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“Talk about some bioprospecting issues. What I wanted to start with since some of these are ethical issues is give you my background [to] the kind of research that I do so you know where I’m coming from. I am a chemical engineer and a professor in the chemical and biological engineering department. I am also the associate director of the thermal biology institute which is an institute at Montana State. Our goal is to study the interactions of biology and geology in these hot springs in Yellowstone. We have about 25 faculty that cover everything from geologists, to microbiologists, to land resources, and more recently engineers and bioengineers into the Yellowstone research. I’ve been coming out doing sampling for about 5 years now. I was at Washington State and did a sabbatical here at MSU to study the organisms in Yellowstone. While I was on sabbatical I interviewed for a position and got the position and have been here ever since. I actually did my PhD at MSU so it’s good to be back

As ~~an~~ engineers’ we look for ways to apply things. So most of the research I do is finding information about the organisms in the hot springs and then looking for possible applications. So as you can guess I am a proponent of being able to take small samples from hot springs and look for possible applications of these organisms. At the same time we are characterizing springs that are mostly focused on the Heart Lake geyser basin, which if you keep going south about as far as you can go in the park you will get to Louis Lake on one side and on the other side of the highway on the east side is Heart Lake; its about seven miles from the highway. The only way to get in there is either to walk or ride a horse. It is way out of the public view. It is not a place that has been studied a lot so there is a lot of fresh territory there as far as research goes. So we go in and we used to do day trips. We originally started looking for these hot springs and these down in Heart Lake are extremely high pH, some of the highest in the park. pH 9 is normal; occasionally we get pH 9.5 and also temperatures anywhere from normal, cold temperatures all the way up to 93 degrees centigrade which, for this elevation the boiling point of water, which is quite a range of temperatures.

So what we typically do is go in and we first started looking for organisms that can degrade cellulose materials like wood, trees, things like that and the goal when we first started going in was to look for organisms that can break down cellulose and lignin into component sugars that can then be used to make ethanol, bio-ethanol. Finding these enzymes from these organisms that can convert cellulose and break down lignin so that the sugars can then be fermented. There are a lot of commercial applications and a lot of fundamental science that needs to be done to discover those and that is basically why we started. We started looking for those organisms, but after that we also started taking those samples we collected and not only looking for organisms of commercial value but also extracting DNA out of the small samples and just trying to characterize the micro organisms the microbial community from these hot springs that nobody has even really pulled samples from ever, that we know of. So what we find when we start doing that is that you take maybe a gram of soil or sediment out of these hot springs, so a teaspoon full. We find on the order of maybe two to three hundred different species of organisms in that gram of sediment, of those probably 50-80% somebody has found DNA of an organism related to that at some point, somewhere. We compare it to an international database. The other 20% of the organisms there are no DNA sequences close to those. So these are entirely new organisms and even of the ones known, very few of those have ever been grown in the laboratory. I don’t know how much microbial background you have, but if you think about all of the biotechnology that we’ve got right now, that’s based maybe 1% or maybe 1/10% of the total microbial diversity that’s out there. So you think, out of all of the biotechnology that exists today is based on less than 1% of the possible biotechnology that is out there. So going to places like Yellowstone and discovering and cataloging new organisms is a valuable effort and trying to grow those in a laboratory is difficult. It is much easier just to take a little sample and extract DNA then to actually get those organisms to grow in a lab. We’ve got a lot of specialized equipment to do that and we get some but we probably get a tiny fraction of what is out there.

“***Do you try at that time to try and simulate then the environment where you took that sample?”*** “We do our best, we take water samples and we measure for all of the elements with ICPMS (inductively coupled plasma mass spectrometry). So we measure all of the elements and try to make growth media that matches those. We measure the pH, we match that. We measure the temperature and we match that. We have special incubators that go up to 80 degrees C in this case. They’re pretty hot. We’ve got lots of gloves and hot pads around for handling our bottles. We’re fairly successful at doing that.

The main method that we use is a sterile bottle tied onto; we used to use a golf ball retriever because they stretch out about eight feet long. We stay as far back from the spring as possible with the sterile bottle on the end and dip it in and get a little bit of sediment. Now we use those extendable window washers and they are much sturdier when you get a big bottle of sediment on the end of one of those golf ball retrievers it gets kind of floppy, but that’s the main way that we sample.

