

**Example 3.3 (Radioactive Emissions).** Rutherford and Geiger (1910) observed the collision of an  $\alpha$  particle emitted from a small bar of polonium with a small screen placed at a short distance from the bar. The number of such collisions in each of 2608 eight-minute intervals was recorded; the distance between the bar and screen was gradually decreased so as to compensate for the decay of the radioactive substance. A Poisson distribution with  $\lambda = 3.870$  was fitted to the data (see Table 3.5).

In almost all cases, random variables possessing a Poisson distribution can be conceptualized as having arisen from a random experiment consisting of a large number of trials. On each trial a certain rare occurrence may or may not take place. Because the occurrence is rare, the probability of its taking place is small. However, the rarity of the occurrence is offset by the fact that a large number of trials are performed. The resultant of these two effects is the Poisson distribution

**Table 3.5: Observed Frequencies of  $k$  Alpha Particles in 2608 Trials of the Random Experiment in Which Alpha Particles Emitted from a Small Bar of Polonium Are Counted Over an 8-Minute Interval of Time**

Number of Alpha particles observed in the interval, $k$	$O_i$ Observed frequency	$E_i$ Theoretical frequency, $\lambda = 3.870$	RELATIVE FREQUENCY $O_i/2608$	$P(X=k)$ $= \frac{(3.87)^k e^{-3.87}}{k!}$
0	57	54.77	.0219	.0209
1	203	211.25	.0778	.0807
2	383	406.85	.1469	.1562
3	525	524.21	.2013	.2015
4	532	508.56	.2040	.1949
5	408	393.81	.1564	.1509
6	273	252.98	.1047	.0973
7	139	140.83	.0533	.0538
8	45	67.81	.0173	.0260
9	27	28.69	.0104	.0112
10	10	10.43	.0038	.0043
11	4	5.22	.0015	.0015
$\geq 12$	2	2.59	.0008	.0008
	<u>2608</u>	<u>2608.00</u>		

Sources: Sir Ernest Rutherford, James Chadwick, and C. D. Ellis (1930). *Radiations from Radioactive Substances*. New York: Macmillan Publishing Co., Inc., pp. 171-72. Ernest Rutherford and Hans Geiger (1910)