The Genomics Leadership Initiative at Juniata College

Vince Buonaccorsi, Jill Keeney, Jim Roney, and Kim Roth

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Vince Buonaccorsi is Professor of Biology, Jill Keeney is Professor of Biology, Jim Roney is Professor of Russian, and Kim Roth is Associate Professor of Mathematics, all at Juniata College.

The overall goal of Juniata College's Howard Hughes Medical Institute (HHMI)-supported Genomics Leadership Initiative is to prepare students for jobs, graduate school, and medical school. We (the faculty running the program) aim to prepare students in a way that can help them to become leaders in these positions by providing training across many disciplines and a depth of knowledge and practical experience within a discipline. We also aim to work towards a scientifically literate public. While the main focus at this point is working with science majors, students outside the natural sciences will benefit from the program as well. We are addressing our goals through both faculty and student activities. Faculty activities are oriented around three learning communities supported by our HHMI grant: 1) an integrated sciences learning community, led by Kim Roth; 2) a learning community focused on the ethical, legal and social implications (ELSI) of genomics, led by Jim Roney; and 3) an intercollegiate genome consortium for active teaching using next-generation sequencing, led by Vince Buonaccorsi. Student activities are oriented into two broad and overlapping pursuits: independent research and a certificate in genomics, ethics, and society. The research program is led by Jill Keeney and includes both summer and academic-year activities. The certificate has seven courses, and one, Genomics, Ethics and Society, is required for all students. This interdisciplinary class has both scientific and philosophical elements, and introduces the entire program. The remaining six classes are comprised of three scientific analysis and three philosophical or cultural analysis classes. Jim Roney will speak about the more philosophical classes. With the sciences classes, we have a genome biology class for majors or non-majors, as well as statistics and informatics offerings. Kim Roth will describe the work of the integrated sciences learning community in supporting those offerings. There are access points for each requirement for students majoring outside the natural sciences.

There are short-term goals and mid-term goals for students in our Genomics Leadership Initiative. In the short term, we are aiming to improve students' skills, knowledge, and attitudes. Skills include, for

example, writing and interpreting graphs, while knowledge includes familiarity with genomics and data analysis. We aim to strengthen attitudes like resilience, and to develop students' sense of ownership of a project by letting them make decisions about the direction of their work. Working at computers can really frustrate students, for example, yet with appropriate support and encouragement students will build their problem solving skills and gain an understanding of what scientific research is really like.

We use a variety of assessments, some of which we developed ourselves. We are going through the process of testing novel assessments for reliability and validity. We are also using assessments that have been previously developed. These allow us to compare what we are doing with national averages, in particular with development of student attitudes.

Some mid-term learning goals of our grant are reinforcing career directions in science, technology, engineering, and mathematics (STEM) disciplines and increasing science literacy of non-majors. We are not as focused on assessing long-term goals, such as success in graduate school, as we are on learning outcomes that we can measure now.

Today we are going to be telling four narratives: 1) faculty development activities; 2) working across traditional academic disciplines; 3) student outcomes; and 4) opportunities for faculty to get involved. In short, we are describing what we are doing, how it helps, and how Juniata faculty might get involved.

GCAT-SEEK

Vince Buonaccorsi: "GCAT" refers to the Genome Consortium for Active Teaching.[1] It was started fifteen years ago by Malcolm Campbell at Davidson College, and the goal was to facilitate the implementation of cutting-edge research tools in classes with undergraduate biology students. In the biological and computational sciences there has been a technical revolution over the last fifteen years. Some really neat technologies have made standard experiments, like DNA sequencing, massively parallel. The focus of the original GCAT network led by Malcolm Campbell was on microarrays, a technology that allows one to examine differential gene expression on a genome-wide scale. This technology is a predecessor to today's massively parallel sequencing technology. Campbell handed Juniata the baton to implement the new technology with undergrads through GCAT-SEEKquence (or GCAT-SEEK).[2] Campbell suggested some guiding principles from the original GCAT network: 1) disseminate what we are doing to reach a broad audience; 2) reach out to underrepresented minorities; 3) stay focused on undergraduate students; 4) keep a focus on assessment; and 5) emphasize faculty development.