***“If you stay that far back, how do you measure all of the other stuff such as the pH and the temperature?”*** We have the ph meters and sometimes we can get close. They way we judge where to go is if there are plants alive it’s probably safe to walk there, but if there are no plants you want to be much more careful. We use our walking sticks to pound the surface, if it sounds hollow you do not want to walk there and if it breaks through you obviously don’t want to walk there. If there is plants you can get closer, otherwise we will use a ph probe which has a temperature probe on it and hook it on the end of the golf ball retriever and hang it out in the spring and move it around that way. That is how we get the samples.

Then what we do is we take those samples and as soon as possible put them on dry ice, so that the organisms that are there do not change, start degrading, or break up there DNA and we get as accurate of a sample of the microbial community as possible. Man asks, ***“If you actually try to culture them later do you have to take a boiling hot sample?”*** The ones that we are trying to culture we carry stainless steel thermoses to keep them warm in. The ones that we want to extract the DNA from we freeze them immediately and that seems to be the best way.

***“How do you get your permits to actually take samples?”*** I just renewed my permit this year, so I have continuously had a permit for five years. I actually brought a copy if anyone wants to see. There is a little bit of information on the front that is project specific and then there are about three pages of regulations. Essentially you write up a little proposal saying that you are going to go into the Heart Lake area to collect some 50 ml sediment samples and collect some water samples. You tell them everything you think you are going to do or hope you are going to do. Also, when you first do it you have to get two or three other scientists to peer review your proposal to make sure that you’re not doing something really stupid. Then that goes to the permit office here and they review that. They have a board here in the park that has a variety of people; microbial people, museum curators, specimen collection people, and resource people. They review it for any potential damage to the park, the esthetics, or the visitors’ pleasure.

***“How many permits do they allow or issue?”*** I think they have around 300 to 500 permits active in any given year, but that includes people like me who are collecting microbial samples, people who are doing coyote studies and elk studies. They cover the whole gamete. “***Did you say it takes a review every five years?”*** No it takes a review every year. I have renewed mine. This is the fifth year I have renewed mine. ***“So that’s a fairly heavy overhead.”*** It takes a few hours. I wouldn’t call it a heavy overhead. It’s not bad. The first time through it’s slower. The renewal process is easier than the first time you go through.

“***Do they limit the amount that you take or do you have to describe it in your proposal?”*** Yeah, you have to describe. The first time we had said we were going to take larger samples and they asked if we could get by with smaller samples. We said that we could and that we were just trying to cover our bases.

***“As a researcher, are you aware of any other research projects that are going on in the park simultaneously?”*** I’m aware of the other microbial, not all of them obviously. I’ve seen a list of the ones that are microbial related. I am also aware of the other researchers from the thermal biology institute that are doing work down here and our affiliates. We’ve got a lot of collaborators that work down here too. So, I am aware of a lot of it, but I don’t know exquisite details on all of them.

***“What are you required to do after your studies?”*** After the studies, we come back, do our lab work, at the end of the year we have to do two reports. One is a summary of our results. It’s a page or two. I think we are limited to 4000 words for their database. We also have to give them a GPS log of every location that we’ve sampled. This is the first year on the permits they require you to take a GPS and give them the coordinates of the locations that you have sampled. We’ve always done that because we’re so far out there.

***“What is the cost of the permits?”*** There is no cost for the permits. Essentially it’s a service that the park provides as a way to manage this kind of research.

***“Then are you able to sell your research?”*** So there are two things. Our goal is to publish the research in peer review journals so that it’s accessible to everybody. At the same time, we do have a project that we’ve isolated some organisms and are considering trying to patent the application of those organisms. Its an algae that produces a lot of oil, so we can grow this organism with sunlight and CO2 from the atmosphere and produce oil for biodiesel. So, we’re kind of on both sides; potentially commercial. I have four patents, but none from Yellowstone organisms.

“***Do you worry about taking a specimen that might be the only one of that kind?”*** With microorganisms, I really don’t. We go in and sample say a spring the size of that one and we take maybe a 50 ml bottle of sediment and you look around and there’s square meters of the same kind of environment. And you go back a few months later and you can’t tell where you’ve sampled. It’s re-grown. Another thing is, I looked through a lot of websites for this bioprospecting thing and there’s a lot of language in there that sounds like mining. It sounds like we’re going in and we’re just going to scoop that spring up with a bulldozer and that is not true. We take a small sample and take it back to the lab and try to grow things from that sample. So, it’s more like taking a seed and growing it somewhere else, than harvesting or mining these hot springs. I don’t condone that by any means.

