Comics and Medicine Script

**1**: (narrator overlooking plains of Africa to see wildlife)

**2**: If you had to look for life beyond Earth…

**3**: how would you do it?
(narrator looking and reading map…. turning to ask the viewer)

**4**: Would you know where to look?

(gazelles looking at moon, narrator asking thumbing upwards)

**5**: ...Would you know what to look for?
(meerkats foraging, narrator holding magnifying glass)

**6**: Would you look for something you might find on Earth?
(walking past montage of different environments + animals)

**7**: What if life beyond Earth…

**8**: *doesn’t look* like life on Earth?
(chimpanzee catching reflection in waterfall…puzzled by reflection; narrator shrugging at viewer)

**9**: Would you look for something new?

(cast shadow against wall… narrator reclined)

**10**: How would you know to call it life?
(creature sees it isn’t an animal, but a projected shadow… narrator sitting up and asking)

**11**: These are all pretty big questions, some you’ve probably never thought about before.

(cut to narrator)

**12**: Researchers at NASA and SETI, however, think about these things all the time.

**13**: They are fascinated with the *big questions* surrounding our existence in the universe, and whether or not we are alone.
(pop out of NASA and SETI buildings, people sitting and discussing behind a conference table)

**14**: Astrobiology is a very unique field of space science that seeks to find *life in space*.
(zoom in on series of chalkboard doodles that show math and planets and aliens)

**15**: That is, extraterrestrial life… *aliens*! (radio playing x files theme song)
(zoom in on alien drawing)

 **16**: But what we may think alien life might look like …

**17**: may actually be closer to what we’re more familiar with on Earth…
(cut into narrator holding a comic book of aliens attacking people)

**18***: Very* familiar with.
(zoom in on narrator peering over comic book)

**19**: They are some of the oldest organisms known to man…

(narrator holding rolled up magazine and walking along NASA hallways)

**20**: ..they are the most populated creatures on the planet...
(walking past other lab crowded with people)

**21**: …they live virtually EVERYWHERE on Earth…
(walking past water cooler with different races of people (turban, sash, chinese, african)

**22**: and yet…. (bending to look into microscope)

**23**: We can’t even see them! (close up of eye in magnifying glass/microscope)

**24**: Microorganisms, like bacteria, are likely the *closest things to life* beyond Earth that we might expect to find.

(zoom in on microscopic view of microbial colonies)

**25**: They are found practically *everywhere*, even in the harshest and unfriendliest environments on earth!

(show landscape montage with callouts on bacteria and their names)

**26**: We don’t really know the conditions or food sources on other planets, making places beyond Earth *extreme environments* to creatures like you and me.

(narrator looking up at narrator and explaining with a pie chart on background demonstrating earth is not extreme and everything else is extreme lol)

**27**: However, bacteria’s *resistance* and *ability to thrive* in these territories makes them good candidates to look for elsewhere in space!
(eyeball looking back into telescope and seeing planet with a microbe on it waving)

**28**: At NASA, many projects are going on to best figure out how to find life beyond Earth.

(overhead view of NASA lab, and callouts on the different projects)

**29**: Of course, it’s hard to know what you’re looking for beyond Earth unless you have a *really good* understanding of how things on Earth work.
(narrator head pop-out in bottom right corner)

**30**: Many projects that astrobiologists work on at NASA are to understand *specific processes* concerning *life* and its *survivability* on Earth.
(black woman holding up petri dish to light, colleague jotting down notes)

**31**: By understanding these processes, we can *hypothesize* how they might occur in other areas beyond Earth. (colleagues talking, one’s thought bubble show microbes)

**32**: Assuming planets and environments in space might have similar conditions, ***terrestrial analogs*** can inform us of what to expect when we investigate the Great Unknown!

**33**: Pavilion Lake, a lake in British Columbia, Canada, is a very special example of a terrestrial analog.

(Earth callout, british Columbia highlighted, large square image of Pavilion Lake with a boat on it)

**34**: It holds one of Earth’s oldest secrets to understanding how microbes have lived for millions – billions! - of years.
(boat swimming out (right to left) with focus on underwater……….. seaweed is forming a question mark)

**35**: The ***Pavilion Lake Research Project*** has kept NASA researchers and scholars busy for over 10 years trying to understand the influence of *microbiology* on *geology*.

(Darlene Lim holding clipboard and talking into walkey-talkey; background is people on boat and loading things up; LOGO is proudly displayed on her vest)

**36**: Deep within the lake is a unique formation of rocks called microbialites.

(overhead view of team lowering things into water from boat, but can see rock formation in water)

**37**: These rocks are believed to be made by the result of tiny, tiny microorganisms *layering* grains of carbonate over *very long periods of time*.

(rover swimming down past cliffs of microbialites)

**38**: The result is a rock that looks like this!

(zoom in of a microbialite!)

