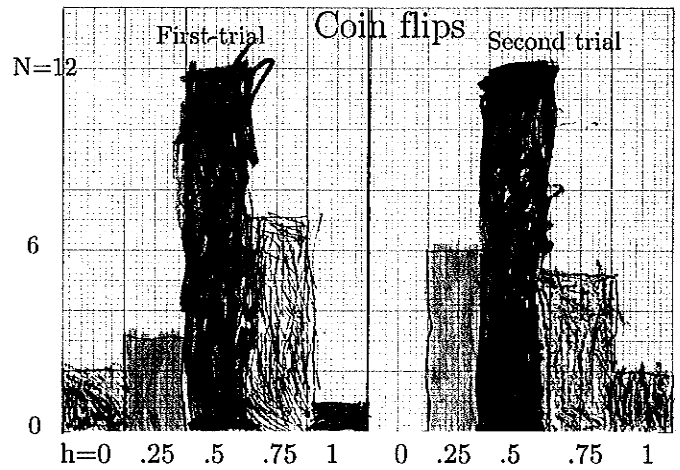

Figure 4.18:

4.3 [Replaces 4.3 in the published book.] *Limitations of passive transport*
Most eukaryotic cells are about $10\,\mu\mathrm{m}$ in diameter, but a few cells in your body are about a meter long. These are the neurons running from you spinal cord to your feet. They have a normal-sized cell body, with various bits sticking out, notably a very long axon (see Section 2.1.2 on page 43).
Many molecules needed at the tip of the axon, for example proteins, are synthesized in the cell body and packaged into vesicles or other particles. Even entire organelles, like mitochondria, need to be transported from their construction sites in the cell body to the periphery. Section 2.3.2 asserted that these objects are all transported along the axon by molecular motors. It might seem that an attractive alternative would be for them to arrive by simple diffusion, but Section 4.4.1 claimed that this mechanism is too slow. Let's see.
Model the axon as a tube 1 m long. At one end of the axon, some synthetic process creates objects similar to those seen in Figure 2.19 on page 56, maintaining them at a number density c_0 (we won't need the numerical value of c_0). Objects arriving at the axon terminal are immediately gobbled up by some other process, and so the number density at this end is zero.
a. Use the Stokes and Einstein relations to estimate the diffusion constant D for an object the size of the vesicle in Figure 2.19b.
b. What is the diffusive number flux j_{diffus} of these objects along the axon?
c. In the microscope one sees organelles and other objects moving at about 400 mm per day. Convert this speed to another number flux j_{obs}, again assuming a number density of c_0.
d. Find the ratio $j_{\mathrm{diffus}}/j_{obs}$ and comment.

4.11 *Flipchart*
Gilbert took four coins, flipped them, and wrote down h, the fraction of coins showing "heads." (Thus h =0, 1/4, 1/2, 3/4, or 1.) He repeated this process twenty-five times and made a histogram of the frequencies of various values of h. To check him, Sullivan did a second batch of twenty-five trials and made a second histogram. Figure 4.18 shows the results.
a. Why don't these histograms look the same? What quantitative features *do* they have in common?
b. Next Gilbert and Sullivan took thirty-six coins, flipped them, and again wrote down the fraction of heads. Again they did twenty-five trials (a lot of work!) and made a histogram of the frequencies of the various values of h. But they lost the dataset. *Sketch* it. Make your sketch realistic: *Estimate*