Astronomy Cast Episode 67:
Building a Career in Astronomy

Fraser Cain: With all the enthusiasm that's being generated with astronomy, it's had a bit of a strange side-effect. We've been causing some of our listeners to have midlife crises about their careers. We've had other people who just want advice – they're moving into college for the first time and they want to direct the courses they're going to be taking into astronomy. Some other people already have skills that are very useful and have wondered how they can help up or even change their career to be working in the field. We thought we'd try and answer everyone's questions all at once and just run through the major career paths you can take that relate to astronomy and space, and what kinds of things you'll need to do to actually make yourself a good candidate for that field.

What I thought we'd do actually, is start with a biography Pamela – we'll do mine afterward.

How did you go from a straight-A high school student to a professor, a researching astronomer with a doctorate in there somewhere… what was the process?

Dr. Pamela Gay: I have to admit – I wasn't a straight-A high school student. There was this class called German that really almost killed me.

Fraser: Oh, okay. All right.

Pamela: Don't ever ask me to speak German, it's just an act of personal humiliation – and there were a lot of B's thrown in there.

Fraser: Okay, okay, fine. I didn't actually find out what your grades were, I just guessed.

[laughter]

You could've just gone along with it, but okay – go on.

Pamela: That's one of the things, a lot of people assume, "I'm not a straight-A student, I couldn't possibly be an astronomer because don't you have to be really smart?"

Well, yeah, you have to e really smart, but grades aren't the only diagnostic of are you a smart person or not. Sometimes grades are more of a reflection of, "I was a high school student: there were times I didn't care about trigonometry."

What you do need is good grades in science and math, and an ability to communicate. You don't have to know how to analyse Shakespeare and poetry (although a lot of scientists can do that), but you do need to know how to

communicate effectively so you can say, "I came up with this great discovery, let me tell you about it!" and other people will understand what you're saying.

But that's neither here nor there.

To get from nerdy high school student (which I will admit to being – if there was a science club, I was there. If there was a band thing, I was there). To get from that to PhD astronomer took 4 years of college and 4 semesters of calculus.

I went to Michigan State University as an undergrad. I took physics classes – every single class that was possible to take, I took. To be a good astronomer, you have to understand all the physics as well as the astronomy. I also took a large number of math and computer science classes. Many astronomers actually end up also getting a degree in mathematics as an undergrad, because there's so much math involved in doing physics and astronomy.

Now, if you're sitting there going, "oh my god, I hate math, I could never do that" that's okay – I'm sitting right there with you. Instead you can learn how to do computer programming. There is so much stuff out there that requires database programming right now. If, instead of becoming an amazing calculus/linear algebra/abstract algebra super-guru, you go out and become an expert database programmer, an expert large number statistics and mathematical modelling programmer, those are other skills that are extremely useful in becoming an astronomer.

Fraser: Right, but I don't think that we can really protect people from the math.

Pamela: No – you have to take four semesters of calculus.

Fraser: Yeah, I mean a lot of what you do as an astronomer is crunch numbers – you look at the math, you make calculations, you're trying to make predictions and that all just comes from math – your gravity, you're calculating light. It's just math, math, math. Not to mention the really hard stuff, like what the cosmologists and the theoretical physicists are working on. That's a whole other level. Even just regular, day-to-day being an astronomer does involve a lot more math than any other career.

Pamela: So you have to survive in math. You have to understand the math, but you can tune what area of astronomy you go into to decide either, "I love/adore mathematics, I'm going to become a cosmologist who does theoretical models of the universe," or you can decide, "I'm going to go off and do research on quasars and the Sloan Digital Sky Survey looking for statistical trends," where you need to understand the statistics, but the majority of your day-to-day work is computer programming.

Fraser: So does the undergrad degree really matter?

Pamela: The undergrad degree matters in terms of that's the first step to getting into graduate school.

Fraser: Would you say a math degree, a chemistry degree, a physics degree, a computer science degree, all those would be appropriate?

Pamela: I've met people in graduate school who have degrees in mathematics, physics and astrophysics primarily. There are other people who have other degrees. There was a woman who went to graduate school with me, Marsha Wolfe, she had a degree in electrical engineering, and she could make telescopes do things that most of the technicians couldn't. she did fabulous work on the Hobby-Eberly Telescope as a graduate student because she had this background in electrical engineering.

