

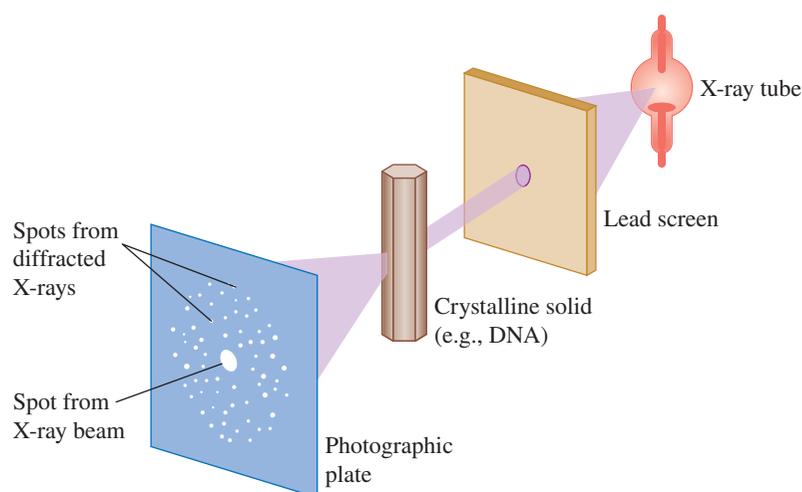
## 13.3 | The Double Helix Structure of DNA

DNA is a gorgeous molecule. The opening photo of this chapter displays a sculptor's rendition of DNA with two silvery strands curving in a gentle spiral, both elegant and simple. Hidden within its structural simplicity is a powerful chemical code for information. The structure—both how the nucleotides are covalently bonded and how the strands pack together—contributes to the function of DNA. Understanding how DNA performs its many functions first required solving the puzzle of the DNA structure.

To see the shape and submicroscopic details of DNA, scientists turned to the technique of X-ray diffraction. This technique has revolutionized our understanding of molecular structures and chemistry by helping us visualize chemical shapes. **X-ray diffraction** is an analytical technique in which a crystal is hit by a beam of X-rays to generate a pattern that reveals the positions of the atoms in the crystal. The X-ray photons interact with the electrons of the atoms in the crystal and are diffracted, or scattered (Figure 13.5). The crucial point is that the X-rays are only scattered at certain angles that are related to the distance between atoms, and that information can be used to determine the structures of a variety of crystalline materials. The X-ray diffraction pattern of a DNA fiber was obtained in late 1952 by the British crystallographer Rosalind Franklin (1920–1958) (Figure 13.6).

James Watson (b. 1928) and Francis Crick (1916–2004) combined Franklin's X-ray diffraction data with earlier chemical and biological analyses to create a model of the structure of DNA. The pattern in Franklin's diffraction photograph was consistent with a repeating helical arrangement of atoms, similar to a loosely coiled spring. Moreover, the X-ray photographs contained evidence of a repeated pattern separated by 0.34 nm within a DNA molecule. The Watson–Crick model explained this repetition by twisting the strands of DNA into a **double helix**, a spiral consisting of two strands that coil around a central axis (Figure 13.6). The base pairs are parallel to each other, perpendicular to the axis of the DNA molecule, and separated by 0.34 nm, the same distance calculated from the diffraction pattern. In addition, Franklin's results also suggested a second repetition pattern separated by 3.4 nm. Watson and Crick took this to be the length of a complete helical turn consisting of 10 base pairs.

The letters in our English words have directionality. For example, the words *ward* and *draw* have the same letters in the same order, but the meaning is different because the direction is reversed. The same is true of DNA, with the bases within its backbone structure being analogous to letters, and the structure of the DNA backbone defining the



**Figure 13.5**

An illustration of X-ray diffraction. A crystalline solid is placed in the beam of X-ray radiation, and is rotated while being impinged with X-rays. Information regarding the molecular structure of the solid is obtained from the symmetry of the spots resulting from diffraction of the incident X-ray beam.

Return to Section 3.1 to find the X-ray region in the electromagnetic spectrum.

James Watson, Francis Crick, and Maurice Wilkins (1916–2004) shared the 1962 Nobel Prize in physiology or medicine for their contributions to the structural understanding of DNA. Although crystallography data from Rosalind Franklin was vital, she died in 1958 and was not eligible for the Nobel Prize in 1962.