**39**: But how are these rocks exactly *formed*?

**40**: How does *life* have a role in *making them*? Does that make them *alive*?

**41**: What does this have to do with *life in space*? (narrator suddenly at lake, talking back to viewer while PLRP team is viewing footage on TV screen)

**42**: It’s an interesting question for rocks…
(walking into building)

**43**: …but one that needs a little bit more understanding on the history and significance of microbialites.

(character sifting through bookshelf, holding one book out)

**44**: (zoom in on book, showing cover “HISTORY OF MICROBIALITES”)

**45**: Shall we? (narrator smiling)

**ACT II**

**1**: Microbialites are some of the oldest rocks known to man.

**2**: They are found all throughout the *geologic record*, meaning they are found *throughout the years* in history…

**3**: …and in *many different places* across the world.

**4**: Astrobiologists studying *terrestrial analogs* are interested in them because they are closely associated with microbial communities.

**5**: See that stuff covering the microbialite? (pointing to microbial mat)

**6**: That’s called a microbial mat, or biofilm (zoom in on microbial mat).

**7**: It looks like a grassy growth on top of some rocks, but it’s actually filled with millions of tiny, tiny bacteria.

**8**: The bacteria that live in the microbial mat are a huge community, and they all live in the mat in different ways.

**9**: In some cases, microbial mats can be divided into sections of individual bacterial species.

**10**: For example, at the top most layer of a microbial mat, you might expect to find *photoautotrophs*.

**11**: These bacteria are the light feeders; they grow closest to the surface since they need the most light.

**12**: Underneath them, however, you might find *heterotrophs*.

**13**: They feed off the byproducts of the photoautotrophs, and rely on them to generate their food.

**14**: The way creatures obtain their energy and use it is called *metabolism*. The metabolisms of these bacteria are very special because they are what drive the formation of microbialites!

(narrator “teaching” by pointing at board where it shows bird + worm = flight)

**15**: That seems a bit weird, doesn’t it?
(zoom in on thinking narrator)

**16**: How do the way that these tiny, tiny creatures eat influence the development of rocks as big as 5 metres tall?!
(character kneeling next to microbialite, unraveling the microbial mat and holding it while outstretched hand is gesturing to microbialite)

**17**: It’s a fascinating question, and it’s where another sector of science becomes involved – *geochemistry*!

(zoom in on narrator; finger pointing, covered in microbial mat)

**18**: *Geochemistry* is the study of chemicals that *make-up* and *interact* within a specific environment.

(walking down slope to a dock)

**19**: The fact that microbialites are found in water is no coincidence.

(looking down from dock into water)

**20**: They are the stunning products of years and years of relentless *geochemical reactions*!

**21**: But they aren’t found in just *any* ol’ body of water.

**22**: If we look at the *water* in Pavilion Lake, we would find that there is *something special* about its *chemical composition*.

**23**: Pavilion Lake has a lot of *carbonate ions* floating freely – aimlessly – in the water column.

***24****: Calcium ions* float around, too!

**25**: There are also a lot of other ions of other elements floating around, too, but we will ignore them!

**26**: Sometimes, two calcium ions will meet a carbonate ion and form *calcium carbonate*… this is called a *precipitation reaction!*

**27**: It looks like a tiny grain of sand!

**28**: Carbonate precipitation occurs frequently in the lake, but it also falls apart a lot due to *other competing reactions* (known as dissolution).

**29**: Bacteria and the way they consume energy makes up part of this system of competing reactions.

**30**: Bacteria interact with the molecules in the water around them, changing the amounts of calcium and carbonate ions available to react with eachother.

**31**: Because of this, they can *influence whether or not carbonate is formed*.

**32**: Most of the time, carbonate is formed very closely with bacterial communities.

**33**: The more bacteria there are more…

**34**: …the more it happens…

**35**: …and the more carbonate that begins to build up!

**36**: Over long periods of time, this continuous process starts to build-up and *form sheets of carbonate.*

**37**: Of course, eventually the amount of carbonate will outrun and grow over the bacteria…

**38**: Unless the bacteria reproduce and grow on top of the carbonate!

**39**: When this happens, the new bacteria can form the same kind of reactions to precipitate even MORE carbonate, forming a NEW sheet of carbonate on top of the old one.

**40**: Over incredibly long periods of time, this continuous process can create large, rock-like structures…

**41**: Microbialites!

**42**: And what’s really cool is that if we cut one in half…

**43**: we can see this *layering process* preserved in the rock!

**44**: It’s because of the way that bacteria helps in making these structures that has NASA astrobiologists so interested in them.

**45**: The close partnership between *geochemistry* and *microbiology* suggests that they can leave behind *signs* in the rocks that life was once there!

**46**: These signs are called *biosignatures*… and they tell us if life lives, or once lived, in a particular environment!