So there are always exceptions to the rules, but in general the straight paths that are most often taken are to get an undergraduate degree in astronomy, physics or mathematics.

Fraser: Okay, so that's four years – what's next?

Pamela: Next is graduate school. While you're doing that undergrad work, you need to look for research opportunities. There are summer programs – the National Science Foundation funds what are called REUs. This is where you get research experience as an undergrad by going off to some university other than the one you're attending, or going off to some centre like Kitt Peak National Observatory in Arizona, and you spend your entire summer doing research.

Fraser: This is probably where our previous podcast on how amateurs can contribute dovetails into this. If you've already been an amateur and have already made some of those connections, you can probably then draw on them and contact some of the researchers and say, "I'm working on my graduate degree now, are there any opportunities to do research work with what you're doing?" If you've done things really well, you've probably had a lot of doors open for you.

Pamela: One of the neat doors is occasionally you'll get amateur astronomers who have an undergraduate degree that they got 10-15 years ago in electrical engineering, computer science – some technical field – and they've been working in that field since they graduated, but they're off doing amateur astronomy. They're off working with researchers or doing day-to-day observational data reduction – all the normal grunt work that gets given to grad students.

They go, and they fill in the things they didn't get that you need to get into graduate school – a few classes in astronomy, a few classes in calculus… then they apply for graduate school right off the bat as a mid-life career change,

going to grad school in their 40's and 50's, jumping headlong into their research… but they're ready because of the stuff they've been doing as amateurs.

This is a very rare case, but I can think of three different people who've made that mid-life change of career.

Fraser: I think some of the people who've emailed us have sounded like they're in that class: people who've been engineers or computer scientists for the last ten years, and have always wanted to get involved in astronomy.

How many years, then, of graduate school? Is there a master's degree first?

Pamela: It's typically a two-year master's degree. You often do your master's and your PhD at the same institution and often in the same area of research.

Fraser: So where did you do your master's degree?

Pamela: I went to the university of Texas. I'm actually kind of an oddball: I did my master's degree on variable star astronomy and then I did my PhD on observational cosmology – I did the evolution of galaxies in clusters.

You can break things apart. The more general ay to do it is to pick a topic and stick with it. You stick with it for sometimes upwards of six, seven, eight different years.

Theorists: people who focus on the math and doing the computer modelling of how the universe behaves, they often escape a little bit faster because they're not waiting to get their data. People who actually build instruments, it'll take them a little bit longer. You might see a theorist escape from starting graduate school to finishing their PHD in five years (that's with both the master's degree and the PhD), whereas someone who builds an instrument will still get the master's degree at the end of two years, but it might be eight years down the line from starting graduate school to getting the PhD before they finally have that sheepskin they can walk away with.

Fraser: How many total years did you do in grad school?

Pamela: Six and a half years.

Fraser: You did six and a half years of graduate school, and four years of undergraduate school.

Pamela: Ten and a half years of my life.

Fraser: That's ten and a half years of school.

Pamela: Yep.

Fraser: It's not like you did it part time – you were pretty solid for most of the at time, right?

Pamela: I never went off to Europe for a summer. The summer between freshman and sophomore year of undergrad I spent working at MIT. The summers after that I spent doing astronomy research. Graduate school was non-stop the entire time. Yeah I went through… I don't always recommend this. I think everyone needs to go somewhere for a summer and just… be 20.

Fraser: Yeah.

Pamela: But yeah, I went straight through.

Fraser: Okay, and then things didn't really get started then… so you're ten and a half years of school in, then what?

Pamela: The normal route after that is to go off and do a post-doc. You spend anywhere from six months to three years at another university learning how to run your own research program.

When you're in graduate school, you're working on your own research project, but you have your dissertation advisor and often an entire dissertation committee to herd you – to say, "you might want to look at these journal articles," or, "you might want to register for this conference, let's work on writing this paper together." You're answering questions where you're the only one working to find the answer, but there's people guiding how you do that.

Fraser: So where did you do your post-doc work?

Pamela: This is where, again, I was an oddball. I've always wanted to do public outreach, so for me the path wasn't a straight one. I actually jumped from getting my PhD to working as an editor at Astronomy Magazine for one year. Then I went to Harvard and worked as instructional staff for three years.

The other route you can do if you don't do the post-doc route is you can go and take a visiting professor position and work as an instructor for a certain period of time. You spend a few years getting teaching experience. That was more the direction I was leaning in.

