FEHLER

Seeking and Blundering

by Katie Davis

[*Music*]

Katie Davis: I'm Katie Davis with a story. An old, moldy one. [*Music*]

> **Susan Byrnes**: So, this image of penicillin mold looks as if you're looking down on an island almost in a yellow sea looking on – down onto treetops almost with a kind of little, tiny spines and surrounded by a circle of white that then becomes this kind of milky, yellow field that it's in. So it seems like we're looking at a close-up of…a close-up of something in a petri dish.

Katie Davis: Susan Byrnes, an Ohio artist, likes the color and the movement of mold. Mold is unruly: sometimes sly, temperamental, surprising, spongy or slimy, and it's best to wash it off with bleach. That's what we do with mold.

> **Susan Byrnes**: As it moves out it's almost as if there's this sort of feathery, whiter field around the outside of it and it's…you can see how the mold has migrated because outside of that ring is the beginnings of another bit of mold growing. And you can see…

Katie Davis: Enough with the mold, you're thinking. Hang on, here's the backstory. London, 1928. Biologist Alexander Fleming had a messy lab. There were test tubes, beakers, rubber bands, string, and petri dishes. And this story of a mistake has been told and retold. Researchers have questioned some details, and still it survives – like mold, reemerging in books, movies, and cartoons.

> **Cartoon**: Having been brought up on a farm in Scotland, scientist Alexander Fleming wasn't afraid of getting his hands dirty examining nasty bacteria like staphylococcus aureus which in humans as well as horses can cause death as well as vomiting and boils.

Katie Davis: In the days before antibiotics a cold, even a blister, could get infected and lead to death. So, here's the story: Alexander Fleming came home from a month-long vacation and his lab bench was full of dirty petri dishes. No surprise there.

> **Cartoon**: But instead of throwing them away he stopped to think what might've caused some of his sample to die and the rest to live? After a lot of time and effort in his lab Fleming worked out that some of the sample had been contaminated by a particular fungus, which he then managed to grow himself. As an ex-soldier in World War I, he'd seen hundreds of soldiers die due to bacterial infection and he figured that if the fungus could kill bacteria on his bench it might also kill bacteria in wounded soldiers. And he was right.

Katie Davis: Fleming studied that mold. How did it kill the bacteria? He called it mold juice and later a more proper name.

> **Cartoon**: Having renamed his mold juice 'Penicillin,' it was ready for public consumption in time for the next war on D-Day.

Katie Davis: Penicillin was a mistake, yes. Alexander Fleming called it chance.

> **Phil Plait**: Well my name is Phil Plait. I am an astronomer and science communicator and I write the *Bad Astronomy* blog for syfy.com. I was taught that you try to be right, right? You memorize facts. You try to repeat them on a test. The teacher asks you a question, you try to get it right in class. And so, you're never really tested on methodology. Maybe in some math classes like geometry where they say, "Prove that the interior angles of a triangle add up to 180 degrees," something like that, and then you go through a series of proofs. But other than that, you're never taught that making mistakes is okay. The only time – and maybe the only time I would say – since I'm thinking of this as you've asked it, I've never really thought of this question this way, in writing class for example you would come up with an outline, a first draft, right? A rough draft which you then fix and correct. So, there's a process there to where you come up with your finished essay, and in fact when I was a kid they would call it the perfect paragraph, the perfect essay. There was a name like that, the five-paragraph perfect essay. And so even then you're striving for perfection. You're not striving just to make steps along the way. The ultimate goal is always to be right. And I – hmm, now that I think about it since you phrased it that way, that's troublesome.

Katie Davis: Phil Plait remembers an exam in grad school with a ten-part problem. In step two he used a minus sign instead of a plus. The professor looked at his work and saw the mistake.

> **Phil Plait**: And that was a big moment in my life when the professor then said, "I'm going to give you not ten percent credit; I'm going to give you sixty or seventy," or whatever percent he gave me, saying "You knew what you were doing, you just sort of screwed up." And that was a big time when I realized yeah, most of this is not about memorizing and everything. It's about understanding what you're doing.

Katie Davis: Phil Plait is an evangelist, an evangelist for mistakes, and he's seen a few epic ones.

Phil Plait: So, the story is that people have been searching for planets around other stars for a long, long time, many, many decades, and it's extremely difficult to do this. The effect of the planet on the stars is incredibly small and nobody had ever successfully shown that there was a planet orbiting another star. And then in '91 a couple of astronomers, Andrew Lyne and Matthew Bailes, announced that they had found a planet orbiting another star. And it wasn't just a star like the sun – it was a pulsar. These are bizarre objects. They're the collapsed cores of massive stars after these stars explode. So really big stars explode in supernovae, and the core collapses, and that's how you get black holes. But if the star isn't quite massive enough you get a neutron star. And it spins rapidly, has a very strong magnetic field, and we call these pulsars. Well it turns out that the beauty of a pulsar is it gives off a radio blip in very, very exacting intervals: bip, bip, bip, bip, bip. And you can measure the time between these pulses, and it's almost always exactly the same. And if a planet is orbiting that pulsar it's tugging on that object, and the pulses get affected. They arrive at different times, slightly different times. And that's what they thought they had found.

