thesis

My pandemic postdoc

In early 2020, Shira Joudan was in the final stages of her PhD when the COVID-19 pandemic hit. Despite the challenging circumstances, she graduated, found a postdoc position and will begin her independent academic career in early 2023.

I have a pandemic PhD. I was working on my final (read: dreaded) thesis project when our lab shut down in March 2020. I was able to collect the last few timepoints of my 4-month experiment and my written thesis was submitted on June 30, 2020 with a defence two months later.

I earned my PhD from the Department of Chemistry at the University of Toronto (UofT), working with Professor Scott Mabury in the Environmental Chemistry subdivision. UofT is quite unique within North American chemistry departments in that it has eight environmental chemistry professors and has an environmental chemistry program stream. Many other departments have perhaps one professor of environmental chemistry, often listed as an analytical chemist. At many institutions graduate students who want to study environmental processes typically enrol in engineering or environmental science degree programs. Being in a chemistry department, however, is best for those interested in determining how substances behave in the environment at the molecular level: the reactions they undergo, their transport processes and distribution based on their physicochemical properties. An all-encompassing term for these processes is 'environmental fate'. When I close my eyes, I can hear Scott repeating 'a molecular perspective' when explaining what differentiates environmental chemists from environmental scientists.

I wanted to work with Scott, not specifically because he is a leader in PFAS (per- and polyfluoroalkyl substances) research, but more so because I wanted to study organic contaminants in the environment. I sometimes joke that as an undergraduate student I knew I liked organic molecules, but I didn't want to be a synthetic chemist. I also enjoyed analytical chemistry and so the idea of using that to study the environment matched up well with my love of the outdoors. I first used mass spectrometry during an undergraduate research opportunity one summer focused on the biological application of lipidomics. The next year, I cold-e-mailed a professor in my hometown of Winnipeg who used mass spectrometry to study organic contaminants in the environment, including pesticides and pharmaceuticals. The two summers and the year after my undergraduate degree that I spent in that lab opened my eyes to what sort of research can be done investigating the fate of organic contaminants in the environment, and I knew that was what I wanted to pursue for my graduate research. Scott had been publishing on PFAS since 2000 and was a leader in the field, but when I started in 2014, PFAS weren't nearly as well-known as they are now. Today there is a lot of mainstream news coverage — and even documentaries and a blockbuster movie about problems related to PFAS. Lots of people I encounter in my daily life now know about them.

Shira in Saturna Island, British Columbia, Canada in December 2021 setting up samplers to collect air and rain to measure the deposition of PFAS (Credit: Cora Young).

For my doctoral research, I performed laboratory experiments to elucidate environmental transformations of PFAS using four different experimental systems: atmospheric oxidation[1], microbial degradation[2] as well as in vivo and in vitro mammalian metabolism[3]. I studied PFAS that were phased out of use because of concerns about environmental persistence, toxicity and bioaccumulation, and I also studied novel replacement PFAS, whose structures were designed to be less persistent in the environment. Identifying environmentally relevant transformation products of contaminants is important for understanding the complete lifecycle of a contaminant considering that transformation products may be more persistent, more toxic and may be more amenable to long-range transport. Additionally, understanding how key structural features of contaminants impact how they are transformed can enable the design of new, environmentally responsible chemicals that degrade to non-toxic and non-bioaccumulative chemicals after their desired usage (one of the fundamental principles of green chemistry is 'design for degradation').

These experiments require a variety of analytical instrumentation, most often ultra-high performance liquid-chromatography tandem mass spectrometry and gas chromatography–mass spectrometry, to characterize chemical transformations under diverse experimental conditions (the range of experimental conditions was actually quite unique for one PhD student to cover). My research is an application of analytical chemistry and organic chemistry with a sprinkle of physical chemistry and biological chemistry.

Before the pandemic, I thought that I absolutely needed to go to a new city for my postdoc — an opinion often propagated in the academic community — and I had begun reaching out to potential postdoc supervisors early in 2020. But, once the pandemic hit, I had no interest in moving to a new city with no personal support system and an unfamiliar (to me) community. What's more important is that a postdoc position is an opportunity to gain new knowledge and skills as well as the ability to discuss research with a new group of scientists. I had previously collaborated with Professor Cora Young at York University, also in Toronto, and when I reached out to her, luckily she had funding for a position. Professionally, I was excited about the research, and personally, I was thrilled to not need to move during the pandemic.

A postdoc is an important time to develop into a unique scientist before beginning an independent academic career. I had been given the advice that it's important to demonstrate how your research is different from your PhD or postdoc supervisor, and later, when interviewing, I was asked this exact question. During my PhD I was exposed to many atmospheric chemists and saw a gap in the field of environmental chemistry and toxicology — many researchers studying anthropogenic organic contaminants do not consider the atmospheric reactions that can impact their environmental fate. Likewise, atmospheric chemists rarely investigate anthropogenic organic contaminants. This is why I wanted to work with Cora, where I would be able to gain more experience conducting atmospherically relevant research and to have the tools I need to answer the scientific questions I am interested in. I also wanted to join a group where my expertise was valued. When starting a new job, whether academic or otherwise, we bring our own perspectives which are a sum and intersection of all of our previous experiences and knowledge, plus new topics that may be of interest. Some of my undergraduate research that I don't do anymore, courses that felt unrelated at the time, or personal experiences outside of formal scientific research, currently impact parts of what I'm interested in, or provide alternate ideas or approaches that others in my field may not consider.

