- Action Takes Place At the Molecular Level

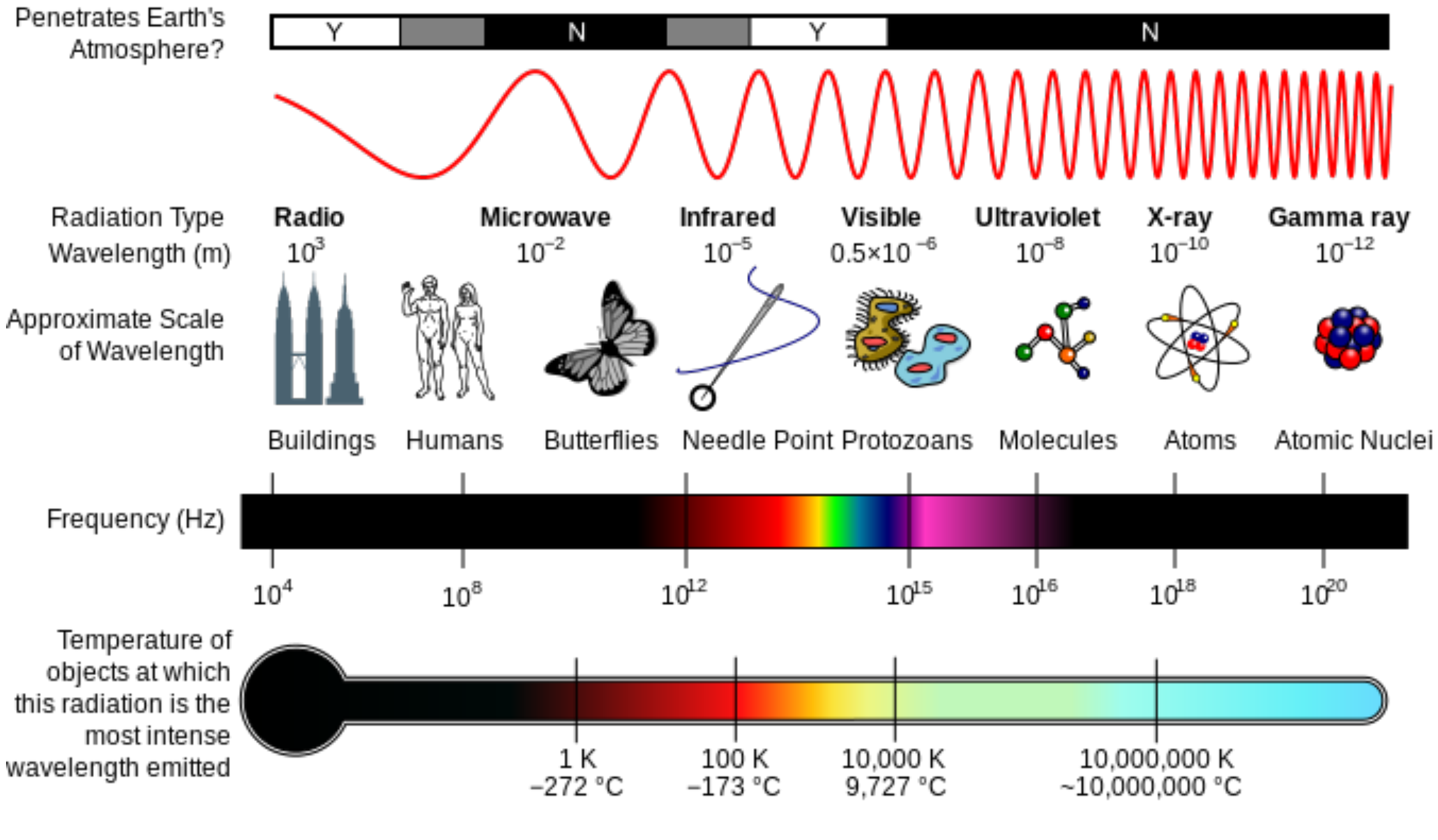
Basics of the Immune System - 1

Pathogen Size

“To contemplate the size of viruses, tap out a single grain of salt onto a table. Stare at the tiny cube. You could line up about 10 skin cells along one side of it. You could line up about 100 bacteria. And you could line up 1,000 tobacco mosaic viruses, end to end, alongside that same grain of salt.”