Who is in the network? While we've recruited some people with a lot of experience to help with our program, most network members are biology professors from small schools with a lot of teaching experience but little practice generating and analyzing massive data sets. They have little experience in

programming and the Unix interface. Since 2012 GCAT-SEEK membership has grown from about a dozen genetics professors in the mid-Atlantic region, to over 200 members from over 150 colleges around the United States. There are about fifteen minority-serving institutions in the GCAT-SEEK network, about ten percent of our membership. We are collaborating with faculty from three minority-serving institutions to put on the workshops in the next three years to build a more diverse membership.

Our student-faculty development workshop is our primary tool for instruction. It is a summer workshop and we invite interdisciplinary teams from the same institution, such as faculty from biology and computer science, or math and biochemistry. We aim to attract pairs of people who have common interests in order to address problems from different perspectives. Teams can be from different institutions, or can be comprised of faculty and student partnerships. The workshop is a major driver of the network. At the workshop we do both the wet lab and computer elements of work and we focus on the preparing and sequencing of participant samples related to their own research interests. The curriculum we present at the workshop helps reshape our classes and research programs, and the reverse holds true as well.

In general, implementation of genomics research approaches with undergrads by faculty who are initially novices has followed a somewhat consistent track. Faculty members come to the workshop in teams, then back at their home institutions they work with a handful of their own research students to develop expertise, then they eventually teach the new approaches in their upper-level classes, and ultimately they may bring the approaches to their lower-level classes. Over time, the number of students using our data, our computer cluster, or our lab manuals has increased to many hundreds per year.

One example of the kind of genomics work we are doing at Juniata is Bio-III lab. This lab has about eighty students in it, and contains an investigation related to my research. The research question is: Can we find important changes between the aging genes of short-lived and long-lived rockfishes (genus *Sebastes*)? Some rockfishes can live a couple hundred years, yet have closely related species that live only a few tens of years. This project has provided Juniata students with learning opportunities because there are hundreds of genes that are candidates for this kind of effect. The lead investigator of the project (at University of Southern California) has done an automated analysis of these genes that leaves room for our students to go into much more depth. We are letting the students pick genes to investigate that are interesting to them, do in-depth analysis in the computer lab, and report interesting results back to the primary investigator. Students start with segments of fish DNA, characterize the genes, and then predict functional effects of protein sequence differences between long- and short-lived species.

Finally, why would a faculty member at Juniata want to join the GCAT network? At this point our primary offering is the workshop (see gcat-seek.org). For faculty interested in experiencing the science with a friend, performing interdisciplinary research projects, and teaching elements of genomics

research to undergraduates, the workshop can help. Usually the way faculty get involved is that they identify a partner to team up with in pursuit of a problem they have a long-standing interest in.

RESEARCH PROGRAM

Jill Keeney: My role in the HHMI grant is director of the research program. It is probably not news to you that research is a high-impact educational experience, giving students the opportunity to investigate ideas as an extension of their course work. The main thrust of the Hughes grant is the summer research program that provides paid summer research opportunities for both students and faculty mentors to engage in cross-disciplinary research projects related to large data sets or the human genome project. Of benefit to faculty is that summer research activities inform course development, and vice versa. As part of the summer research program on campus, we provide a weekly seminar series followed by lunch. Near the end of the summer, students present their research projects at the annual Landmark Summer Research Symposium, which involves the schools in the Landmark Athletic Conference. The sixth annual symposium was held this past year at Juniata. The grant encourages presentation of research off campus by providing funding for students and mentors to travel to not just regional locations, but to national and international meetings as well so that students get the opportunity to go to the large meetings and present their research.

