

Genome LIFE



Catch the Wave

At IGSP, Undergrads Find Fast Track to Success in Early, Open-Ended Research Experiences

When recent Duke graduate and A.B. Duke Scholar Nick Altomose '11 spoke to *The Chronicle* after learning he had won a prestigious Marshall Scholarship that would send him straight from Duke to the University of Oxford for two years of graduate study, he gave the credit first and foremost to his research mentor and "to all the professors who took care to give attention to undergraduates."

Nick did work as an undergraduate that you might sooner expect of an advanced graduate student. He spent four years in IGSP Director Hunt Willard's lab, studying little-known portions of the genome that had been left out of the Human Genome Project – what Altomose describes as a "final frontier of the human genome." For his trouble, Altomose earned not only the Marshall Scholarship, but also a Barry M. Goldwater Scholarship in science, mathematics and engineering and a Gilliam Fellowship for Advanced Study from the Howard Hughes Medical Institute, which will support his pursuit of a doctoral degree after he finishes up in Oxford.

Nick's story and his research accomplishments are exemplary by any standard, yet he didn't come to campus with any research experience under his belt. He is also just one of many students who have found their way almost from the start of their college careers into one IGSP research group or another, making the interdisciplinary institute a kind of intellectual "home base" and springboard for launching them in the direction of their choosing.

Successful Launch

"I think we've had amazing success if you look at the career paths of the students who have come through," says Bob Cook-Deegan, Director of Genome Ethics, Law & Policy in the IGSP. "It's our Focus program, it's the research, the certificate program – there is a whole series of things the IGSP offers, and they all fit together to give students experiences as undergraduates that make them really attractive to grad-

Catch the Wave (continued on pg 3) >

INSIDE

<i>Director's Message</i>	2
<i>Creativity Spoken Here</i>	5
<i>Let's Work Together</i>	6
<i>Two of a Kind</i>	7

Message from the Director

This issue of *GenomeLIFE* focuses on our educational mission and highlights the achievements of many of our students, from first-year undergraduates just arriving on campus to seasoned and newly hooded PhD graduates. The very concept of being an interdisciplinary institute at Duke always anticipated a need for education in the broadest sense, educating each other – especially those in other disciplines and in other corners of campus – about very different views of the human genome and the genome sciences and their implications for us as individuals, as a society and as a species.

When I was first approached about the position of director almost 10 years ago, what attracted me in particular was the institute's breadth in both science and policy and the possibility of broad engagement of scholars across the disciplines, something that had fascinated me since my own very early days as a graduate student in genetics some (gulp...) 35 years ago. But even as I arrived on the Duke campus, I was unprepared for just how important interdisciplinary education would become for our institute and just how satisfying that would become for me, both personally and professionally.

An essential feature of good education, it seems to me, is a focus on what we don't know, on untilled soil. To some, that will seem self-evident; to others, it may seem counter-intuitive. Especially in research (and I use that term in the broadest sense of all original open-ended scholarship, not simply laboratory-based experiments), the transition from studying what others have already learned to what still remains to be found out represents a fundamental phase shift that distinguishes true scholars from mere learners. This approach has been a foundational element of graduate education in the U.S. for over 130 years, but only recently has found its way into the dialogue of mainstream undergraduate education, perhaps most especially in the sciences.

It may seem ironic, but, at least in the sciences, it is small liberal arts colleges – not top-tier research universities – that have excelled at encouraging their students to pursue research careers. The “why?” of that fact is what drives many of us in the IGSP to focus attention on undergraduates, and the earlier the better. These efforts strive to combine the benefits of a highly personalized experience more typical of a small liberal arts college with the extensive opportunities of a research-intensive university.

We're hardly the only ones to have tried this approach, but as the articles in this issue describe, the IGSP has met with enough success thus far to embolden us to try more. Going forward, the challenge will be to expand the reach of this approach, both in terms of student numbers as well as its disciplinary footprint, and to take better advantage of the physical and scholarly juxtaposition of our undergraduate and graduate

programs for the mutual benefit of both. Graduate students present undergraduates with mentors and role models who are only a few turns in the road ahead of them. In return, undergraduates offer a fresh reminder of the virtues of broadening one's focus across disciplines and perspectives, at least from time to time, as graduate students appropriately drill down into the depths of their specific thesis projects.