Excerpt From: Carl Zimmer. “A Planet of Viruses.”

Electromagnetic Spectrum and Detectable Objects



Basics of the Immune System - 1

Pathogen Size

Electron Microscope Image of Bacteriophages Swarming a Bacterium

Basics of the Immune System - 2

Proteins and Protein Folding

Proteins are **large, complex molecules** that play many critical roles in the body. They do most of the work in cells and are required for the structure, function, and regulation of the body's tissues and organs.

- Central Dogma: DNA Makes RNA; RNA Makes Proteins; Video
- Proteins Are Long Chains of Amino Acids, Synthesized At the Ribosome, and Coded For By mRNA (messengerRNA)
- Some Amino Acids Are Hydrophilic, Some Hydrophobic. Some Have Unbalanced Electrical Charges (Ionized).
- These Characteristics Result in the Folding of the Amino Acid Chain

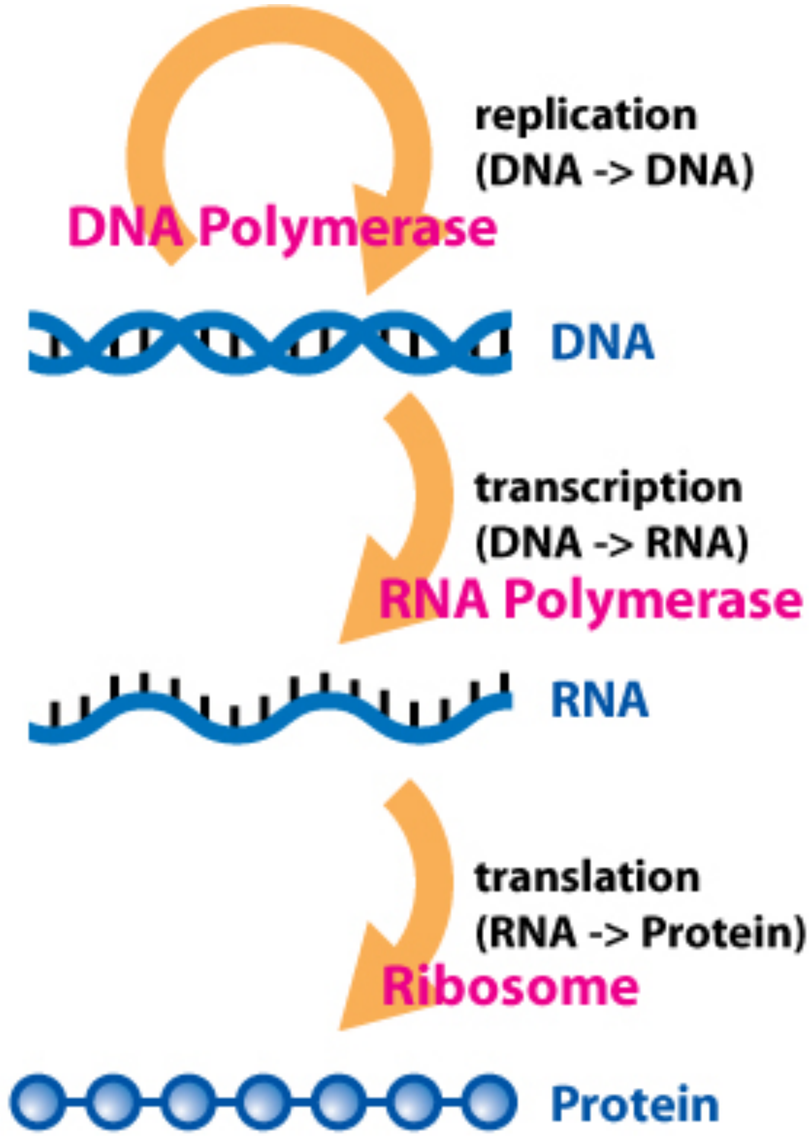
Basics of the Immune System - 2

Proteins and Protein Folding

- The Folding Gives the Protein a Specific Shape, and Specific Function
- Some Proteins Are Transported To the Cell Membrane, and Some Proteins Breach the Membrane With Part of the Protein Outside the Cell and Part Inside - Transmembrane Proteins
- Functions of the Membrane Proteins Include:
  - Transport of Molecules Across the Membrane
  - Signal Transduction
- “Lock and Key” Method of Recognition