For this coming summer, I have selected some project examples that are particularly interdisciplinary, which is what we are trying to encourage. Gina Lamendella and Kim Roth are working on a project modeling the bacterial community of contaminated groundwater in poor rural communities using statistical models. In a nutshell, Lamendella has datasets from water samples that may identify which bacteria are involved in the breakdown of dichloromethane, which is an environmental contaminant. She and Roth are going to model with students how microbial communities affect the breakdown of those contaminants. They are going to be working together on the modeling to provide the datasets to people. Peter Rothstein and I are embarking on a project to investigate knowledge of and attitudes about infant and prenatal genetic testing in various rural healthcare settings. With the wonderful cooperation of local physician Dr. Laura Siems, we will be interviewing patients and health care providers at three or four different local health care facilities. We decided rather than attempting to devise and distribute a survey, we will begin with extensive interviews and employ qualitative research to get an idea of the issues and what people are thinking, including both patients and healthcare professionals. We will be employing two students this summer. We will first have to develop the survey instrument and get IRB approval, and then we have Lynn Cockett to help train the students to do the interviews. Rothstein and I came to collaborate on this project through our participation in the learning

community. Through meetings and workshops, we had the opportunity to talk about ideas and decided that this is the kind of project we would like to do.

What is in the HHMI summer research program for you? For the summer of 2016, which will be the last summer of the grant, there will be eight awards available for faculty projects, each with two students. Preference will be given to faculty participating in one of the learning communities or GCAT, with interdisciplinary project proposals. This is another reason to get involved with the learning community. For each project the budget includes a $5,000 faculty stipend, two students each with a $4,500 stipend, and up to $5,000 in supplies. As I mentioned previously, funds are available during the school year to present at national or international conferences. There will be a call for proposals about August 1, with an application deadline of October 1. Notification of awards will be at or near the beginning of the 2016 spring semester, so that faculty have time to gather applications and select research students by April 2016. The obligation, if you decide to apply for one of these awards, is availability for ten weeks over the summer to mentor your students, guide them in preparation for the Landmark Summer Research Symposium, and attend it in mid-July. A project report is to be submitted by September 1, 2016. Additionally, you are expected to encourage student attendance at conferences during the year, and we hope that you would continue to engage students with ongoing research throughout the academic year.

LEARNING COMMUNITY ON THE ETHICAL, LEGAL, AND SOCIAL IMPLICATIONS (ELSI) OF GENOMICS

Jim Roney: I am going to talk about the ELSI learning community, and more generally the purpose of a learning community. In short, the purpose is to create and sustain a group of faculty.

Jill Keeney, Wade Roberts, Jack Barlow, David Sowell, and I are the five people who actually created the ELSI learning community before the grant was submitted. We met for close to a year, talking about this before the grant was done. We started thinking, why have interdisciplinary projects at Juniata not worked the way we thought they would work? I hesitate to give the example, but why is Cultural Analysis (CA) not what we thought it would be? Why is International Studies not what I once dreamed it would become? We decided it is because we need a community of scholars who make it work. Our primary emphasis became, "How can we create a group of people who interact on an ongoing basis intellectually, socially, and telling stupid jokes at lunchtime?" That is what we wanted to put together.

We wanted to draw people from all over the campus, and to a certain extent that has succeeded and in another way it has not worked. It is so important for me in a classroom to be able to say to students, "When I was debating this with Jill Keeney, here is how she talked about the biology of this issue," or "When I was talking about this with Vince Buonaccorsi I realized he lives in a world of virtual models on computer screens, where I live in this messy, sloppy world, and that we get along." I think it

makes a huge difference that we can talk about these things and actually know what we are saying, or that I can talk about the epistemology of science and I can say what happened when I debated it with Wade Roberts. I think this makes a huge difference in my ability to teach, and I will talk later on about how it has affected my research.

I also believe that we in the humanities have to accept more that there is a connection between the quality of teaching and scholarly activity or research. What activities do we do? First we have an e-mail list with twenty-five people on it. They come from all over the place. That means that every couple of weeks you are going to get an email from me that says, "We are going to meet for lunch, do you want to come?" and tries to talk you into it. It also means that if anything is happening, we tell you about it, and we encourage you to email us with any ideas. That is free, join it. You can put it on your résumé and I will not tell anybody if you never did anything.