A common feature of successful programs at both levels has been summed up (perhaps a touch indelicately) by a professor at The University of Virginia as the need to teach our students how to be “productively stupid.” Such an aspiration is critical for true scholarship and is especially inviting in interdisciplinary education, where it is more commonplace to accept that one cannot possibly know “everything.” Being “ignorant by choice”, as our UVa colleague put it, acknowledges the truism – frequently hidden from sight by pride or just plain embarrassment, but a truism nonetheless – that the more important and impactful a question is, the less likely it is that we know the answer ahead of time.

Interdisciplinary education of the sort we encourage in the IGSP, enabling and validating young scholars to seek answers that can't be found in the backs of books or to ask questions that no one else has even thought to ask before, reminds me of what I used to call “the Helios question”. In my first faculty position 30 years ago, we had a faculty member – very smart and very much at the top of his game – who would always ask a “stupid” question at the end of every seminar. Of course, as only the most attentive graduate students and even faculty figured out at the time, the questions weren't stupid at all; it was just Helios being willing to reach outside of his comfort zone into new areas where his “ignorance” was neither wrong nor embarrassing, simply inquisitive. It was an epiphany to me when I realized the impact he was having, week after week, especially on graduate students in the department. Asking stupid questions became the norm; everyone was comfortable confessing their “ignorance.” It was, indeed, “productive stupidity” at its best.

“**Be comfortable with your stupidity and stroll purposefully into the realm of the unknown.**”

So, to all of our students – undergraduate and graduate students, fellows and even faculty whose base lies in other areas – be comfortable with your stupidity and stroll purposefully into the realm of the unknown. The genome sciences and policy are full of enough unknowns for all of us, and we need all the help we can get. ▶

Huntington F. Willard, Director



“I think we’ve had amazing success if you look at the career paths of the students who have come through.”

—Bob Cook-Deegan

Catch the Wave (continued)

uate schools, law schools and medical schools. They’re on these spectacular post-Duke career paths that I think are tightly tethered to the fact that they were here in the IGSP.”

Willard doesn’t take credit for inventing that special brew himself. Rather, he says the IGSP undergraduate program and its core elements are largely modeled on his own experience as an undergraduate, when he spent nearly three years working in a research lab on totally open-ended questions. His goal from some of the IGSP’s earliest days has been to get undergraduate students engaged and into the “breaking waves of current research” as early as possible in their time at Duke, leaving them plenty of time for authentic research experiences with all the exhilarating possibilities and uncertainties that come with them. “I had to craft my own experience back then, but I wanted to develop a program here that would encourage students to jump into multi-year, open-ended research projects and to take ownership of those projects right from the start.” That kind of ownership and long-term engagement has historically

been a feature of graduate education. “It’s worked for a hundred years in doctoral programs, so, it’s an idea overdue to be tried with younger minds. They can get more out of their college experience and then will make fabulous graduate students themselves.”

That program led to Willard being named a Howard Hughes Medical Institute Professor in 2006, allowing him to focus expressly on ways to foster an interest in ongoing research experiences in the genome sciences among undergraduates and to encourage them to consider pursuing a PhD after finishing their undergraduate degree at Duke.

“We’ve been very fortunate in attracting some really terrific students,” Willard says. “Some know ahead of time that they love science and the possibility of research; but others are pre-meds who catch the research bug only once they are given a chance.”

The results? Of now nearly 60 students who have participated in multiple aspects of the program since it began, almost half have gone on to advanced study involving research in genetics, genomics or related biomedical science. “This yield is spectacular by national norms,” Willard adds. “Our students have ended up in doctoral programs, either PhD or MD/PhD, at some of the best universities around.”

An Early Focus

For many, like Altemose, the entry point has been to enroll in the fall of freshman year in the IGSP’s Focus program, one of about a dozen interdisciplinary seminar clusters designed to nurture first-year Duke students’ intellectual



Award-winning Scholar Nick Altemose (back left) is one of many Duke undergraduates who have found their way into one or another IGSP research group very early on in their college careers.

curiosity. But that's just where they get their intellectual feet wet. The Genome Focus Program serves as a kind of "feeder" to get students interested in joining a research lab during the semester and to apply for a spot in the IGSP's Summer Research Fellowship Program, which brings undergraduates from Duke and elsewhere – almost all of whom are freshmen or sophomores – into IGSP labs full-time for 10 weeks each summer.

An impressive number of Duke summer fellows find ways to continue in research throughout their undergraduate careers at Duke through additional fellowships, independent study or work-study arrangements. They frequently write their work up in the form of senior honors theses or professional journal publications.