***“What’s the benefit to the national parks?”*** Right now, that’s really hard to say. The benefit of the research is, that most people can see, by knowing more about the park they know more about the resources that they’ve got. There’s more understanding and when people want to learn about hot springs then someone has something to tell you rather than its blue. As far as the commercial side of things, that was tied up in the courts for quite a while. The environmental impact statement is back in Washington D.C. right now with the Department of the Interior being reviewed. With the change in the administration I heard that no one knows when that will be done. Potentially the park, if anyone commercializes anything out of the park from not long ago on, the park should get some revenue stream back from that to help either preserve or help the scientific efforts.

***“Do you know what percentage?”*** No, I don’t. From what I can tell because I’ve never done it, it’s a reasonable percentage but it’s on a case by case basis. So you guys are probably familiar with the Diversa case? Apparently Diversa was ready to make payments to the park and this whole lawsuit stopped that. So as far as I know, the park has never gotten any money out of Diversa. And I know, Diversa still has a permit and is still sampling. So, the lawsuit kind of backfired as far as I can tell.

“***As an academic from an accredited institution is the permit process simpler or easier for you for you than it would be for a commercial entity or are there other commercial entities working in the park at the moment?***” I’m sure there are. I’ve seen lists of who has permits and who historically who has had permits and there are commercial entities in the park. Diversa is the big forefront one, but there are others. I don’t know if it’s easier for me to get a permit or not. They probably look at theirs a little more closely I would guess, but I don’t know if that is an official policy or not. Do you guys know **Christy *Hendricks*** *(Christie L. Hendrix – Research Permit Facilitator, Yellowstone Center for Resources, NPS, Christie\_hendrix@nps.gov)* have you talked to Christy? “Well I know Christy and she’s kind of the permit…I don’t know her official title.” The permit coordinator I think or something. “She’s the one that you go through from the start to make sure you get the proper scientific collecting permits to obtain specimens for study….” (Microphone problems?)

“***So is it public knowledge, can I gather that information about who’s in the park? Is there a list somewhere?”*** There is a list of the annual reports that each person with a permit is required to put in. So yes, you can find that on the park website. It’s on the park website and you can also call and they will send you a copy. That changes maybe by the month or by the year. Certainly the month. They try to get all of their permit applications in by March. That doesn’t always happen, in fact I’m guilty of getting mine in late this year. But, the area that we sample we can’t even get in until July 1st because of the bear enclosures. So, she processes them year round, but they try to get the bulk of them in by March.

*(permits web site, http://www.nps.gov/yell/naturescience/researchpermit.htm)*

“Well I’m just thinking out our time and I’m not sure what you’d like to do, but we can head down and there is kind of a dead end at the boardwalk down here by Canary that you can see a little bit of a closer view of the different microbes and the interesting thing is that there’s a killdeer down there feeding. So there’s a cool little process, a food chain happening right there where the killdeer is feeding in the kind of bacterial mat, but not going after the microbes, it’s actually going after something that’s eating the microbes. There are some small little afidrid flies that might be living in there, so the bird eats the flies or the spider that’s eating the fly and then you’ve got the flies eating the bacteria feeding on something in the water. So, there’s a small little food chain right of the boardwalk that 99.9% of people wouldn’t even pay attention to.

 ***“Do you know what the acceptance rate of applications is?”*** I’d guess it’s pretty high. It’s an iterative process so if you turn it in and they don’t like it. They will tell you why and then you can choose to change it or not. So, I think it’s pretty high. “Is it similar here to other places? Or have you researched other places?”

“Someone actually took their sandals off and walked out there.” “Geeze” “As much as we say about the rules and regulations and everything, but what I think is cool is like back in February I guess there was water flowing through here and that wolf. Also, I like to talk about the changes in colors too, kind of that temperature gradient. You can tell a lot by colors to some extent because of the changes between summer and winter, but also just the heat of the spring’s run out channel compared to the dark colors off to the cooler. I’m really shocked that one track goes out there and then more people decide to step off.” “Here’s your wolf track.”

“For the most part that is coming out of the….the hot water goes through deeper formations and then as it cools it deposits, or precipitates out.