After spending a year doing something totally different with my brain, I went and worked at Harvard where I was an instructional laboratory associate. While I was there, I got to do some teaching and learn how to develop good labs, work

with the telescope there. From there I came to Southern Illinois University Edwardsville where I'm on the faculty.

Fraser: All right. You're really just getting started.

Pamela: I'm a baby astronomer.

Fraser: Yeah, being on the faculty… what will the future hold, theoretically for your position? You've only essentially been a professor for a couple of years now.

Pamela: Right now I'm what's called an adjunct professor.

There's lots of different positions. We usually talk about them as soft-money positions and hard-money positions. people can spend their entire life in either one of these categories.

Soft-money positions, which is kind of what I have right now, means some of your salary comes from grant money, from contracts with NASA or other agencies to do specific work. It basically means you're constantly writing grants and begging for money (Hi! Donate to Astronomy Cast!). You're doing things you choose to do.

I also teach in this adjunct position, which means I look for whatever classes are open – those are the ones I get to teach.

Hard-money positions are sort of holy grail. These are positions funded by the university that if you don't have grant money you may not get promoted, but you're there to stay. Often you start off in a tenure-track position (this is what I'm hoping to find sometime in the future).

A tenure-track position means you're on a probationary period (often for six years). During that probationary period, you demonstrate you're capable of supervising graduate students, that you're capable of bringing in grant money, and that you're a teacher that knows how to teach to the population of students at your particular university.

Every university's students have their own particular needs and personality that you have to know how to interact with. Someone who's an excellent professor at Princeton may not be an excellent professor at a liberal arts university. You have to find the right voice for your audience.

So you spend anywhere from three to six years in this probationary tenure-track position and then you either lose your job or you go on and you end up becoming the tenured professor. Tenured professors really can't be fired unless they totally screw up. The reason for this system is to allow you the academic freedom to follow questions that may not have an easily found answer where

you might spend three years following the rabbit down the rabbit hole only to discover that the rabbit really didn't exist.

Once you have tenure, you have the freedom to ask the questions that are risky questions.

Fraser: Let me see if I can do the math here: four years of undergrad, five-ish years of graduate school, a few years of post-doc and then if you get in with a university you're looking at six years of tenure-track and then you might end up as a tenured professor at a university.

Pamela: Yes.

Fraser: Wow.

Pamela: So you're often in your late-30's

Fraser: Or early 40's.

Pamela: Yeah, before you're finally done. There's lots of people who will do two, three, four post-docs. It's quite common right now for people to do two post-docs and then start looking for the tenure-track position.

In my particular case, I did one year at Astronomy Magazine (to do something totally different) and then worked at Harvard for three years. Now I'm in the adjunct professor position. I'm not going to move unless I find a tenure-track position to look for.

Fraser: Right.

Pamela: I have my soft-money. I have students I love working with, and I just have to see what the future holds and hope the grant money and (Hi! Donate to Astronomy Cast!) that our audience is friendly to us.

Fraser: Right. Let's say you took a different course - that's the traditional, academia, on your way to being a tenured professor track. You come out with your post-doc and let's say you're purely into the research – where does that course take you?

Pamela: That's another perfectly normal path for people to take. You come out, you do your post-doc for say three years, and then you start looking at the national observatories and at research centres to see what positions they have. These are the people that work at the Jet Propulsion Laboratory, at the Southwest Research Institute near where Phil lives, and people who work at Kitt Peak National Observatory, at the National Radio Astronomy Observatories… all these different places have staff astronomers who are full-time researchers who

aren't doing the teaching, but instead are able to dedicate all their time to the development of new knowledge. That's pretty much all they do.

Fraser: But that takes a certain kind of personality – that's the kind of person who really enjoys just the research and doesn't necessarily want to spend the time doing the outreach and the teaching, etc.

Pamela: There are those of us (and I fall into this category) that get a certain high off of teaching. There's something wonderful about having an audience full of students. There are these magical days, occasionally where the students just start firing out questions and getting into an idea. It may not be the idea you meant to teach that day, but you get them talking, you get them thinking, and you realise, "I have just made them think about something they've never thought of before". That really makes it more interesting for me to work on my research, because I can see someday this is something I can get someone fired up with. This is something I can use to get people interested in wanting to learn.

But that's my personality. There are other people who don't need the same people contact that I need, and they do very well sitting down and chewing through the numbers and working with the equipment, getting amazing results while working with their peers, their collaborators.

