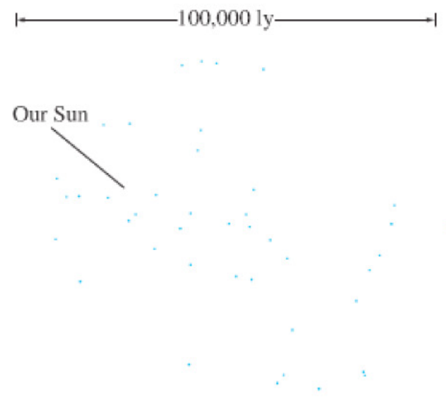
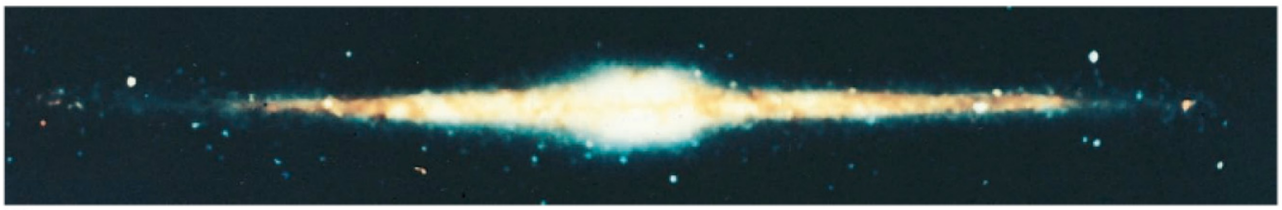
FIGURE 33–2 Our Galaxy, as it would appear from the outside: (a) "edge view," in the plane of the disc; (b) "top view," looking down on the disc. (If only we could see it like this—from the outside!) (c) Infrared photograph of the inner reaches of the Milky Way, showing the central bulge of our Galaxy. This very wide angle photo extends over 180° of sky, and to be viewed properly it should be wrapped in a semicircle with your eyes at the center. The white dots are nearby stars.

(a)



(b)



(c)

Our Galaxy has a diameter of almost 100,000 light-years and a thickness of roughly 2000 ly. It has a bulging central "nucleus" and spiral arms (Fig. 33–2). Our Sun, which seems to be just another star, is located about halfway from the galactic center to the edge, some 26,000 ly from the center. Our Galaxy contains roughly 100 billion (10^{11}) stars. The Sun orbits the galactic center approximately once every 250 million years or so, so its speed is about 200 km/s relative to the center of the Galaxy. The total mass of all the stars in our Galaxy is estimated to be about 3×10^{41} kg, which is ordinary matter. In addition, there is strong evidence that our Galaxy is surrounded by an invisible "halo" of "dark matter," which we discuss in Section 33–8.

EXAMPLE 33–1 ESTIMATE Our Galaxy's mass. Estimate the total mass of our Galaxy using the orbital data of the Sun (including our solar system) about the center of the Galaxy. Assume that most of the mass of the Galaxy is concentrated near the center of the Galaxy.

APPROACH We assume that the Sun and the solar system (total mass m) move in a circular orbit about the center of the Galaxy (total mass M), and that the mass M can be considered as being located at the center of the Galaxy. We then apply Newton's second law, $F = ma$, with a being the centripetal acceleration, $a = v^2/r$, and F being the universal law of gravitation (Chapter 5).

SOLUTION Our Sun and solar system orbit the center of the Galaxy, according to the best measurements as mentioned above, with a speed of about $v = 200\,\mathrm{km/s}$ at a distance from the Galaxy center of about $r = 26{,}000$ ly. We use Newton's second law:

$$F = ma$$

$$G\frac{Mm}{r^2} = m\frac{v^2}{r}$$

where M is the mass of the Galaxy and m is the mass of our Sun and solar system. Solving this, we find

$$M = \frac{rv^2}{G} \approx \frac{(26{,}000\,\mathrm{ly})(10^{16}\,\mathrm{m/ly})(2 \times 10^5\,\mathrm{m/s})^2}{6.67 \times 10^{-11}\,\mathrm{N\cdot m^2/kg^2}} \approx 2 \times 10^{41}\,\mathrm{kg}.$$

NOTE In terms of *numbers* of stars, if they are like our Sun $(m = 2.0 \times 10^{30}\,\mathrm{kg})$, there would be about $(2 \times 10^{41}\,\mathrm{kg})/(2 \times 10^{30}\,\mathrm{kg}) \approx 10^{11}$ or about 100 billion stars.