Drake Equation Background Information Sheet

$$N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

R - This number represents how many billions of stars in the galaxy meet the following three criteria:

1. The star must be a second or third generation star formed from an interstellar cloud that included the necessary heavy elements for life (e.g., carbon, oxygen, etc.). The elements are created during the evolution of first generation, super-massive stars and supernova events that occurred early in the history of our galaxy. A reasonable estimate for this number is 400 billion stars.

2. The star must release enough energy to have a sizeable habitable zone. A habitable zone is the region around a star where liquid water could exist on an orbiting planet. 90% of the stars in our galaxy are too cool to have a sizable habitable zone. This eliminates stars with spectral type K5 and cooler.

3. Of the remaining 10%, nearly a quarter of those have lifetimes too short for life to develop. This eliminates stars warmer with spectral type F8 and warmer as they have lifetimes shorter than 4 billion years.

Our Sun, a G2 star, fits all of these categories and thus is one of the target stars. Such target stars are often referred to as Sun-like stars. A reasonable estimate for the number of target stars is
400e9 * 10% * 75% = 30 billion stars.

f_p - This number represents the fraction of those stars meeting the above criteria that also have planets or planet systems around them. Recent discoveries of numerous extra-solar planets suggest that most stars like our Sun probably have planets.

n_e - This number represents how many "earth-like planets" there are at the right temperature for liquid water to exist (i.e. in the habitable zone). Recent discoveries suggest that we should also consider including moons around gas giant planets that are orbiting their central star in the habitable zone. A reasonable estimate for this number is difficult to imagine. In our solar system, the number ranges from one to three depending on if you include Venus or Mars. If Saturn were to migrate into the habitable zone, its 22 moons would make this number much larger.

f_l - This number represents the fraction of earth-like planets where life actually develops. Some scientists believe that the evolution of life is inevitable when the conditions are right. Alternatively, we only know of one instance where life has successfully developed (Earth), therefore it is difficult to estimate this fraction.

f_i - This number represents the fraction of earth-like planets where at least one species of intelligent life evolves. Intelligent life could develop early on some planets and later on others and therefore again it is difficult to estimate this fraction.

f_c - This number represents the fraction of earth-like planets where the technology to communicate beyond the planet exists. In our own civilization, we have been using television and radio signals for nearly a century. These signals have leaked into outer space and might be detectable by extraterrestrial civilizations. As before, it is extremely difficult to estimate this number.

L - This number represents the number of years that communicating civilizations have existed out of the total lifetime that the galaxy has existed. We call this fraction of years "Lifetime." This number depends both on social issues and technological issues. It is possible that intelligent civilizations elsewhere in the galaxy have existed for millions of years and may or may not choose to communicate beyond their own planet. Alternatively, when civilizations develop the technology to communicate they might simultaneously develop technology capable of making their environment uninhabitable (e.g., weapons of mass destruction). These factors make this number extremely difficult to estimate. L could range from only 100 years to many millions of years.