Then there were two summer workshops. These are over, but we are hoping to get grant funds to do them again in the future. I cannot tell you what a transformative experience they were for people. For the first one, we spent ten days, five hours a day, and here is what we did: we said, "Okay, we each have one day. Teach me what you think is pretty cool in your field that is related to genomics research. What do I need to know?" So a psychologist came in and taught a psychology book, and so on. I taught them a Russian short story and a science fiction novel. Over those ten days, we really got to understand each other and what we are about, what language we speak, what makes us excited, what we could not care less about, and it was a very transformative thing. Phil Dunwoody, for example, picked a book from psychology for us all to read. I do not think he had any idea that he was going to walk into a hornet's nest when Wade Roberts and I said, "This book is not only misguided, it is immoral." After five hours of talk, we said, "Hey, we are friends." We were friends before we started, which may have helped, but it is really important to finish as friends, and you cannot do that without time. You just cannot.

I will say, a workshop is a mind-numbing thing. We all received eight to ten books per year for these workshops, and none of us had read them all completely. But most of us had read parts of them, which is another useful teaching skill: when you are trying to read something you do not understand, read the first sentence and the last sentence of each paragraph and find out whether you want to read the middle.

We have biweekly lunches and a lot of on-campus events. This is the area in which we are not completely satisfied with what we have accomplished, but on the other hand we have done some pretty awesome things. Topics have ranged from films to panel talks with local physicians or with psychiatrists on the practice of psychiatry in the field. Most recently we had a one-day conference organized by Jill Keeney and Belle Tuten about teaching ethics in genomics, where about sixteen people came from six or

seven schools and talked about their experiences in trying to teach ethics in science classes. I thought it was really eye-opening and I want to do more of it and even better.

The ELSI learning community faculty membership is diverse. We really want to get more people from the arts and politics, and reengagement with the rest of the humanities beyond philosophy and Russian. History has been awesome.

Many courses have been developed, and each one received course development money. Again, talking from a faculty point of view, this is something administrators have to think about. It takes time to take a course you are currently teaching and transform it to teach new content. It takes time to add problem-based learning to your default setting of coming in and being a genius in front of your class and telling jokes. It really is something that is well done with grant money, and that is one of the reasons I would even argue that if you do not write grants, start writing them. They are invaluable to you.

Belle Tuten used problem-based learning in her certificate course, and working with Dan Dries from chemistry, they had the students researching the genetic identification of the plague virus from the Middle Ages. The students actually worked through the process of finding out what we now know about this thing that was part of a historical event. What Belle Tuten was trying to get them to understand is that the world was experienced differently in the Middle Ages than it is in a science lab in 2014.

Phil Dunwoody turned his course on decision-making into a course on moral judgment. Marlene Burkhardt and Kathy Baughman developed a business course on leadership and are trying to work genomics issues into that. Jill Keeney and David Sowell are in our Interdisciplinary Colloquium course and have been working hard on it. Sowell totally refocused his Social History of Medicine course and used the work on eugenics and genetic research. Without the grant he would not have been able to completely change the focus of his existing course.

I am doing a course on medicine and literature. When you actually get into one of these interactive things and develop a course on it, I wound up asking myself, "What is the difference between philosophy and literature? What is the difference between literary studies and history? Do we understand knowledge differently? What am I trying to teach my students in my course? If they read these novels, am I trying to get them to think historically because they were written in another time? Am I trying to teach them how to do philosophical ethics to deal with it?" When you work in this you start to sort out in your own head who you are and how what you do works, and how it differs from other people.

What happened? I wound up going to conferences and giving papers on utopian science fiction, how it conceives of science and technologically driven paradise, and how we critique that using ethical insight. I do not think I would have written that paper if I had not been part of this group. I am going to another conference and reading a paper on how we evaluate the way a doctor in a story by Tolstoy interacts with his patients. It helps me understand that story better, and I found it really fun and eye-

opening to debate back and forth and talk to my science colleagues about how they understand all this. What we really looked at during lunch time was, "What does it mean to think of people statistically? What does it mean to think of us as statistical clouds, and how will that change medicine, change science, change the view of education?"