**47**: In the case of microbialites, we can only really see existing life that grows up top of the microbialite.

(narrator straddled on top of microbialite, pointing down at it and explaining how it has an active population)

**48**: But when we look at the base of really large microbialites, ones that have taken *many, many* years to grow…

(panel of narrator at bottom of microbialite, pointing at the structure)

**49**: it could potentially tell us *who* lived there and *how* it helped make the rocks.

(marching lines of bacterial forms showing the communities of bacteria that once made the striated appearance of microbialite)

**50**: Of course, the organisms that made the bases of larger microbialites *many* years ago would have died off by now.

 (narrator brushing himself off)

**51**: So we might look for something else *left behind*.

**52**: It’s kind of like entering an abandoned town…
(narrator walking along)

**53**: and seeing tons of deserted buildings.

(zoom out of narrator walking into abandoned town)

**54**: Abandoned buildings are not examples of life, but they are evidence of life *once living there…*

**55**: and they can tell us how they lived.
(two panels of a house populated with people…then same house but deserted and abandoned)

**56**: So then…what exactly are we looking for?

(Narrator looking at map and scratching head)

**57**: What is it about the old part of microbialites that can tell us what kinds of bacteria lived there?
(pointing at sketch of microbialites with bottom part circled and question mark and bacteria)

**58**: The cool thing about biosignatures is that there are LOTS of them –
(back to looking at narrator)

**59**: The easy ones to spot can be minerals…

(holding a gem from a collection of gems in corner while panel shows buncha mineral shapes)

**60**: …fossils…

(zoom in on fossils; narrator holding a bone)

**61**:… shapes...

(zoom in on shapes in rock; narrator making square with palms)

**62**: …and most importantly, chemicals.

**63**: Remember that microbialites are made of the chemicals that are being *directly u*sed by bacteria.
(zoom in on narrators palms, holding bacteria in one, and holding carbonate in other)

**64**: In that case, what we’re looking for is a *chemical biosignature*.

(magnifying glass into microbialite while holding it with one hand)

**65**: Researchers at PLRP have been working to understand how these chemical biosignatures are formed and preserved in the microbialite carbonate.
(narrator on back of boat while NASA people are looking at screens and over boat at microbialites)

**66**: It’s no easy task! Remember how I said that carbonate can be *unformed* by *competing reactions* through dissolution?
(microbialite breaking apart and dissolving into water)
**67**: Even when a carbonate particle is formed, the surrounding water’s chemistry can still have effects that *break it apart*.
(later part of dissolved particles showing smaller breakdown, and the chemical separation of ions)

68: If a chemical signature exists in a piece of carbonate that was formed hundreds of years ago…

69: it could still potentially be *destroyed* by *random competing reactions*.
(microbialite with a lil flag saying “BIO!”…..but broken apart and lost in the water)

70: In some cases, new bacteria or other life forms can disrupt the structure or even chemical composition of the microbialite to *alter* biosignatures.

(a crayfish coming by and taking the flag)

71: It’s a very tricky thing to investigate, but researchers are adamantly working to uncover the system of processes that affect the *production* and *preservation* of biosignatures.
(narrator standing behind shoulders of Darlene and Allyson while Darlene and Allyson look puzzled Lol)

**72**: In doing so, we gain a better understanding of how life existed on Earth many years ago…

**73**: and how it has changed over time.

(narrator standing in between, showing Precambrian once upon a time on left, and the evolution from cell to man in modern world on right)

**74**: This research is very important to forming a *starting point* for finding life in extraterrestrial environments.
(narrator holding hand up to night sky with planet in the background, with a space ship going up; narrator holding a helmet)

**75**: Imagine if we found a dried-out lake on a planet far away… and we could find *chemical biosignatures* like the ones on Earth?
(narrator in ship, holding up hands to window to look at planet with lakes on it)

**76**: Maybe we won’t find life like on Earth… but it would be another stepping stone to uncovering the potential for survivability in our solar system.

(jumping down from spaceship)

**77**: And who knows?
(narrator turning around to look at viewer)

**78**: Maybe it could lead us to finding new, *unknown forms* of life as well!

(threatening shadow from the NASA rover)

**79**: NASA already has a rover on Mars…

(rover comes into view and is trailing along)

**80**: and we’ve already started sending satellites deep into space to collect data on far-away planets.

(satellites travelling in space)

**81**: (same panel but a black circle around it)

**82**: Maybe someday we’ll be able to find out that something…or someone… is out there.

(narrator looking back from telescope)

**83**: Until then, we have *a lot* of work to do.

(cut to scientists working, narrator walking behind them)

**84**: A lot of *exciting* and *thrilling* work.

(cut to scientists working, walking behind more)

**85**: And we’re just getting started!

(cut to narrator reading book in front of class children studying/looking at microscopes)