Since 2008, the most dedicated students have also been able to pursue their interests through the Genome Sciences and Policy Certificate Program. The interdisciplinary equivalent of an academic minor, the certificate requirements include a combination of interdisciplinary coursework and research experiences. The program culminates in a capstone course in which students take on real clients, many of them based in Washington, D.C., to complete projects at the intersection of genome sciences and policy. This semester, a record 15 seniors are focusing on issues related to genome technologies in health care, including noninvasive fetal genetic testing and direct-to-consumer genome testing.

Open Door Policy

In some of the earliest plans for the IGSP, education took a backseat to research, Willard has noted. Whether part of the original plan or not, Cook-Deegan says he is sometimes still amazed himself at the remarkably important place that undergraduates and undergraduate education hold in the maturing institute and in his role as director of genome ethics, law and policy.

Still, it is a reality that is now well appreciated by those positioned in other parts of the university. "I think we've always known there could be a role for undergraduates in all parts of the IGSP," said Alex Rosenberg, chair of philosophy and director of the A.B. Duke Scholarship program, who has made a habit



Computational biology researcher and Duke senior Daphne Ezer won a Marshall Scholarship and an opportunity for graduate study at the University of Cambridge. "Research is only half of the process of science," she says. "For science to have any impact, research must be shared with others."

IGSP Undergrads *By the Numbers*

- 8** The number of years since the IGSP first opened its doors to undergraduates.
- 93** The number of IGSP summer fellows who have spent 10 weeks as full-time researchers in IGSP-affiliated labs since the program began in 2005.
- 11** The number of Duke alums who graduated with a Genome Certificate in the program's first 3 years.
- 14** The number of students expected to graduate with a Genome Certificate in 2012.
- 10** The number of majors represented by Genome Certificate students past and present.
- 26** The number of IGSP certificate and Program II students who got their start through the IGSP's Focus Program as freshmen.
- 3** The number of Duke Marshall Scholars with research ties to the IGSP.

of introducing some of the very best students to IGSP labs and research.

Nick Altomose is an example of one of those students, he said, as is this year's Duke Marshall Scholar Daphne Ezer, who conducted computational biology research in the lab of Alex Hartemink. "These are people who, from beginning of their undergraduate careers, have taken on the opportunities in research labs that the IGSP offers," Rosenberg said. "These are opportunities that Duke provides undergraduates that I suspect do not exist in similar programs elsewhere in the country, partly because ever since Hunt began running the IGSP, he was interested in the undergraduate education dimension of this whole place. For me, it's just been pushing against an open door and finding ways to encourage undergraduates to get involved."

If this year's bumper crop of certificate students is any indication, there will be plenty more to come.

"Looking at the number of students enrolled in our certificate program and where we are in the field of genomics, we will continue to blossom," says Susanne Haga, a long time IGSP faculty member who was recently appointed director of education in the IGSP. She says a goal for the future is to expand the IGSP undergraduate pool to include a greater number of non-science majors.

Thinking more broadly, Willard has said he would like to see the development of similar academic tracks aimed to students all across campus. "There is an opportunity to extend what we've learned at the IGSP for engaging faculty and students to create a range of coherent and creative four-year intellectual pathways, not just in the sciences but across various disciplinary and interdisciplinary initiatives." ▶

Creativity Spoken Here



After graduating with a Genome Certificate and majors in biology and economics, Kelly Schiabor headed straight for graduate school at UC Berkeley where she now studies genomics and decision-making in fruit flies.

Many IGSP student researchers do spend much of their time working to answer essential biological questions in the lab, but others like **Swathi Padmanabhan '10** came to Duke as freshmen not so interested in pursuing science at all. Swathi was interested in public policy, with plans for law school.

Swathi still signed up for the Genome Focus Program and continued on with Bob Cook-Deegan in research exploring issues of intellectual property as they related to the accessibility of vaccines globally, and especially in India. She traveled to Hyderabad and met directly with the heads of research and development at major vaccine manufacturing companies.

Her work turned into a *Nature Biotechnology* report suggesting that vaccine manufacturers in India and other developing countries might be able to produce lower-cost HPV vaccines in spite of complicated patent protections on various aspects of the technology. As for Swathi, she graduated *cum laude* with highest distinction in Public Policy Studies, a minor in history, and a Genome Certificate. She is now in her second year at Vanderbilt Law School.