And so they made this big announcement saying we found this change in the arrival times of these pulses, it must be caused by a planet, and there was a big foofarah about that. A lot of people were celebrating it, other people were skeptical.

But then, it turns out some comments from astronomers said, "You know, the change that you're seeing in these pulses appears to be a simple multiple of Earth's orbital period." And that's a big red flag. When you're looking at something in space and you say this thing is changing and it's changing on a period of 365 days the first thing people are going to say is that sounds like the orbit of the Earth is affecting your measurements, not that this is a real thing. And it turns out, sure enough, when they looked at their data more carefully they realized yeah, that's exactly what was going on. The Earth going around the sun was affecting their observations and when they subtracted that away their planet disappeared basically. The change that they saw went away.

And so, they had to stand up and say, "Yeah, we made a mistake. This is wrong. We did not discover a planet around a pulsar." And Andrew Lynn did this at an American Astronomical Society meeting, which is a big meeting of astronomers in the U.S.. And amazingly he stood up and said "Yeah, we messed up. This is not a planet, and we apologize." And everybody applauded him. They were proud of him for standing up and admitting this mistake, a very embarrassing mistake. And I was actually – when I heard about this I was quite pleased. I thought that was pretty amazing.

The really fun thing about this is the next guy literally to stand up and give his talk at this meeting, Alexander Volshan, he and his team had been looking at a different pulsar, and they found the same effect. And it turns out they knew that the Earth's motion around the sun could affect their data, they accounted for that, and their planet persisted.

Katie Davis: At times, Phil Plait says people try to shame him over mistakes.

> **Phil Plait**: Shaming is not a scientific process, I would say. In fact, I've had people try to shame me for mistakes like that but I refuse to be shamed. Am I embarrassed? Yes. But am I shameful? No, because I've learned from that mistake. I try not to make them again. I try to fully own up to it. And like I said I've made some pretty big errors [*laughs*] and then I'll follow up with a mea culpa and say, "Here's how I messed up. Here's the mistake I made."
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> I also try to say "This is why that mistake happened. Here's what I was thinking." And that I think is important. People say when you apologize don't talk about why you made the mistake that you're apologizing for. And it's like well if I hurt somebody's feelings I understand that I shouldn't try to explain what I was thinking because that kind of digs a hole and it's not about me, it's about their feelings.
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> On the other hand, when it's science, if that thought process that I was employing led to my mistake then I have to examine it and say oh, here is what happened. I was distracted by a phone call or I made a typo and for some reason that typo made me think of some other thing and I just went with it. And so now I have circled that mistake. I understand what I did, I've shone a light on it, and I can try not to make it again. And I think that is the key.
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> In a story I read many years ago somebody said the main part of the word absolution is solution. So, you know, people can forgive if they see that you're trying to fix the process that led to that error in the first place.

[*music*]

> **Newsreel**: Filling bottles with the medium in which will grow the mold that produces penicillin. [*Inaudible*] this amazing drug, perhaps the medical discovery of the war, has been greatly increased. The medium has here been sterilized, an early process which is later followed by its inoculation with the seeds of penicillin mold. After its incubation, we see in these bottles the mold that contains this new life-saving product.

Katie Davis: Later on, other scientists discovered a way to extract penicillin from the mold, and they shared a Nobel Prize with Alexander Fleming. Fleming began to paint water colors with the mold, tiny portraits, a woman giving a bottle to a baby, two stick figures dancing, and a face. The petri dish was the frame.

> **Susan Byrnes**: In the arts there's a kind of concept of 'wabi-sabi,' and it's a way of coming across something that you didn't expect and appreciating it for what it is and looking into it and trying to understand that mistake or that crack in the – you know, when the ceramic in the kiln cracks. Instead of throwing the pot away, or when it breaks and is repaired, it's repaired with gold and the crack itself is revered, understood as a whole new form. I have to applaud Dr. Fleming for really examining what this material is and why it developed and finding something that we would

normally discard immediately in nature and seeing in it the possibility of something very valuable.

[*music*]

Phil Plait: I'm not saying you should go out and make mistakes necessarily – certain kinds of mistakes certainly. You know, don't drink bleach to try to kill coronavirus for example. That would be a huge mistake. That would be a life-threatening mistake. On the other hand, science proceeds by making mistakes, and so it's a process that meanders quite a bit but hopefully leads somewhere closer to understanding.

Katie Davis: Phil Plait is a science communicator, a.k.a. the Bad Astronomer, and Susan Byrnes is an Ohio artist, and she helped us imagine the mold. And I'm Katie Davis.

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