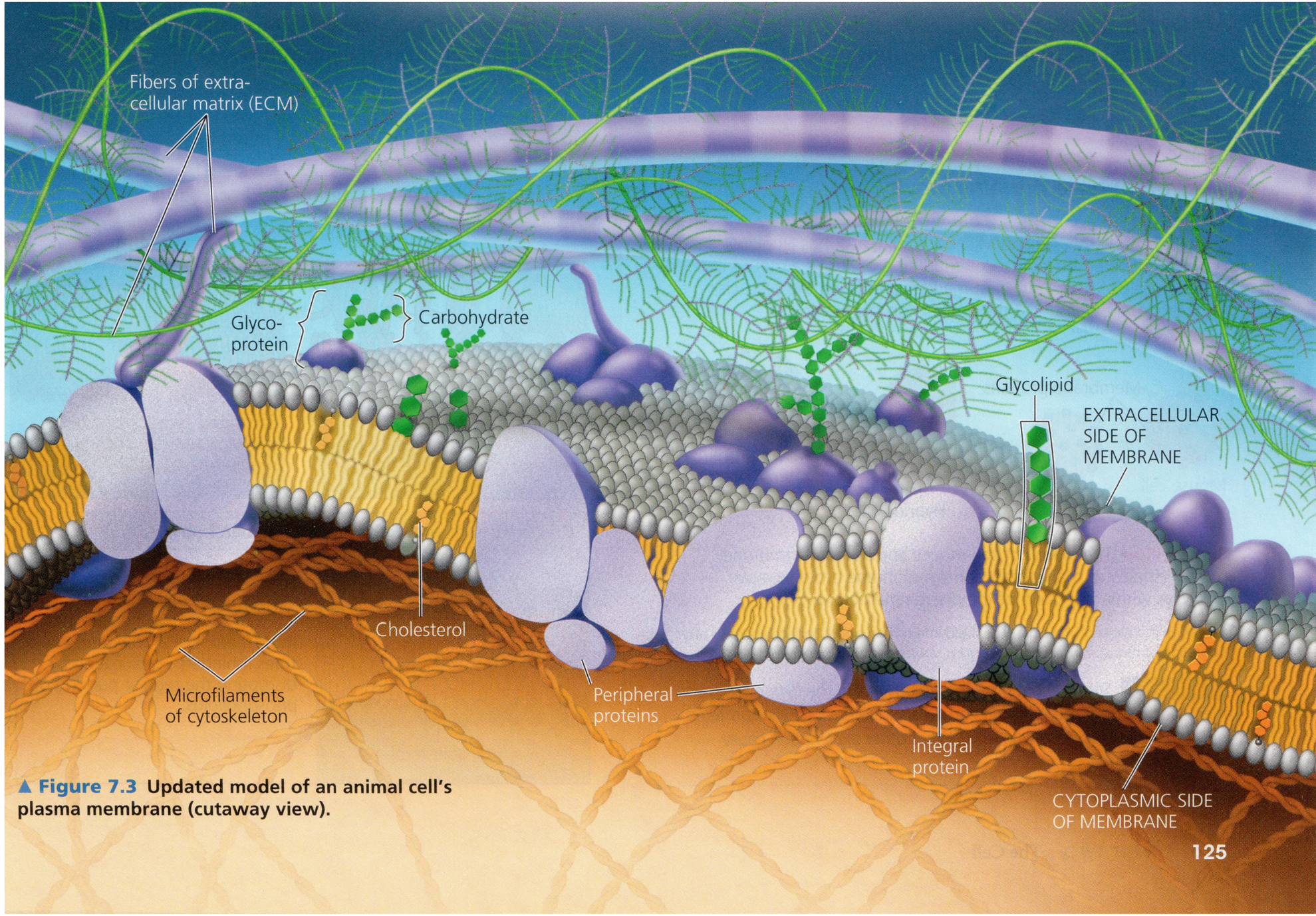
Basics of the Immune System - 2

Central Dogma



Basics of the Immune System - 2

Cellular Membrane Proteins