Why would you want to do this? Why do I like it? It is fun, and I do think students like me doing it. This sounds really old fashioned, but I think it makes me a better person. I grow a lot. For example, I really enjoy meeting practicing physicians who talk to me about how moral empathy, which I can teach through literature, is essential to their practice. They tell me, "What do I do when a woman is telling me that she has a breast cancer result and she really does not want a mastectomy? I look into her eyes and how do I deal with that?" I realized physicians were talking about that like an art form, and I really find that improves what I can do. It also affects how I can act as a citizen and vote on issues; the more you know the better you can do.

I really want to encourage you to come to the ELSI learning community lunches. It is a safe zone to say stupid things. You can take risks. You can throw an outrageous assertion out there, and some other faculty member will say, "You know that is stupid, right?" Not everybody likes that sort of robust, jokey exchange, but it is a great place to figure things out. A lot of these lunch conversations end up being used in my classes. Also, the lunches are a place where you can say, "I was trying to teach this and it failed. Why?" Someone goes, "You know what, it did not work for me either. I wonder why." I found that to be a very refreshing atmosphere and very fun to be in. And people will bring anything that interests them: genetically modified food, what is the attitude towards people who are labeled as obese, how does a Mennonite clinic differ from a clinic in another community? We have talked about a whole range of things.

Regarding future plans, one of the issues we have is that non-biologists do not do the genomics certificate. We have wondered whether we should offer something for people who are really not in biology but are interested in the ethics and implications of scientific research. We also want to work on undergraduate research. People in the humanities have discovered that, with the exception of our History colleagues, we are not as good as our natural science colleagues at preparing undergraduate students to do independent research. Some of us have starting wondering, "What can we do in our intro classes? How could we change our attitudes to produce students who are more capable of doing that?"

The last thing is that we want to institutionalize ELSI. What is great about grants is what you can do with them; the problem with grants is that once it goes away the thing may stop existing. When the money dries up, are people still going to come to the lunches? We hope so, and that is where you get to the next thing, like some way to teach about ethics in the liberal arts. The learning community might even be a component of that. We want more grants, want to get out and go to conferences, and want to use this

network to create a GCAT-ELSI consortium where we get some of those member institutions to implement this more fully. We have found that one of the most exciting things has been interacting with those people who teach physicians, and those people who teach psychologists and psychiatrists. We want to increase the cooperation and find ways to get more of them here so that we can learn more from them. Then we can increase education both for undergraduate students and for doctors, improving their residencies in the hospital.

INTEGRATED SCIENCE LEARNING COMMUNITY

Kim Roth: I am going to talk a little bit about the Integrated Science Learning Community (ISLC). As in the GCAT-SEEK network, the goal is to bring scientists from various disciplines together to discuss topics related to genomics. Most of the people in the group are scientists, including the occasional social scientist, who get together and talk about topics related to both our research and our teaching. We meet once every few weeks during the semester. Past events have included genomics research presentations and presentations of where sciences other than biology intersect genomics. For example, Mark Peterson, who is a postdoc, spoke to the ISLC last year about where the chemistry, physics, math, and computer programming came in as he conducted his biological research. We have had presentations about research in genomics from faculty who are not biologists doing genomics research. For example, Cathy Stenson talked about her work with Lucas Lingenfelter on Gray Codes and what research skills and interests she had to offer other people. We are looking to make connections between the sciences based on the skills you need and the skills you have, and using those to make pairings, both faculty to faculty and faculty with students.

We also support the science-related genomic certificate courses. That would be the informatics, biology, and statistics courses, and other tools that people need to do genomics research. Questions come up such as: Where do I find data that I can use in my course that I can explain to my students even though it is not a genomics course? What sorts of statistics show up in my genomics research that students should hear about before they get to my genomics labs? How do I manipulate my data? To answer the last question, Loren Rhodes came in and talked about regular expressions and programming language and how to make that work. This is a community where we mostly meet and talk about making connections among people and supporting them in the things they need to know.

We also ran a program last summer where we met once a week. We read through about a third of a book on Bayesian data analysis. Once a week we met and discussed what we had read, how it worked, and what we were learning about statistics. We may do something else like that another summer.

