Advice for Prospective Complex Systems Students and Scientists

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Many people have asked me for advice on how to get into the field of complex systems science. This document reflects my own opinions on this topic and I hope it will help in giving some guidance to people interested in studying or working in this exciting field. I write this document in the style of a "Frequently Asked Questions" document. I am hoping that once it is online, this document will spur others to add suggestions and ideas, which I can incorporate in future updates.

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Question 1: What academic background do I need to work in complex systems science?

Answer: This depends on the particular aspect of complex systems you want to study. But in general, a basic literacy in mathematics and programming is important for any aspect you study. In mathematics, the most important subjects are calculus, linear algebra, differential equations, and probability and statistics. In programming, I suggest becoming fluent in any high-level language (e.g., Python, Java, C++, or even Matlab). Once you are fluent in one language, it's pretty easy to learn a new one. I'd also highly recommend taking at least one physics course — in addition to the actual content, physics teaches you how to think about problems in general.

In addition to this, my own list of the core disciplines for complex systems includes dynamical systems theory, statistical mechanics and statistical physics, information theory, theory of computation, statistical inference, and evolutionary biology. Particularly for graduate students and postdocs — learn as much about these fields as you can — you won't regret it.

If your university has an Introduction to Complexity course, by all means take it – otherwise, you can take our free Introduction to Complexity online course and other, more advanced courses, on complexityexplorer.org.

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Question 2: What universities allow a major in complex systems at the undergraduate or graduate level?

Answer: You can go to the Complexity Explorer "Resources" page (http://www.complexityexplorer.org/explore/resources), browse by Type, and scroll down to look for "Degree or Certificate Program". There are a growing number of universities that allow a minor or "certificate" in complex systems (e.g., University of Michigan, Indiana University). I don't know of any universities that allow majors in complex systems at the undergraduate level, and I don't even think such a major is a good idea. It's important to be thoroughly prepared in a traditional discipline before you branch out to interdisciplinary research. So I would advise students to major in the traditional area that interests them the most, whether it be physics, mathematics, biology, chemistry, computer science, etc., and to make sure that they have the math and programming (and physics) background discussed in in the first question above.

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Question 3: What's the best field for an undergraduate to major in if I want to study complex systems in graduate school?

Answer: As I said in the answer above, any major is fine as long as you have the math and computer science background I mentioned. In general, the more math, programming, and perhaps physics, you know the better.

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Question 4: How can I get a summer internship working in this field?

Answer: In the US, there are a number of so-called "REU" (Research Experiences for Undergraduates) programs, funded by the National Science Foundation, in which undergrads work with mentors to do research in various fields. Santa Fe Institute has such a program specifically geared towards complex systems, but there are several other programs with topics related to this area. See http://www.nsf.gov/crssprgm/reu/reu_search.jsp for a list of current programs that you can apply to.

For both undergrads and graduate students, if there is a particular area, research group, or individual who is doing work of interest to you, you can contact them directly to describe your interests and ask if they have any summer internships available. Don't be shy — if you don't ask, you don't get! Again, the Resources pages on complexityexplorer.org might be helpful in finding groups and centers whose work interests you.

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Question 5: What other resources are there for me to learn about complex systems?

Answer:

The Complexity Explorer site (http://complexityexplorer.org) offers free online courses and other educational materials for complex systems, and its Resources section is a searchable index of other resources available on the web and elsewhere. There are also good courses on coursera.org and edx.org on modeling, game theory, networks, and other topics. Many of these are listed on the Resources page on Complexity Explorer, under the type "Course".

Santa Fe Institute also has a number of courses designed for graduate students and postdocs — see http://www.santafe.edu/education/ for a list. SFI also offers an annual "short course" aimed particularly at professionals (although anyone can register): http://santafe.edu/education/schools/short-course-complexity/.

The New England Complex Systems Institute (NECSI) offers short courses on complexity in the Boston area. Santa Fe Institute occasionally offers short courses on complexity at different locations around the US — I suggest following them on Twitter or Facebook to get announcements for these.

There are several great textbooks to teach you about complex systems – which ones are best depend on your particular interests and your level of mathematical knowledge. We are in the process of collecting an annotated list of these on the Resources list of the Complexity Explorer site.

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Question 6: How can I get invited to visit the Santa Fe Institute or to an SFI workshop?

Answer: Santa Fe Institute is very small and cannot handle large numbers of visitors. Thus they operate in a "bottom-up" manner, in which researchers already associated with the institute suggest visitors (often, the visitors are people that SFI researchers are collaborating with). Workshops are typically small, "invitation only" events; the workshop organizers invite the people they think will best contribute to the workshop and who will complement the other invitees. Thus if you ask me "how can I get invited", it's hard for me to answer. A primary motivation for creating the Complexity Explorer website was in response to this problem: many people want to learn about complexity and get involved with SFI, but the institute is too small to accommodate all of them. That being said, there are a few options. If you are a graduate student or postdoc, you

can apply to attend one of the Institute's summer programs. If you are an undergraduate, you can apply for the Institute's REU program. All of these programs are quite competitive, but if you feel you are qualified, it is well-worth applying. If you share interests with an SFI researcher, you can contact them directly. If you live in Santa Fe or visit the city, you are welcome to attend SFI talks and to take a look around the institute. Finally, even if you live far away, SFI typically videotapes all of the seminars and colloquia there, and puts the videos online for all to watch: http://www.santafe.edu/research/videos/catalog/

You can keep up with the institute's work by following them on Twitter (@sfiscience) or Facebook (search for "Santa Fe Institute"), or via their website: http://santafe.edu.

Here is a statement on visitors from the Institute's VP for Science, which reiterates some of what I said above:

SFI is a "bottom-up" institution, which means that research collaborations, talks, meetings, and visitors are initiated by particular researchers, typically SFI's resident faculty, postdocs, or visiting external faculty members. Generally, scientific visits are arranged as a result of interactions with resident researchers, who bring people to SFI to collaborate or to give a research talk in some area of interest to the SFI community. In addition, people who live in Santa Fe or who are visiting Santa Fe are welcome, on their own initiative, to attend SFI's noon seminars and our colloquium talks (these are open to the public)—information about those talks are posted on the website. Also, people are welcome, during regular working hours (M-F, 9-5), to stop by and look around, and if there is time and availability, to get a brief tour of SFI from one of our staff members. SFI asks that casual visitors sign in at the front desk, where the receptionist can give them more information.

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If you have additional questions or comments on this document, please e-mail me at admin@complexityexplorer.org, and I will try to address them in subsequent updates of this document.