Kathryn Hess Interview

Conducted by Melinda Lanius

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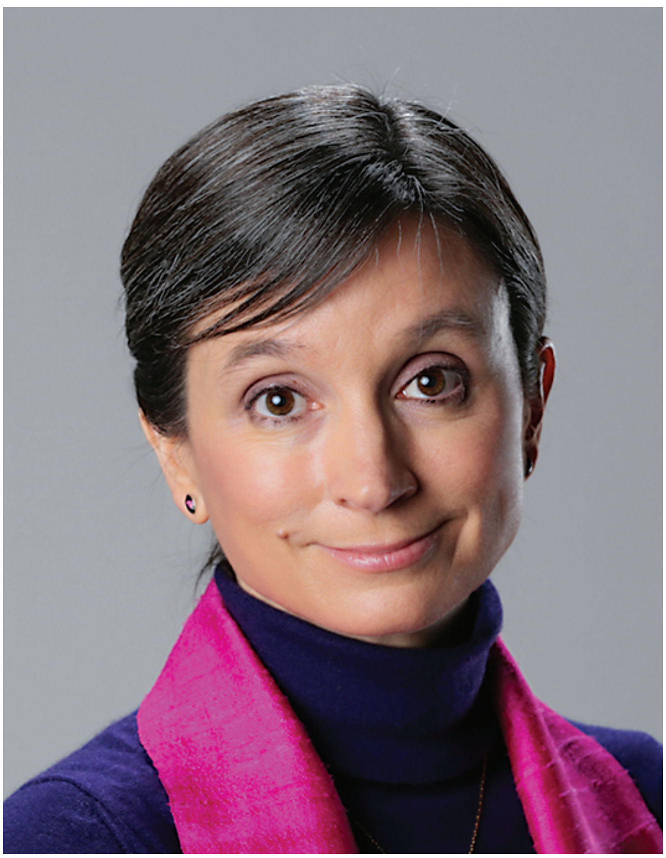

Kathryn Hess is associate professor of mathematics at École Polytechnique Fédérale de Lausanne. Her laboratory focuses on homotopy theory, category theory, algebraic topology, and their applications, primarily to the life sciences, in particular to neuroscience. Kathryn is a Fellow of the American Mathematical Society.

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Lanius: *When and how did you know you wanted to be a mathematician?*

Hess: Like many mathematicians, I started off thinking that I wanted to be a physicist. I fell in love with astronomy at the age of ten when I participated in an extracurricular astronomy course. I decided then that I wanted to be an astrophysicist, which was still my intention when I started my university studies. Of course, as a physics major I had to take many math courses, most of which I enjoyed very much, so that I was considering a double major in math and physics as I started my junior year. In the first semester of my junior year, I took a course in electricity and magnetism from the only woman math or physics professor I had during my studies, Bernice Durand. About halfway through the semester, she called me to her office and told me that, based on her observations, the only reason for my success in her course was that I was a very good mathematician, since I didn't seem to have much, if any, intuition for physics. I realized that she was right—in fact, it was almost a liberation to realize that I could focus on math instead of struggling to develop physical intuition—and I happily switched to being a math major, though I did still love astronomy.

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Lanius: *Who encouraged or inspired you?*

Hess: My parents, first and foremost! They believed in my mathematical potential long before I did. Inspired by the fast-paced math courses founded by Julian Stanley at Johns Hopkins in the framework of the Study of Mathematically Precocious Youth, they created a similar program—the Mathematical Talent Development Project—in the town where we lived at the time, Eau Claire, Wisconsin, with the support of some of the math faculty there. I was a participant in the inaugural class of the program, which enabled me to get through all of precalculus high school math by the time I was 13. Remarkably, of the 14 students in that inaugural class, at least two of us have gone on to become academic mathematicians at research universities.

While a student in that program, I heard a guest lecture from Dr. Karin Chess, a UW–Eau Claire mathematician, who provided my first inkling of what pure math might be. She spoke to us about non-Euclidean geometries, which I found absolutely fascinating: that one had the right to fiddle with the axioms of geometry, leading to such remarkable consequences for the overall structure!

Lanius: *How would you describe your work to a graduate student?*

Hess: My work in "pure" algebraic topology concerns homotopy theory. I'm particularly fascinated by what Waldhausen called "brave new algebra" (though he may have meant it in a somewhat more restricted sense): studying up-to-homotopy analogues and generalizations of classical results in algebra and algebraic geometry, such as the beautiful Galois correspondence.