All of astronomy is a social endeavour. If you look at the journal articles, almost everything is authored by more than one person, but the people you work with vary with what type of job you choose.

Fraser: But from my place here, that sounds like a really hard slog. To go through all of those steps and to get all of that education in place – either for the research route or for the academic route. I wouldn't mind hearing some other ways you can come in from the side, some other kinds of careers that are tangentially related to it.

If you are enthusiastic about astronomy, if you are willing to put in an investment of education but not necessarily a full tenure-track… what are some possibilities?

Pamela: There are all sorts of different career options. All because you choose one path doesn't mean you have to stay on that one path. It's harder when you switch paths, but nothing is ever set in stone.

Rick Feinberg, who is the editor-in-chief of Sky and Telescope Magazine has a PhD in astronomy from Harvard. He went from doing the whole PhD researcher thing, to now leading one of the most prestigious astronomy magazines you can find in the bookstore. That's a different route, and he has many people on his staff who have different levels of science degrees. David Tytell has an

undergraduate degree from Caltech. Kelly Beatty (I think) also went to Caltech. They have people with master's degrees on their staff.

This an extremely well educated in science staff, working in the field of journalism. They get to live and breathe the science, and talk to the scientists on a daily basis and be involved… but they're using their astronomy knowledge to communicate rather than produce new knowledge. They do have people on their staff out there searching for asteroids and doing amazing science in their spare time as well, which really says something about the staff they have.

You can also get involved as a docent at your local museum. Say you don't want to switch careers, but you want to get involved in astronomy. You can get involved at your local museum doing sky tours. A lot of museums have telescopes associated with them you could perhaps get to use – and perhaps get high school students involved in doing research. You work as the broker between the researcher and the high school student, to help scientists get better research done and get students doing that research.

There are also all sorts of side-tasks that somebody needs to do, that take different skills than necessarily a PhD in astronomy. There's all the software we use, there's the planetarium software – Starry Night, for instance. There's data analysis software like IRAF or MIRA.

There's also all the hardware that we use, from developing better cameras like Apogee and Santa-Barbara Instruments do at the amateur level. At the professional level, there are people who build individual, specific cameras where an institution will spend anywhere from thousands of dollars to millions of dollars on building new instrument systems to take better spectra, to take deeper images, to improve our ability to capture photons from distant objects in the universe. That requires optical engineers, electrical engineers. These are people who often have only bachelor's degrees… but without them the PhD researchers could do nothing.

Fraser: Right, so you've got people who are creating the software that can scan through the big databases or be able to store the data. You've got the engineers and the people who help with the optics and the CCD cameras and all that stuff.

In many cases, the people working the observatories, helping support the astrophysicist or astronomer coming in to record their data… you've got someone who work with the observatory who helps to make sure the recording equipment is ready to go, the equipment is properly prepared so they can start doing their tests.

Pamela: Every observatory has the individuals who basically are the shepherds that allow the astronomers to function. We sort of fly in and we're there for three or four nights. Maybe we get to come back several times a year, but we don't live

and breathe the observatory atmosphere. There are people who are the night assistants, who are there every night working the telescopes for the astronomers. There are the people who are there to switch out the instruments.

A given telescope may have half a dozen or more different instruments that you can take off and put on, depending on what research you're doing. It takes an extremely skilled set of individuals to swap out the instruments and get everything up and running smoothly and correctly calibrated.

The night assistants I think have one of the coolest jobs. They get to see everything; they're not specialists on planets, galaxies or stars… they're specialists in making the telescope do whatever needs to be done. They get to see the data on everything as they sit there and basically they're the puppeteer that makes the telescope go.

Fraser: Are there other fields… I know there's the SETI institute, and you work with the AAVSO. There must be some positions in those as well – some volunteer organizations?

Pamela: In addition to the national centres and the university-based centres, there are also a whole set of different non-profit research organizations. We have the Planetary Society, there's the Astronomical Society of the Pacific, the American Association of Variable Star Observers, SETI – the Search for Extra-Terrestrial Intelligence. These are all non-profit centres that are run primarily off of individual donations and grants that do specified research. The AAVSO studies variable stars. SETI is doing astrobiology. The ASP is working to better integrate astronomy and education. These groups work with a focus on specific projects, and partner with the national research centres and different universities to better meet their goals.