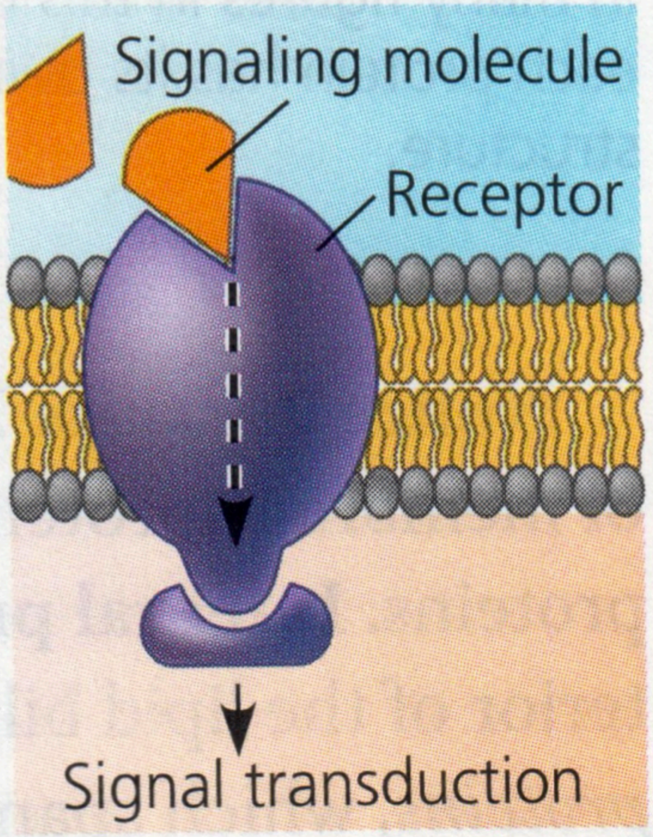


▲ **Figure 7.3** **Updated model of an animal cell's plasma membrane (cutaway view).**

