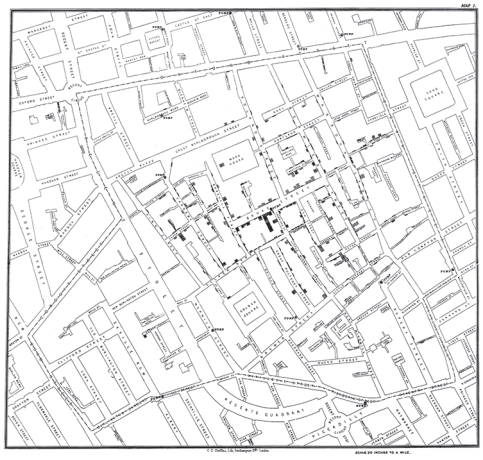
The Study of Disease and the Discovery of Vitamins

The study of disease made quantum leaps in the mid-1800s. English physician John Snow is credited as the father of epidemiology (the study of infectious diseases). Over a three-day period in 1854, a sudden outbreak of the bacteria-based illness cholera killed 127 people who lived on or near Broad Street in the Soho district of London. Dr. Snow marked the locations of the victims on a map and noted that they were all close to a community water pump. At the time, diseases were thought to be caused by bad smells from rotting material, a "miasma" in the atmosphere, but Dr. Snow hypothesized that cholera might instead be related to contaminated water. His proposal was met with extreme skepticism, but when the handle was removed from the water pump, the cholera epidemic came to a stop. In the 1860s, the disease-causing role of microscopic organisms was being discovered, and the germ theory of disease was developed. French chemist Louis Pasteur is regarded as the father of bacteriology (he is also known for pasteurization, fermentation, and observing enantiomeric tartrate crystals).



A novel mapping of cholera victims by Dr. John Snow supports the germ theory of disease.

The revelation that germs, microorganisms such as bacteria and viruses, could cause disease eventually led to new practices to kill germs and avoid their spread, such as sterilizing medical instruments with steam (or by treating them with a chemical solution), and having physicians wash their hands before performing surgery or delivering babies. These hygiene practices were not new ideas—American physician Oliver Wendell Holmes proclaimed in 1843 that "doctors were agents of death" because they could pass infectious diseases to their patients. To prevent the spread of the deadly puerperal fever, Holmes recommended that physicians wash themselves after performing an autopsy and wait one day before attending a childbirth. This theory was put to the test in 1847 by Hungarian physician Ignaz Semmelweis. While working in a hospital in Vienna, Austria, he sterilized instruments and instructed physicians to wash their hands after leaving the morgue and before and after tending to patients. As a result, the mortality rate for new mothers in the maternity ward dropped from 18% to 1%. British wartime nurse Florence Nightingale intuitively focused on improving hygiene in military hospitals in the 1850s, where disease among injured soldiers accounted for more deaths than the injuries themselves. In her book "Notes on Nursing," published in 1860, Nightingale stressed the importance of handwashing. Most of these theories were met with skepticism, but scientific research by Pasteur and others helped good hygiene practices become widely accepted by the medical community by the late 1800s.

Florence Nightengale promoted hygiene to mitigate disease.

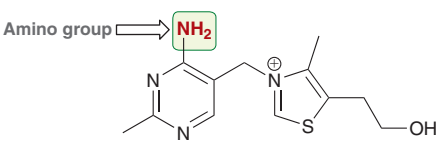
Medical research next turned to explore and explain non-communicable diseases such as scurvy and anemia. These diseases could not be explained by exposure to pathogens; instead, they seemed to be related to diets that were lacking in some "vital" component. In 1906, English biochemist Gowland Hopkins (University of Cambridge) conducted a series of experiments in which he fed rats purified carbohydrates, proteins, and fats (covered in Chapters 24, 25, and 26, respectively). The rats did not thrive on this purified diet, and he concluded there must be "accessory food factors" outside of these categories that are necessary for promoting growth. In 1911, Polish-American biochemist Casimir Funk isolated one such component (a nitrogen-containing compound called an amine, as we will explore in Chapter 22) and he and coined the term "vitamines" (a combination of *vital* and *amine*) to describe these mysterious organic compounds that were essential for good health. Although most vitamins lack an amino group, the term "vitamins" persisted.