This is supposed to be my narrative, so I will talk about what this has been like for me. I teach a statistics course in the genomics certificate program, Introduction to Probability and Statistics and the

ISLC helped me find content that I could add to it. In particular, issues that frequently show up in genomics research, because there are many variables to test, are the statistical ones tied to performing multiple tests. If you do twenty tests, what should you be worried about? However, here it is more like a thousand tests. I have also talked at ISLC about data I need for the class. I need examples of data sets that are not horribly huge, because genomics data sets tend to be large, and also data that I can explain to my students without having to assume they all know something about genomics (because my course covers a large audience of students, from the intrepid business students to the math major to the biology major). Members of ISLC have helped me find appropriate data sets for in-class examples.

The students in Introduction to Probability and Statistics do three projects, and the ones who are there for genomics certificates do them with genomics data. I grab genomics data from various faculty at Juniata for the students.

Having my course as part of the genomics program has influenced my statistics teaching. I gave a talk at a national math conference about using genomics data in an introductory statistics course, and at a conference on teaching statistics I will probably be giving a poster about further things I have done since then.

Gina Lamendella and I have been working with some students who work with her in the fall and with me in the spring. Last year that student was Vicky Arthur. She applied taxonomic units in fracking ground water in the fall with Lamendella for the biological end. In the spring, we looked at the data pipeline and examined the process of clustering reads together to determine which microbes belong in which operational taxonomic units. Then we did a couple refinements of the process. This year, Connor Hunter-Kysor was a shared student. He worked with Lamendella on dichloromethane contamination in ground water, and adapted an existing model for a slightly different situation to model how the dichloromethane is degraded. In the spring he is learning about time series analysis in order to model the data over time. Hopefully we will have enough data that we will be able to try different models in the future.

For me, this has been great. When I started out I could not remember what a base was; my genomics knowledge coming in was high school biology. I have learned large amounts. Why should you join the ISLC? Well first, you do get to learn genomics. It is fun, and it is okay to come in with whatever knowledge you have about what genomics is and how it works, and we will all learn together. This is a group just like the ELSI community. We are asking questions and learning about genomics. This is a place to learn, and to learn where you can fit in. If you want to learn what work is being done already, this is a great place where people talk about their research. If you are interested in pursuing a new line of research or seeing where you can fit into this community, ISLC can help you find opportunities for research. In fact, two presentations that will happen this spring in the ISLC will be about collaborations

between faculty in different departments and their students. Vince Buonaccorsi and Uma Ramakrishnan will talk about their work with coyotes, and Neil Pelkey and Gina Lamendella will discuss their work with snails.

NOTES

1. A. Malcolm Campbell, Mary Lee S. Ledbetter, Laura L.M. Hoopes, Todd T. Eckdahl, Laurie J. Heyer, Anne Rosenwald, Edison Fowlks, Scott Tonidandel, Brooke Bucholtz, and Gail Gottfried, "Genome Consortium for Active Teaching: Meeting the Goals of BIO2010," *CBE-Life Sciences Education*, 6 (2007): 109.

2. Vincent P. Buonaccorsi, Michael D. Boyle, Deborah Grove, Craig Praul, Eric Sakk, Ash Stuart, Tammy Tobin, Jay Hosler, Susan L. Carney, Michael J. Engle, Barry E. Overton, Jeffrey D. Newman, Marie Pizzorno, Jennifer R. Powell, and Nancy Trun, "GCAT-SEEKquence: Genome Consortium for Active Teaching of undergraduates through increased faculty access to next-generation-sequencing data," *CBE-Life Sciences Education*, 10 (2011): 342; Vincent P. Buonaccorsi, Mark Peterson, Gina Lamendella, Jeff Newman, Nancy Trun, Tammy Tobin, Andres Aguilar, Arthur Hunt, Craig Praul, Deborah Grove, Jim Roney, and Wade Roberts, "Vision and Change through the Genome Consortium on Active Teaching using Next-Generation Sequencing (GCAT-SEEK)," *CBE-Life Sciences Education*, 13 (2014): 1.