Basics of the Immune System - 2

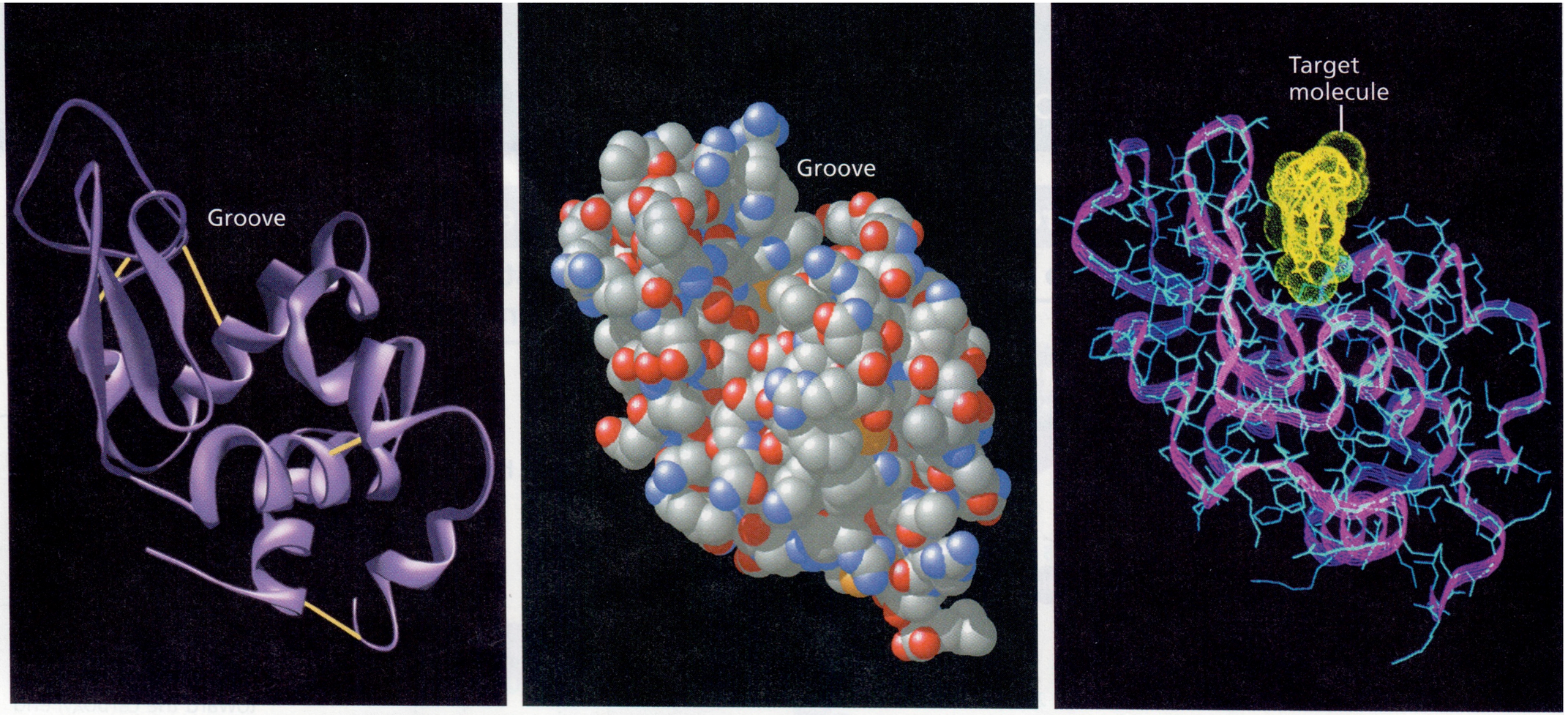
Proteins and Protein Folding

(c) Signal transduction. A membrane protein (receptor) may have a binding site with a specific shape that fits the shape of a chemical messenger, such as a hormone. The external messenger (signaling molecule) may cause the protein to change shape, allowing it to relay the message to the inside of the cell, usually by binding to a cytoplasmic protein (see Figure 11.6).



Basics of the Immune System - 2

Proteins and Protein Folding



(a) A **ribbon model** shows how the single polypeptide chain folds and coils to form the functional protein. (The yellow lines represent disulfide bridges that stabilize the protein's shape.)

