Introduction Draft

For years, people have wondered: Are we alone in the vast universe? Over the past decade, the new field of exoplanets has exploded into one of the most popular topics in astronomy. In 2009, NASA launched the Kepler observatory into space, beginning a new era of space exploration: The search for Earth-like planets orbiting other stars. Kepler surveyed over 150,000 stars searching for these Earth-like planets. Kepler detects planets by looking for periodic dips in the brightness of stars. Some planets pass in front of their stars as seen from our point of view on Earth; when they do, they cause their stars to dim slightly. This is what is called the Transit Method. The Kepler satellite continuously surveyed a selected area of 10 degrees by 10 degrees in the Cygnus-Lyra region of the Galactic field to determine the proportion of stars, particularly Main Sequence type stars, showing the planetary transits using light curves (Rhodes and Budding, 2014). To get an idea of how powerful the detectors of the telescope are, that from up in space, it could detect someone in a small town turning off an outer light at night. Kepler has been placed in what's called an "Earth trailing" orbit around the sun. A little wider and slower than our own orbit, the spacecraft will take 371 days to complete one circuit. Each day Kepler falls farther and farther behind Earth—eventually the distance will open to tens of millions of miles. This uncommon orbit, used for the first time with the Spitzer infrared space telescope in 2003, has advantages for astronomical telescopes. One is that Earth doesn't obstruct their view of the sky. The spacecraft doesn't need to be boosted periodically to maintain its altitude above Earth. And best of all, it's a very fuel-efficient orbit, requiring less energy (smaller rocket, lower cost) to reach than the L2 Lagrange point which is where Kepler was originally planned to be Kepler's target. Expect these Earth-trailing orbits to become a popular choice for future astronomy missions.

One year in to its three and one half year mission approximately 3000 planetary transits had been recorded and analyzed. Mostly these are attributed to planets larger than the Earth, although about 10% of candidates hitherto are of a size comparable to that of the Earth. The majority of known examples are smaller than Jupiter, although around 10 percent are of about the same size or larger. About 5% have been located in the 'habitable zones' of their parent stars. NASA announced the positive identification of Earth-sized planets towards the end of 2011. It should also be noted that a fair proportion of initially announced planet finds, perhaps more than $\sim$30% have since been marked as false positives (Rhodes and Budding, 2014).

Specifically, in this article, we will address the formation of exoplanets and what it has to do with stars. As a star begins to form, the protoplanetary disc around it has a collection of debris and other gases that did not fall into the protostar. The debris and gas begin to accrete and eventually will create either rocky planets or gas giants, much like Jupiter or Neptune. In the classical picture developed to explain the Solar System, the process starts with a disk of small solids having just enough mass to reproduce objects in the Solar System. Collisional processes merge small solids into km-sized or larger planetesimals, then Mars-mass protoplanets, and finally Earth mass planets (Kenyon et al., n.d.). These processes are violent and tear apart the protoplanets many times adding new material and also ejecting it. The ejected material is what later forms into the satellites of the planet by the same process on a smaller scale. Therefore, in these early stages the mass of the planets changes often and rapidly. When the star these protoplanets are orbiting finally begins hydrogen fusion, there is and initial “kick” which blows away most, if not all of the debris in the accretion disk revealing the star and its protoplanets. During this time, the protoplanets and their satellites are subject to heavy bombardment, which is one of the last steps in becoming a planet. After the bombardment period has ended, the final structure of the new solar system is exposed.

There are a lot of ways to detect if there is a planet orbiting a star, including transit events, radial velocities, microlensing, imaging, and pulsar timing. The main method of detection is the first, transit events. This was the type of detection the Kepler observatory used. Light curves produced by these transits show dips in the star’s brightness as the object transits in front of it. However we will briefly discuss the other types of exoplanet detections. Pulsar Timing is the method that was used in 1992 by Aleksander Wolszczan and Dale Frail to detect the first confirmed exoplanets. These exoplanets orbit a pulsar, which is a rapidly rotating neutron star. As they spin, pulsars emit intense electromagnetic radiation that is detected on Earth as regular and precisely timed pulses. By analyzing any irregularities in the timing, astronomers can determine if there is a planet orbiting it. Direct imaging of exoplanets is extremely challenging, and in most cases impossible. Being small and dim planets are easily lost in the brilliant glare of the giant stars they orbit. Nevertheless, even with existing telescope technology there are special circumstances in which a planet can be directly observed. Microlensing is the only known method capable of discovering planets at truly great distances from the Earth. Objects that are normally not visible or dim are magnified, leading to discoveries of planets orbiting them. The radial velocity method relies on the fact that a star does not remain completely stationary when it is orbited by a planet. It moves, ever so slightly, in a small circle or ellipse, responding to the gravitational tug of its smaller companion. When viewed from a distance, these slight movements affect the star's normal light spectrum.

There have been a lot of theories as to if there is life out there on these other planets, but we have to take into account the type of star that the planet would be orbiting. Giants and super giants have a relatively short life style. White dwarfs are too old because the event that made them into white dwarf, a supernova, would have likely destroyed any form of life on a planet orbiting. Therefore we are left with regular main sequence stars and to narrow it down to Sun-like stars. The Drake equation for calculating the number of intelligent, communicative civilizations is famously uncertain, with estimates of the civilization incidence per habitable planet ranging from 10^{-5} to arbitrarily small values. Combined with our estimates of the number of Earth-like planets and the fact of our existence, this would result in 1 to 10^{15} civilizations in the Universe and 1 to 10^{4} in the Milky Way at the present time. (Behroozi and Peeples, 2015). The more planets we observe with missions like Kepler, the better odds we have of finding another civilization out there in the unknown.

The trend in data so far shows a correlation between terrestrial planets within 1 AU and solar-type stars. Rocky planets within 1 AU appear to be fairly common companions to solar-type stars. Here, we focus on a comprehensive analysis of Kepler data which provides a detailed estimate for the occurrence rate of Earth-mass planets inside 1 AU (Kenyon et al., n.d.). Assuming the occurrence of Earth-like planets is this common we can reasonable assume that this would be a reasonable place to search for life on another planet. M-type stars have been found to have many exoplanets in recent studies. Tidally locked planets orbiting M-dwarfs face unique challenges to their atmospheric stability. The atmosphere may “collapse” if the volatile inventory freezes out and becomes trapped on the night side. The atmosphere is also subject to erosion by stellar winds, which are denser and faster for M-dwarfs than Sun-like stars. (Kreidberg and Loeb, 2016). The atmosphere must be able to withstand the harsh environments of space and hold in the elements necessary for life and the star must keep the planet at a suitable temperature.