Hypergeometric distribution: The hypergeometric can be considered as sampling without replacement. Consider a bin with $N$ balls of which $M$ are red, the remaining balls are blue. You draw $n$ balls and record the number that are red as $m$. This procedure is sampling without replacement and the distribution of $m$ is hypergeometric

$$P(m; N, M, n) = \binom{n}{m} \frac{\binom{N-M}{n-m}}{\binom{N}{n}}.$$ 

Multinomial distribution: The multinomial distribution is a generalization of the binomial distribution. Consider $K$ possible categories (instead of two) with the probability of drawing an observation for each category as $p_k$ where $k = 1, ..., K$ with $p_k \geq 0$ and $\sum_{k=1}^{K} p_k = 1$. The probability of drawing $\{x_1, x_2, ..., x_{K-1}, x_K\}$ observations from each category assuming we draw $n$ observations is

$$P(\{x_1, ..., x_K\}; n, \{p_1, ..., p_k\}) = \frac{n!}{\prod_k x_k!} \prod_k p_k^{x_k}.$$ 

Geometric distribution: Consider two possible events $X = \{0, 1\}$ (say heads and tails) that are Bernoulli with parameter $p$ and you want to write down the distribution of the number of times $T$ you need to draw an observation until you observe a 1. This distribution is the geometric distribution

$$P(t; p) = (1 - p)^t p,$$

this is the probability of observing $t$ zeros and then a one.

Infinite outcome spaces: The geometric and Poisson distributions are examples of discrete distributions with infinite outcome spaces, the number of possible outcomes is infinity. A property of both spaces is that there will be zero probability outcomes

$$\lim_{t \to \infty} [P(t; p > 0) = (1 - p)^t p] = 0, \quad \lim_{k \to \infty} [P(k; \lambda < \infty) = \frac{e^{-\lambda} \lambda^k}{k!}] = 0.$$ 

To see why the second limit is zero note the following approximation

$$n! \approx C \left( \frac{n}{e} \right)^n \sqrt{n}$$

so

$$\frac{\lambda^k}{k!} \approx C^{-1} \left( \frac{e\lambda}{k} \right)^k, \quad \lim_{k \to \infty} \left[ \left( \frac{e\lambda}{k} \right)^k \right] = 0.$$