Vitamins are compounds that our bodies require for normal functioning and must be obtained from food. An inadequate intake of certain vitamins causes specific diseases. This phenomenon had been observed long before the exact role of vitamins was understood. For example, sailors who remained at sea for extended periods would suffer from a disease called scurvy, characterized by the loss of teeth, swollen limbs, and bruising. If left untreated, the disease would be fatal. In 1747, a British naval physician named James Lind demonstrated that the effects of scurvy could be reversed by eating oranges and lemons. It was recognized that oranges and lemons must contain some "factor" that our bodies require, and lime juice became a normal part of a sailor's diet. For this reason, British sailors were called "Limeys."

This burial scene drawing recounts a 1621 ocean expedition in which 61 of the 64 voyagers died of scurvy.

In 1889, Dutch physician Christiaan Eijkman was investigating the cause of beriberi, a disease characterized by weakness, weight loss, confusion, and sometimes death. Beriberi was common in parts of Asia that had rice-based diets. Eijkman used chickens as animal models, and he discovered

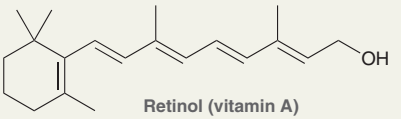
that the chickens exhibited symptoms of the disease when they were being fed white rice—rice from which the fibrous husk had been removed (called refined or polished rice). When he fed the chickens unpolished brown rice, their condition improved drastically. It was therefore realized that the fibrous husk of rice contained some "vital" factor that prevented beriberi. In 1911, Funk thought he had isolated a minute amount of it from extracts of rice polishings, but the material was not characterized beyond elemental analysis. In 1926, Dutch chemists Barend Jansen and Willem Donath successfully isolated and fully characterized crystals of the "anti-beriberi factor." This was the first vitamin to be isolated, and it was later named vitamin B_1 or thiamine:



Thiamine (vitamin B_1)

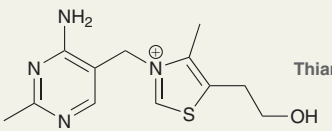
For their discovery of the role vitamins play in nutrition, Eijkman and Hopkins were awarded the 1929 Nobel Prize in Physiology or Medicine. Vitamins are grouped into families based on their behavior (rather than their structure); each family is designated with a letter. For example, vitamin B is a family of many compounds, each designated with a letter and a number (B_1, B_2, B_3, etc.). Shown here are representative vitamins from several families.

In 1933, British chemist Sir Walter Norman Haworth (from the University of Birmingham and inventor of Haworth Projection 3D drawings) devised a synthetic strategy for preparing vitamin C in the laboratory. Success earned Haworth a share of the 1937 Nobel Prize in Chemistry, and it led to the commercial preparation of vitamin C on an industrial scale which made the vitamin widely available as a low-cost nutritional supplement. Such early successes encouraged the notion that chemists would soon elucidate the structures of all vitamins and devise methods for their preparation in the laboratory. The synthesis of vitamin B_{12}, however, would prove to be more complex, as we will see later in this chapter.



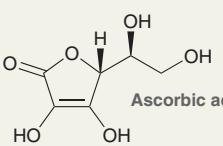
Retinol (vitamin A)

Sources: Milk, eggs, fruit, vegetables, and fish
Deficiency disease: Night-blindness (see Section 16.13)



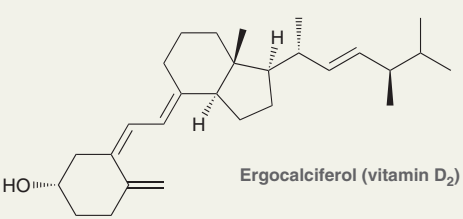
Thiamine (vitamin B_1)

Sources: Liver, potatoes, whole grains, and legumes
Deficiency disease: Beriberi



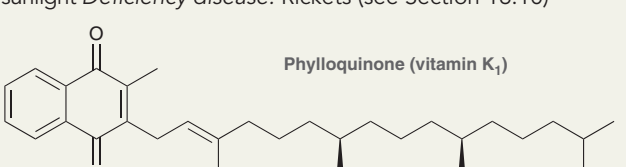
Ascorbic acid (vitamin C)

Sources: Citrus fruits, bell peppers, kiwifruit, and broccoli
Deficiency disease: Scurvy



Ergocalciferol (vitamin D_2)

Sources: Fish, produced when our bodies are exposed to sunlight *Deficiency disease:* Rickets (see Section 16.10)



Phylloquinone (vitamin K_1)

Sources: Soybean oil, green vegetables, and lettuce
Deficiency disease: Hemorrhaging (internal bleeding)