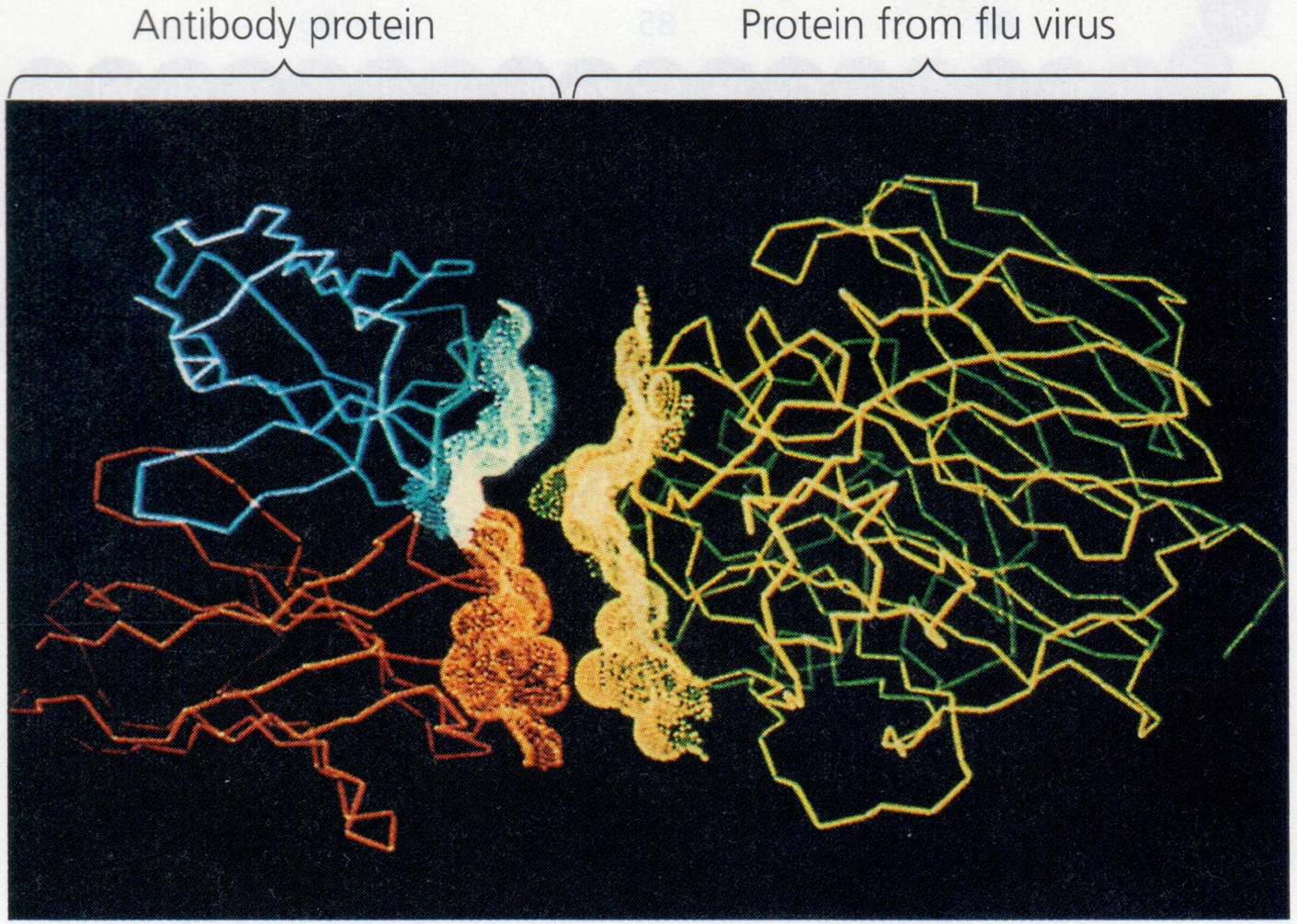
(b) A **space-filling model** shows more clearly the globular shape seen in many proteins, as well as the specific three-dimensional structure unique to lysozyme.

(c) In this view, a ribbon model is superimposed on a **wireframe model**, which shows the backbone with the side chains extending from it. The yellow structure is the target molecule.

▲ **Figure 5.16 Structure of a protein, the enzyme lysozyme.** Present in our sweat, tears, and saliva, lysozyme is an enzyme that helps prevent infection by binding to and catalyzing the destruction of specific molecules on the surface of many kinds of bacteria. The groove is the part of the protein that recognizes and binds to the target molecules on bacterial walls.

Basics of the Immune System - 2

Protein Binding



▲ **Figure 5.17 An antibody binding to a protein from a flu virus.** A technique called X-ray crystallography was used to generate a computer model of an antibody protein (blue and orange, left) bound to a flu virus protein (green and yellow, right). Computer software was then used to back the images away from each other, revealing the exact complementarity of shape between the two protein surfaces.

