**Dictation:**

Why extremophiles bode well for life beyond Earth?

We’ve all seen movies about terrible insects from outer space or stories of abduction by little green man, but the study of life in the universe, including the possibility of extraterrestrial life, is also a serious, scientific pursuit. Astrobiology draws on diverse fields, such as physics, biology, astronomy and geology. To study how life was formed on Earth, how it could form elsewhere, and how we might detect it.

Many ancient religions described other worlds inhabited by known human beings, but these are more like mythical realms or parallel universes than other planets existing in the same physical world. It is only within the last century that scientists have been able to seriously undertake the search for extraterrestrial life.

We know that at the most basic level, organisms on Earth need three things: liquid water, a source of energy and organic, carbon-based material. We also know that the Earth is just the right distance from the Sun, so as not to be either frozen or molten. So, planets within such a habitable range from their own stars may be able to support life.

But while we used to think that life could only exist in such Earth-like environments, one of the most amazing discoveries of astrobiology has been just how versatile life is. We now know that the life can thrive in some of the most extreme environments that’d be fatal for most known organisms. Life is found everywhere, from black smoke of hydrothermal vents, in the dark depths of Earth’s oceans, to bubbling, hot, acidic springs on the flanks of volcanoes, to high up in the atmosphere. Organisms that live in these challenging environments are called extremophiles. And they can survive at extremes of temperature, pressure and radiation. As well as salinity, acidity, and limited availability of sunlight, water or oxygen.

What is the most remarkable about these extremophiles is that they are found thriving in environments that mimic those on alien worlds. One of the most important of these worlds is our red and dusty neighbor, Mars. Today, astrobiologists are exploring places where life might once existed on Mars using NASA’s Curiosity rover. One of these is Gale Crater, an impact crater created when a meteor hit the surface of Mars nearly 3.8 billion years ago. Evidence from orbit suggest past traces of water, which means the crater might once have supported life.

Planets are not the only places astrobiologists are looking at. For example, Europa, one of the moons of Jupiter, and Enceladus and Titan, two of Saturn’s moons, are all exciting possibilities. Although these moons are extremely cold. and two are covered in thick ice, there is evidence of liquid oceans beneath the shell. Could life be floating around in these oceans, or could it be living around black smoker vents at the bottom? Titan is can particularly promising, as it has an atmosphere and Earth-like lakes, seas and rivers flowing across the surface. It is very cold however, too cold for liquid water, so these rivers may instead be flowing with liquid hydrocarbons such as methane and ethane. These are composed of hydrogen, and, more importantly, carbon, which is the basic building block of all life as we know it. So, could life be found in these lakes?

Although instruments are being designed to study these distant worlds, it takes many years to build them. And even longer to get them where they need to be. In the meantime, astrobiologists work in our own natural laboratory, the Earth, to learn about all the weird and wonderful forms of life that can exist, and to help us one day answer one of the humanity’s oldest questions: Are we alone?

**Dictation:**

The operating system of life.

Every chicken was once an egg, every oak tree an ancon, every frog a tadpole. the patch of mold on that old piece of bread in the back of your fridge, not so long ago that was one solitary cell. Even you were once but a gleam in your parents’ eyes. All these organisms share the same basic goal, to perpetuate their own existence.

All lifeforms that we’ve discovered so far, stay alive by using basically the same rules, materials and machinery. Imaging a factory full of robots, these robots have two missions, One, keep the factory running, and two, when the time is right, set up an entirely new factory. To do those things they need assembly instructions, raw materials, plenty of energy, a few rules about when to work normally, when to work quickly or when to stop, and some exchange currencies, because even robot need to get paid.

Each factory has a high security office with blueprints for all the possible factory configurations and complete sets of instructions to make all the different types of robots a factory could ever need. Special robots photocopy these instructions and send them off to help make the building blocks of more robots. They colleagues assemble those parts into still more robots which are transported them to the right location in the factory and given the tools they need to start working.

Every robot draws energy from the central power plant, a giant furnace that can burn regular fuel, but also scrap materials if not enough regular fuel is available. Certain zones in the factory have harsher working conditions so these areas are walled off. But robots inside can at least communicate with the rest of factory through specialized portals embedded directly into the walls.

And you probably figured out, what we are describing here is a cell. The high security office is the nucleus. It stores the blueprints and instructions as deoxyribonucleic acid or DNA. The photocopied instructions are RNA. The robots themselves are mostly proteins, build form amino acids. But they’ll often use special tools that are or are derived from vitamins and minerals. The walls between factory zones and around the factory itself are mostly made up of lipids, a.k.a. fats. In most organisms, the primary fuel source are sugars, but in a pinch, fats and proteins can be broken down and burned in the furnace as well. The portals are membrane proteins, which allow very specific materials and information to pass through the walls at the right times.

Many interactions between robot proteins require some kind of push, think robot minimum wage. A few small but crucial forms of money are transferred between proteins to provide this push. Electrons, protons, oxygen and phosphate groups are the main chemical currencies, and they’re kept in small molecular wallets or larger tote bags to keep them safe.

This is biochemistry. The study of how every part of the factory interacts to keep your life running smoothly in the face of extreme challenges. Maybe there’s too much fuel; your body will store excess as glycogen or fat. Maybe there’s not enough; your body will use up those energy reserves. Maybe a virus or bacteria tries to invade; your body will mobilize the immune system. Maybe you touched something hot or sharp, your nerves will let you know so you can stop. Maybe it’s time to create a new cell or a new person. Amazingly, oak trees, chickens, frogs, and, yes, even you, share so many of the same basic robot and factory designs that biochemists can learn a lot about all of them, all of same time.