

Overview: I estimate that the universe has about 41,629 planets with civilizations we could contact. The following variables estimates have been collected using both personal intuition and space data from NASA and the Kepler Space telescope. I must acknowledge the inherently arbitrary nature of many of these estimates.

- **R* (Rate of Star Formation)**

- **Estimate:** A uniform distribution between 1.5 and 3 stars per year. This was the recommended distribution from the assignment.

- **fp (Fraction of Stars with Planets)**

- **Estimate:** A discrete distribution with values [0.8, 0.9, 1] and probabilities [0.25, 0.25, 0.5]. The assignment suggests that this value should approach 1. I created a simple discrete distribution to reflect this.

- **Habitable Planets per Star with Planets**

- **Estimate:** A normal distribution with a mean of 3.0 and a standard deviation of 1.0. Again the assignment instructions made the suggestion here, which is a distribution with the range of 1-5. A mean of 3 and a standard deviation of 1 would create a distribution that closely fits this criteria.

- **Fraction of planets with life out of planets that can support life.**

- **Estimate:** A normal distribution with a mean of 1/30 and a standard deviation of 1/90. Given that Earth is the only planet where life is proven to exist, the probability of life on other planets is speculative, but I based it on the number of planets with life-supporting conditions (around 30 prime candidates identified by NASA).

- **Fraction of planets with life that develop intelligent life**

- **Estimate:** A normal distribution with a mean of 0.04 (4%) and a standard deviation of 0.01. This reflects the estimate that intelligent life is a rare phenomenon. Based on Earth's history, only a few animal classes have developed evolved intelligence. These classes, in my opinion, include Primates, Cetacea, Elephants, and Cephalopods. While I acknowledge that other planets can produce multiple animal classes, thus increasing their odds of generating intelligent life, I wanted to set this estimate on the conservative side. Earth is the only planet that provides a frame of reference but it is important to remember our lack of confidence with this estimate due to such a small sample size.

- **Fraction of habitable planets with Technologically Capable Life**

- **Estimate:** A normal distribution with a mean of 0.01 (1%) and a standard deviation of 0.003. Technological capability on Earth has only emerged with human civilization,

making this parameter extremely rare. The estimate is again conservative for the same reasons mentioned in the intelligent life parameter

- **Lifetime of Technologically Capable Civilizations**

- **Estimate:** A discrete distribution ranging from 1 million to 1 billion years, with varying probabilities. With Earth as our only example to use as a Case Study, it is still incredibly speculative to project how long our civilization will last. I think that humanity has quite a bit of runway left, considering our innate ability to adjust and leverage technology in pursuit of improved well-being. I also believe that we will eventually develop the technology to relocate from planet Earth if/when needed.