When starting my postdoc position, I had two main projects I was assigned to, that are mutually beneficial for both me and Cora. The first was to develop and apply an online chromatography based method to quantify organic acids in gas and particle phases to better understand sources of atmospheric acidity in the atmosphere. Since regulations have been put in place to prevent acid rain, the acidic component of particles is no longer solely dominated by NO_x and SO_x, and now organic acids like formate, acetate or oxalate are much more important to understanding the acidity. But, these organic acids are rarely measured due to analytical challenges.

Additionally, of the limited measurements that have been made, the organic acid concentrations in particles is an ongoing mystery, with their abundances higher than what is thermodynamically expected when compared to gas-phase concentrations[4]. This research is new for me and I am both gaining new skills with a new instrument as well as learning about environmental systems I am less familiar with. Making measurements of chemicals in particles is challenging because if you collect aerosols onto a filter, you must store the filters, extract the filters, and often concentrate the extracts in the lab — these steps offer opportunities for losses of volatile species and the introduction of contamination during sample processing.

Being able to use an online system removes these challenges and also enables us to make hourly measurements compared to daily, weekly or monthly measurements. In order to study processes in the environment, the time resolution of the measurements must be fast enough to capture the processes involved (for example, diurnal trends associated with photochemistry or episodic point-source contamination). Any sort of method-development work is challenging, often takes longer to publish, and can have many unexpected instrumental challenges, such as broken parts. But this work is highly impactful and I can already see the fascinating trends from our mini rooftop campaign from November 2021. The goal is to collect data over multiple seasons, so we will be doing another campaign soon! This project has been useful for me to gain experience with larger datasets and making field measurements (compared to my PhD which focused on lab-based experiments).

The second project was to support students measuring PFAS on a large government-funded project. Here, the science is not new to me, but I am able to mentor and provide technical support to graduate students, gain experience being a part of a large collaborative team, learn more about field work (see Illustration), and be involved in multiple students' work. A nice thing about being a postdoc is that I'm not working towards a thesis (like in grad school) so the projects don't need to be as cohesive. Thus, I've found it easier to go along with some side projects based on early observations, or to add on to existing projects using methods I have been developing in the lab. One such example is when I was given the chance to analyse precious ice core samples from the Canadian Arctic. These samples were dated to 1967–2016 and capture only remote atmospheric deposition, because no ocean currents reach this site. By making measurements of acidic transformation products in these samples, we gain insight to changes in chemical usage and long-range transport of their volatile precursors, which are mostly high-production-volume industrial chemicals. Generally, the chemicals captured in these ice cores originate from large urban centres, are emitted into the atmosphere, and undergo oxidative reactions before the acidic transformation products are deposited (wet or dry deposition) into the remote Arctic.

Another unexpected project, that is small yet impactful, focuses on the fact that our analytes are everywhere, including in our lab. We have lots of quality control to assess and to determine whether we are contaminating our own samples or to at least characterize the background levels when performing our analyses. I realized that no one has done a deep dive to understand some of the sources, but with my new analytical method, I am better suited to analyse this. In addition to having implications for laboratory experiments and extractions, this information also provides a greater understanding of unaccounted sources of contaminants in the environment because currently the measured concentrations in the environment surpass the expected concentrations based on known uses.

During the height of the pandemic when lab access was still limited, Cora and I explored the false narrative that trifluoroacetic acid (TFA) has a natural source[5]. Given the surprisingly high concentrations of TFA in environmental samples including the deep ocean and 'old' ice, and given the lack of a balanced global budget, it has been suggested that TFA may have a natural source — this is often claimed by some in the fluoropolymer industry and used to justify contamination[6]. At first I was nervous to write such a bold paper with a statement of a title ('Insufficient evidence for the existence of natural TFA'), but we knew we were synthesizing the current literature, and using our expertise to explain the state of the science — which is that there is no evidence of TFA being natural, and that the high concentrations in the ocean can be explained by poor analytical chemistry, limited understanding of how chemicals can reach the deep ocean, additional TFA precursors (pesticides, pharmaceuticals, and industrial fluorinated chemicals that transform to TFA in the environment) and assuming that the entire ocean is homogeneous. It felt good to demonstrate my expertise and to use my voice, through a peer-reviewed article, in order to disseminate this information to the target audience. This was the first paper I wrote where I truly felt like a scholar in addition to a scientist — it was an empowering moment of realization as a postdoc.

My postdoc position has given me the chance to use my existing expertise, gain new expertise, and grow as a mentor and scholar. I truly feel prepared for my next challenges, although it is also possible that I am a bit naïve. I see some advertisements for postdoc positions that I interpret as a professor searching for a technician, or for someone to do their work for them. It may be merely poor advertising, but I think it's really important that postdoctoral positions are not only about being productive in research. Yes, that is important, and yes, I am trying to publish many papers, but we also need time and support to hone other skills. I will be finishing up my postdoc in the fall, and will be taking all of my expertise, knowledge, experiences and interests into my new independent research career as a tenure track assistant professor at the University of Alberta in January 2023. ❐

Shira Joudan ✉
Department of Chemistry at York University, Toronto, Ontario, Canada.
Twitter: @ShiraJoudan
✉*e-mail: sjoudan@yorku.ca*

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Competing interests

The author declares no competing interests.