So you can also get in through the non-profit link, if that's a direction you want to go. There are so many different ways to get involved in astronomy, it's just a matter of looking around your community and asking, "what can I afford to do?"

Many of these jobs… let's face it, most of us would do what we do for free if it weren't for the fact we have bills to pay. Astronomy is not exactly a highly-paid field, in general.

Fraser: I was going to ask that. Let's say we've got a tenured professor – they make a bundle, don't they?

Pamela: Sort of?

Fraser: Okay…

Pamela: A freshly-minted, tenured professor and a freshly-minted computer scientist, where the computer scientist is someone who just finished their bachelor's degree, will often make the same amount of money depending on the market.

Fraser: Right.

Pamela: So, you don't go into academe because you want to make a lot of money. It also depends on where you end up.

We recently had one of our undergraduates in physics finish her degree here at SIUE and she got hired to work at Fermi lab, which is an accelerator up near Chicago. She was hired at basically the same salary a starting professor would get hired at. When you go to work at national labs, the pay's a little higher. When you work at little state universities, the pay's a little lower.

Because we're all state or federal employees, it's actually possible to look up most of our incomes online, which is a little bit sad because it means really – we have no privacy. But all the numbers are out there, and there's an excellent link on the Chronicle of Higher Education's page (which we'll work on getting in the show notes), that allows you to look up how much professors and instructors are paid at different universities across the United States. These numbers tend to be biased by the fact that business professors make way more than anyone else.

Fraser: Right.

Just to give people my bio, I'm completely different. I actually went to UBC here in Vancouver for engineering and sort of stopped part-way to go and found a software company here in Vancouver and run a series of software companies of the course of about ten years. Finally recently I finished getting my computer science diploma (even though I've been working in computer science).

One of the things I was doing on the side, I had astronomy as a hobby, so I was maintaining Universe Today as a way to sort of learn how to manage a website but also to sort of follow one of my hobbies. Sometimes your hobbies have a way of becoming your life. Over time, over the years as I was managing, I built up a larger and larger following. In the last couple of years, I've been able to do this as my full-time job.

I think you and I took probably the most different directions that we possibly could have, and yet here we are doing Astronomy Cast. I think that says you can take the traditional route, you can take an alternative route. As long as you clearly know who you are and know what you like, and have a good sense of how you work, then almost anything's possible.

Pamela: There's room in this field for people of almost every background. That's one of the most amazing things. I've had the opportunity to work with amazing

graphical artists to help figure out how to communicate visually to people better.

Fraser: Oh yeah – almost every day I'm exposed to three or four paintings or computer renderings of an astronomical object or a piece of space equipment, that's been done by some computer animator. That's a huge field as well.

Pamela: When you start looking in the education and public outreach offices of the national labs and the big universities, you start finding people who have marketing degrees, who have art degrees, who have literature degrees… who are working to bridge between the scientists and the public. They're immersed in astronomy all day, every single day, even though they have backgrounds that are anything but astronomy. They're necessary to the communication of astronomy.

Fraser: Right, that would probably be which basket I would fit into – I've got the physics and chemistry from my engineering education, but I definitely don't have the astrophysics and I only have a little bit of calculus under my belt, not the amount you have.

I think as long as you really immerse yourself in the subject matter and bring yourself up to speed, there's quite a lot you can do if you're interested in the communication side. If you really want to do the research side, I don't think there's any short circuit around doing school.

Pamela: No, and it really does help if you're a straight-A student and if your undergraduate GPA is above 3.5. That's kind of the magic number – and you need to do research as an undergrad.

You can go the whole route being a B-student, with not doing the research, but it's going to be a lot harder and your chances of making it are a lot lower.

When I was a freshman at Michigan State, one of my faculty looked at a room of about 70 students and said, "about ten of you are going to go to graduate school, about one of you is going to get a PhD." I know that three of us in the room did go on and get PhD's, and two of us are still active in astronomy.

But that was a room of 70 people.

Fraser: Out of 70, yeah. Wow.

Pamela: Now, there are people in the room I lost track of, but those are the people I know.

Fraser: Right, right.

Okay, I hope that gives people a fairly good idea of what kinds of sacrifices are involved and some ways to find out what people are getting paid. We'd love, as always, to hear from listeners and see if anyone has some additional fine-tuning to that. We'd be happy to follow it up with some questions shows.

This transcript is not an exact match to the audio file. It has been edited for clarity.