

# Chapter 1 Understanding proteins

Any fool can know. The point is to understand.

**Albert Einstein**

## 1.1 Background

Biopharmaceuticals are more complex and have larger molecular weight, variable structure, dynamic protein, and antibody molecules compared to pharmaceutical products wherein a fixed structure is always present. Some prominent examples include cytokines, antibodies, and hormones (Figure 1.1).

Cytokines are a broad and loose category of small proteins (~5–20 kDa) that are important in cell signaling. They are released by cells and they affect the behavior of other cells. Cytokines can also be involved in autocrine signaling. Cytokines include chemokines, interferons, interleukins, lymphokines, and tumor necrosis factor (TNF), but generally not hormones or growth factors (despite some terminology overlap). Cytokines are produced by a broad range of cells, including immune cells like macrophages, B lymphocytes, T lymphocytes, and mast cells, as well as endothelial cells, fibroblasts, and various stromal cells; a given cytokine may be produced by more than one type of cell. Cytokines act through receptors and are especially important in the immune system; cytokines modulate the balance between humoral and cell-based immune responses, and they regulate the maturation, growth, and responsiveness of particular cell populations. Some cytokines enhance or inhibit the action of other cytokines in complex ways. They are different from hormones, which are also important cell signaling molecules, in that hormones circulate in much lower concentrations and hormones tend to be made by specific kinds of cells.

An antibody, also known as an immunoglobulin, is a large, Y-shaped protein produced by plasma cells that are used by the immune system to identify and neutralize pathogens such as bacteria and viruses. The antibody recognizes an antigen, via the variable region. Each tip of the Y of an antibody contains a paratope that is specific for one particular epitope (analogous to a key) on an antigen, allowing these two structures to bind together with precision. Using this binding mechanism, an antibody can tag a microbe or an infected cell for attack by other parts of the immune system, or can directly neutralize its target (for example, by blocking