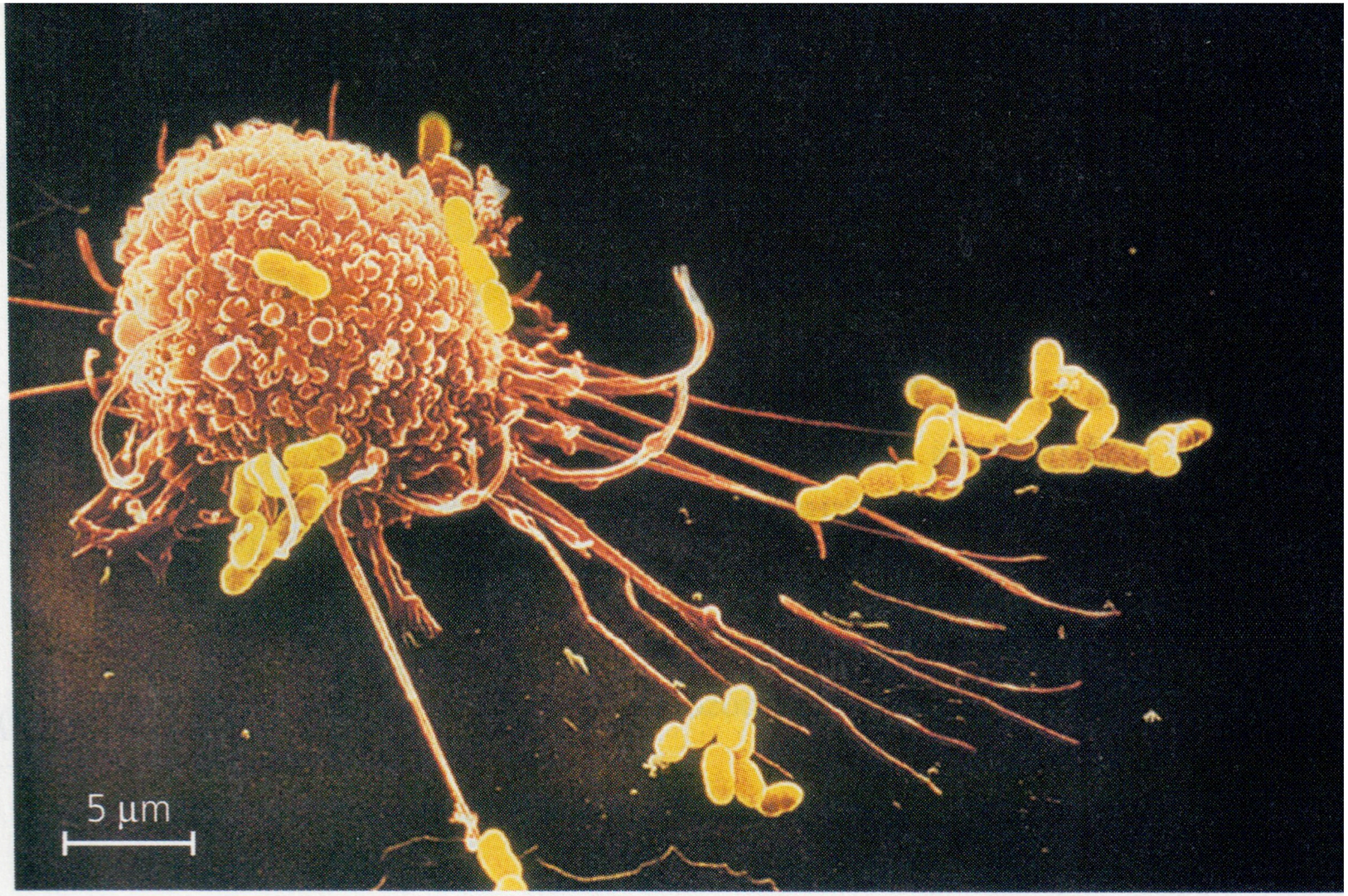
Basics of the Immune System - 3

Action of the Immune System Cells

- Phagocytosis is the main mechanism used by immune system cells to remove and destroy pathogens - the pathogens are literally eaten and digested.
  - Video of a Macrophage “Eating” Bacteria
  - Video of Macrophages “Eating” Yeast
- Other mechanisms include cellular degradation of the pathogen using enzymes or antimicrobials, interference with pathogen function, and alerting other immune system cells to the presence and location of pathogens.

