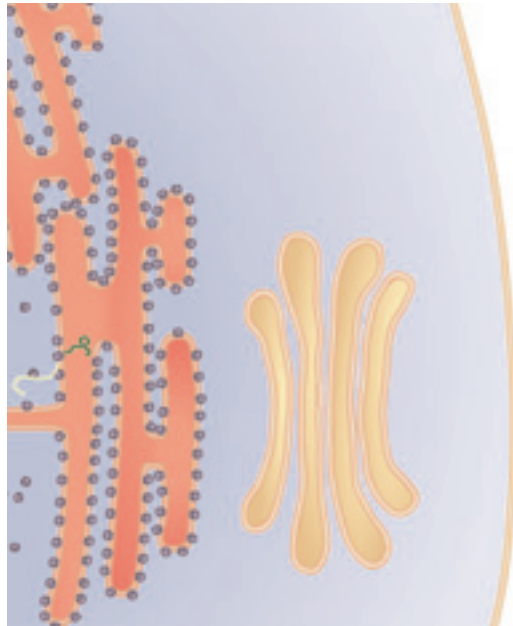


## WEB TUTORIAL 4.2

# A Protein Pathway



### Text Sections

Section 4.3 A Tour of the Animal Cell: The Protein Pathway, p. 59

### Introduction

One way to think of a cell is as a living factory. In this tutorial, we'll begin learning about the animal cell by tracing the way it manufactures a product—a protein—for export outside itself. Just as a new employee might tour an assembly line as a means of learning about factory equipment, so you are going to follow the path of protein production as a means of learning about cell equipment.

### Learning Objectives

- Understand the role of mRNA in protein synthesis.
- Describe the cellular structures involved in protein synthesis.
- Know what exocytosis is.

# Narration

## Protein Synthesis

Proteins are critical working molecules in living things, and DNA contains the information for producing these proteins. In the eukaryotic cell, DNA is largely confined within a nucleus bound by a membrane. The process of protein synthesis requires that the DNA's instructions first get copied onto another long-chain molecule called messenger RNA (mRNA). Given that mRNA goes to the cytoplasm, it must, of course, have some way of getting out of the nucleus; its exit routes turn out to be thousands of channels that stud the surface of the nuclear envelope—the nuclear pores.

As the messenger RNA leaves the nucleus, it attaches to a small structure in the cytoplasm called a ribosome. For now, we can define the ribosome as an organelle that serves as the site of protein synthesis in the cell, acting as a kind of playback head on a cassette deck. The ribosome reads the instructions provided by the mRNA molecule, and produces a chain of amino acids that folds up into the molecule we call a protein.

For proteins destined for export out of the cell, after a very short sequence of the amino acid chain has grown from the ribosome, the ribosome, bound up with its mRNA and amino acid chain, will migrate to the rough endoplasmic reticulum (RER) and dock on its outside face, thus joining many other ribosomes that have done the same thing.

The endoplasmic reticulum is a network of membranes that aids in the processing of proteins in eukaryotic cells. The rough endoplasmic reticulum is “rough” because it is studded with ribosomes. The amino acid (or polypeptide) chain that is being output from the ribosome is, in essence, an unfinished protein that needs to go through more processing before it can be exported. The first step in this processing leads only to the other side of the ER wall the ribosome is embedded in. As the ribosome goes on with its work, the amino acid chain it is producing drops into chambers inside the rough ER.

As amino acid chains drop into the sacs of the ER, they first fold up into their protein shapes. Beyond this, most proteins that are exported from cells have sugar side-chains added to them here.

The proteins that have been processed within the rough ER need to move out of the ER to the next station of the assembly line before being exported. Part of the ER membrane containing the newly synthesized protein buds off and enters the cytosol. These membrane spheres, carrying proteins and other molecules, are called transport vesicles.

Once a transport vesicle has budded off from the rough ER, it then moves through the cytosol to fuse with the membrane of another organelle called the Golgi com-

plex. The Golgi complex is a network of membranes that processes and distributes proteins that come to it from the rough endoplasmic reticulum.

The Golgi is similar to the ER in that it amounts to a series of cisternae, or connected membranous sacs with internal spaces. According to one model of Golgi function, proteins arrive at the Golgi housed in transport vesicles that fuse with the Golgi “face” nearest the rough ER, at which point the vesicles release their protein cargo into the Golgi cisternal space for processing. Some side-chains of sugar may be trimmed from proteins in the Golgi complex, or phosphate groups may be added. Once processed, proteins of the sort we are following will move through the Golgi complex and eventually bud off from the outside face of the Golgi, now housed in their final transport vesicles.

For export proteins, the journey that began with the copying of DNA information onto messenger RNA is almost over. Once a vesicle buds off from the Golgi, all that remains is for it to make its way through the cytosol to the plasma membrane at the outer reaches of the cell. There, the vesicle fuses with the plasma membrane of the cell and the protein is ejected into the extracellular world. After this last step, called exocytosis, one finished product of the cellular factory has rolled out the door.

### **You should now be able to...**

- Explain how eukaryotic protein synthesis can occur in the cytoplasm if the information for making proteins is located in the nucleus.
- List the steps involved in the processing of a protein that is destined for export out of the cell.
- Describe the structures of the endoplasmic reticulum and the Golgi complex.
- Discuss the role of transport vesicles in protein synthesis and exocytosis.