[Eerie music]

[Music continues] Jasper: Space is big. You just won't believe how vastly, hugely, mind-bogglingly big it is. I mean, you may think it's a long way down the road to the chemist's, but that's just peanuts to space."

Jasper: Douglas Adams captures the enormous size of space quite well with that quote from The Hitchhiker's Guide to the Galaxy. But if space is so vast, why haven't we gotten contact from aliens yet?

[Eerie sound]

Jasper: Think of it this way. From our current understanding of physics, information cannot travel faster than the speed of light. This means that if we were to get signals from a planet 300 light years away, it would take 300 years for it to get to us. These signals are some of what SETI, the Search for Extraterrestrial Intelligence, searches for.

Jasper: I spoke with Dr. Alex Howe, a NASA astrophysicist studying exoplanets as well as a podcaster and science fiction writer for "Science Meets Fiction" on the topic of *where are the aliens?*

[Eerie sound]

Jasper: I first wanted to know what exactly SETI was.

Alex: Well SETI stands for the Search for Extraterrestrial Intelligence. There are several meanings of it. One is the SETI institute, which mainly looks for radio signals. SETI can also mean the search for extraterrestrial intelligence generally, which can mean looking for what we call technosignatures, which are any kind of visible signs of technology that we can see in space or around other planets.

Jasper: The Fermi paradox states that if intelligent life is common in our galaxy then there should be a lot of aliens in it, many of which would be older civilizations than ours that would have technology comparable to or better than ours. So there should be a lot of aliens to see, but we haven't seen any. It is not a paradox in the strict sense, but a question of "why haven't we seen aliens?" The simple solution is that aliens are very rare, or maybe there aren't any other aliens. But there are other "solutions", one of which Alex told me was The Great Filter.

Alex: The Great Filter, which is the idea that somewhere between a planet and intelligent life that can communicate across space there is a filter where most planets or biospheres or civilizations don't get through it, and that would be why the aliens are so rare. Now, we think that the emergence of life is pretty common since it happened so early in Earth's history and because we now know there are a lot of planets out there that are potentially earthlike. The emergence of complex multicellular life might be rare because that happened fairly late in Earth's history. The emergence of intelligent life that is able to build a civilization might be rare. And the worrying prospect is that it could be that most civilizations do not live long enough to communicate across interstellar distances. And the worry with that is that that means that the Great Filter might still be in our future.

[Eerie sound]

Jasper: One other aspect to this is that the technosignatures such as the radio signals we are looking for are hard to keep visible across interstellar distances. However, future generations of telescopes will be

better at detecting many different types of technosignatures, such as laser communication, pollution in the planet's atmosphere, or large structures built around a planet.

[Eerie sound]

Jasper: The James Webb Space Telescope could not see this even for the closest stars. But the Nancy Grace Roman wide-field infrared space telescope, a telescope designed to survey wide areas of the sky, would be able to. However, it will only look at planets some. But there is good news ahead. The 2020 decadal survey in astrophysics has the community comes together every 10 years to recommend the most important issues for space institutes such as NASA to research for the next decade. The number one recommendation from the most recent decadal survey was a 6- or 7-meter optical telescope specifically designed to detect biosignatures around nearby stars. Biosignatures are substances or phenomena that provide evidence of past or present life, such as certain atmospheric gases, variability in those gases, and even technosignatures.

[Eerie sound]

Jasper: If you, the listener, want to contribute to the search for extraterrestrial life, there are two main citizen science projects that you can participate in at home. One was SETI@home, which was a volunteer computing project that used your computer's idle time to analyze radio signals. However, that stopped in March of 2020. Another is through Zooniverse, where you can choose a project such as looking at light curves of distant stars and answering simple questions about them to help scientists understand whether or not an exoplanet is going around them. A light curve is a measure of how bright a star is over time, and transits of exoplanets or other structures create dips in the brightness we observe. Human volunteers are important here because humans are really good at pattern recognition tasks. And if you look at enough light curves looking for exoplanets, you might find something interesting.

[Eerie sound]

Jasper: For instance, in 2015, citizen scientists noticed unusual light fluctuations in Boyajians's star. While we now are pretty sure it is just dust, at the time there was talk of it being a large alien-made structure. I asked Alex how scientists would know whether or not something was an alien megastructure.

Alex: It would depend on the design of the megastructure. Basically, if it was larger than a planet could possibly be. Or, you could tell from the shape of the dip something about the shape of the structure and if it turns out to be a square structure than that's definitely artificial.

[Eerie sound]

Jasper: So far, we've only talked about one-way communication. Two-way communication is more difficult, as you have to live long enough as a civilization to get a message there and back. There are a couple of ways to search for life this way, or what we call CETI, Communication with Extraterrestrial Intelligence. For one-way communication, we could look for stray radio signals from alien television broadcasts. There could be older civilizations that have been beaming out signals for thousands of years, which we would likely not be able to communicate with, but we could at least get their signals. We could try for two-way communication by "playing the odds" and beam signals, such as radio waves or

lasers, at a bunch of nearby stars in the hopes that one of them has intelligent life that we just haven't seen yet.

[Eerie sound]

I wonder if we will get an answer to this question in my lifetime? It's a big unknown. Humans are so tiny on the cosmological scale, both in the time we've been here and in the size of the area we have explored. So even if there was intelligent life that was also looking for us, it could struggle to find us just as we have struggled to find them. I myself am an even tinier blip. Learning of the Great Filter was worrying for me. Again, that is the idea that somewhere between a planet and intelligent life that can communicate across interstellar space there is a filter where most civilizations don't get through it which is why we haven't found other life. There are numerous things the great filter could be, such as the emergence of life, the emergence of complex life, intelligent life…. We think that life itself is relatively common, but "complex" and "intelligent" are two important keywords. The Filter could still be ahead of us. It could be that most civilizations do not live long enough to cross interstellar distances, so the Great Filter could still be in our future. There could have been other alien civilizations that worked roughly as our own but grew to die out for one reason or another before they could truly become capable of colonizing space.

Jasper: Maybe one day soon we will receive a signal from a society far away from us, one with technology comparable to ours or perhaps that makes us look primitive. Or maybe it will continue to be mystery for the rest of my life.

[Eerie sound]

Jasper: Which is more unnerving? Being alone, or being one of many? To me the scary part is that we do not know, but I would be far more unnerved to be alone in the galaxy. I asked Alex for some closing thoughts.

Alex: I think it would be more unnerving if we were alone, because it would be very strange – especially given what we know about the origin of life – it would be very strange to find that we are alone in the universe. Life in general, as I said, we suspect is quite common. Complex life, maybe not, but it would still be very surprising if there was no one else out there.

[Eerie music]