Basics of the Immune System - 3

Action of the Immune System Cells

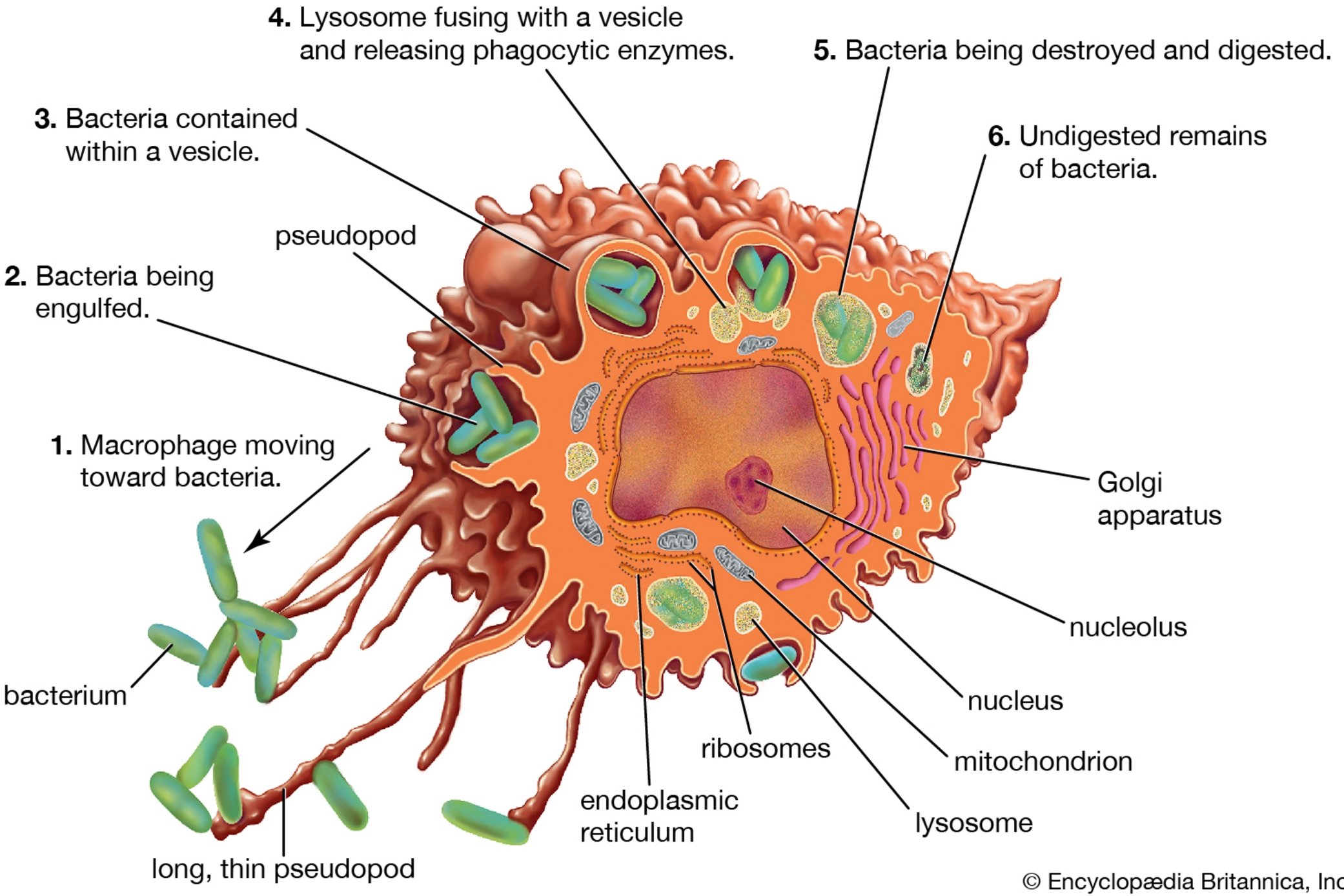


▲ **Figure 6.31 The emergence of cellular functions.** The ability of this macrophage (brown) to recognize, apprehend, and destroy bacteria (yellow) is a coordinated activity of the whole cell. Its cytoskeleton, lysosomes, and plasma membrane are among the components that function in phagocytosis (colorized SEM).

Basics of the Immune System - 3

Action of the Immune System Cells

Macrophage Cross Section



Next Up

- Charles Janeway and the Discovery of the Innate Immune System
- Read the Overview and Chapter 1 - Dirty Little Secrets