Throughout my career I have worked on a number of side projects in applications of topology, such as applying knot theory to the study of polymers. This mathematical hobby started to play a central role in my research life a few years ago, when I began to collaborate more seriously and regularly with life scientists, particularly neuroscientists. Currently, together with the neuroscientists from the Blue Brain Project, we are applying algebraic topology to analyzing how the structure of the brain shapes its function, which is one of the central mysteries of neuroscience. The connections among the neurons in the brain form an incredibly rich and intricate structure, of which it is difficult to provide a quantitative global description. The spiking patterns of neurons in reaction to stimuli are, if anything, even more complex. Examining structure and activity through the filter of algebraic topology gives rise to quantitative descriptions of both and enables us to discern a reflection of the connectivity structure of a neural circuit in the shape of its response to stimuli. If we develop a deep understanding of what a normal pattern of response to a given input stimulus looks like, expressed in the language of algebraic topology, then we could perhaps use this knowledge to detect and quantify brain pathology, such as that arising in Alzheimer's or schizophrenia. Better comprehension of the brain's fantastically efficient information-processing structure could also probably be leveraged to improve artificial neural networks.

Lanius: *What is a typical workday like?*

Hess: It's easier for me to say what is involved in a typical workweek during the semester, since the structure of my days varies quite bit, which I appreciate. If I'm not traveling, I meet individually with each of my graduate students and with any project or masters' students I might have at least once a week. Teaching—preparation, classroom time, and related administrative work—usually fills the equivalent of a full day of work, more if I'm teaching a new course. I try to spend one day a week at the headquarters of the Blue Brain Project, to work with the members of my group who are there. We'll typically meet as a group for a brainstorming session, discussing the progress different team members have made over the past week and planning the next stages of each project on which we're collaborating. I'll also meet individually with various group members in order to discuss particular details of their projects in more depth.

Some time during the week—perhaps 20 percent on average—has to be devoted to various service tasks, either to the mathematical community or to my university: editorial work, refereeing, conference planning, writing letters of recommendation, committee work, etc.

When all is said and done, if I have the equivalent of one full day in the week for quiet thinking about research and reading articles, I feel lucky!

Lanius: *What is the work culture like at École Polytechnique Fédérale de Lausanne and in the Laboratory for Topology and Neuroscience?*

Hess: The team with which I work on applied topology projects is composed of members with varying backgrounds. Among my postdocs are researchers with PhDs in homotopy theory, knot theory, computational algebraic topology, and theoretical computer science. We collaborate closely with neuroscientists, cancer biologists, and material scientists, among others. It's a challenge learning to speak a common language, but once we do, the variety of our backgrounds enables us to progress rapidly, in directions in which none of us could have ventured alone.

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I have complete freedom to choose the projects on which the team works and am always open to initiatives from team members. Many of our projects have been the result of pure serendipity, such as the time I ended up standing in a buffet line just behind a new colleague in material science. The informal chat that started as we waited in line led to a publication in *Nature Communications.*

One aspect of our applied work that I find very exciting is the way that it is leading to new theory as well, the development of new theoretical tools motivated by the applications we're studying.

Lanius: *How do you balance career and outside interests?*

Hess: The balance has shifted throughout my career, based on the number and ages of my children, as essentially all of my non-math time is devoted to family. As often as possible, family time involves hiking in the mountains, since we're lucky enough to live in Switzerland.

When the children were young, spending time with them was my highest priority. Once they were all teenagers or adults, I felt that I could let mathematics have an equal priority.

Vacation and relaxation time is important, of course, to avoid running out of energy or inspiration. A crucial lesson that I learned was that I couldn't force my brain to continue thinking about mathematics if it was sending me messages that it needed a break. It's more efficient to take a break—and go for a walk, read a book, or work in the garden—and then to return to work refreshed and relaxed.

Lanius: *Are there any speed bumps in your journey that you could share with us?*

Hess: I was clearly less productive as a researcher while I had young children, which I think is probably almost inevitable. The academic world is often not very understanding about women—or, more generally, parents—who have less time for research when their children are young. It helped me that there were a few senior colleagues who continued to believe in me as a researcher and told me so, even in the years when I was less productive.

Lanius: *What advice do you have for graduate students?*

Hess: Learn to give good talks! Many colleagues' first impression of you will come from hearing you speak. If you succeed in communicating your passion for your work, then more people will be interested in what you're doing.

Learn to give good talks!

If there's no formal framework in which to practice giving talks, set one up with the other graduate students at your university. Remember that constructive criticism from your peers is an important part of such a learning process. Ask your professors if they can recommend any videos of particularly good talks that you can watch for inspiration.

Lanius: *If you could recommend one article to graduate students, what would it be?*

Hess: I suggest that graduate students ask their advisors for two or three examples of beautifully written articles in their field, even if the subject is not directly related to their thesis problem. In order to learn to write well, it's important to be exposed to exemplary writing.

Lanius: *Any final comments or advice?*

Hess: Embrace serendipity! It may lead you to an exciting, unexpected destination.

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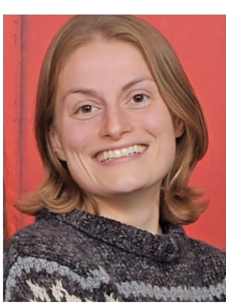

Melinda Lanius

ABOUT THE INTERVIEWER

Melinda Lanius, a Wellesley College graduate, is currently earning her PhD in mathematics at the University of Illinois at Urbana–Champaign.