Other IGSP students and graduates are following equally creative and distinctive paths. **Kelly Schiabor '09** graduated with a double major in biology and economics, and she, too, once expected to go to law school. Instead, she headed straight from Duke to work on a PhD at the University of California, Berkeley.

Schiabor's interest in pursuing research started with the Focus program and a summer working in Beth Sullivan's lab on fundamental questions in genome biology. From there, she took her newfound interest and skill in genomics to Scott Huettel's lab in the Department of Psychology and Neuroscience, where she collaborated on a study designed to overlay genetic analyses on behavioral and imaging studies aimed to unravel why we humans so often make risky decisions. Those same questions now motivate her doctoral work in the much easier to manipulate fruit fly.

"The IGSP is a really accessible place for people who are interested in science, but unsure where it might lead them," Schiabor said. "You learn to tackle problems from so many angles and find out what makes you tick."

When **Alessa Colaianni '07**, a major in biology and philosophy, first got involved with the IGSP as a summer fellow, she expected to find herself working in a lab. Instead, she wound up constructing contemporary histories of seminal genome technologies.

Now in medical school at Johns Hopkins, she traveled back to Duke last year to pursue one of her other loves; she read the role of double helix researcher Rosalind Franklin in "Photograph 51," a play exploring science and sexism put on as a

“The IGSP opens its arms to undergraduates right away.”

—Jared Blau, '10

collaboration between the IGSP and Department of Theater Studies.

Marni Siegel '11 graduated with a Genome Certificate last year after working on cancer research in the lab of Phil Febbo, now at the University of California, San Francisco. She is now a first-year MD/PhD student at the University of North Carolina, Chapel Hill, a path she decided on in part based on advice she got from IGSP faculty over dinner.

As an undergraduate, Marni also dedicated herself to playing the piano, taking lessons and practicing for many hours every week. For a creative and interdisciplinary thinker like Marni, piano and her interests in science and medicine are intimately intertwined. The lessons learned from piano even formed the basis for the essay that helped get her into the MD/PhD program.

And then there is **Jared Blau '10**, who spent four years conducting independent research in the Willard lab, published part of his senior honors thesis in *PLoS Genetics*, graduated with a Genome Certificate, and is now teaching physical science to disadvantaged eighth graders in Las Vegas through Teach for America. "It's been a tremendous experience," he says. "I've been able to combine my love for teaching science with a huge social issue: that where you are born influences where you will end up. The schools and the opportunities are not the same."

Jared, too, has plans to return to school. But no matter which direction he ultimately goes, he'll take his IGSP experiences with him.

"The IGSP has been so important in my life to date," he says. "When I look back, no other place would have given me the chance that Duke did. I didn't have research accolades coming in, but by October of my freshman year I was in a lab, and I wasn't cleaning glassware either. The IGSP is a wonderful place for undergraduates to grow their interests. It's not about just earning your stripes; the IGSP opens its arms to undergraduates right away." ▶

Let's Work Together

With Interdisciplinary Research at its Core, the CBB Program and its PhD Students Thrive

Ask anyone involved with Duke's Computational Biology & Bioinformatics PhD Program (CBB), from the alums to first-year students to faculty, to describe what is most attractive and defining about the program and you are sure to find a common theme emerging: it all comes down to the strength of the research collaborations that are at its core.

"What struck me about Duke was the openness to collaboration," said Dave Orlando, who received his PhD with the program's very first class and is now a post-doc at the Whitehead Institute in Boston. It wasn't about a token person in one department or another, as it seemed to Orlando it was at some other schools he considered; the desire and commitment to collaboration here spanned many departments, from biology to computer science, physics to math.

"When I first visited Duke, it was clear that the faculty were already collaborative," Orlando's classmate Jeff Headd, now a post-doc at the Lawrence Berkeley National Laboratory, agrees. "You could see faculty in different departments were working together, and without competition or tension."

"There is something really special here. It's truly interdisciplinary, and the faculty and students are just so excited to do science," says current first-year student Rotem Ben-Shachar, who majored in computational biology as an undergraduate at the University of California, Los Angeles. "It's infectious."

Learning the Easy Way

That kind of interdisciplinary collaboration doesn't always come naturally, and it is clear that the CBB program simply could not work as it does without such a solid foundation. "It's a whole lot easier to develop an interdisciplinary graduate program when it is driven by actual interdisciplinary research," says John Harer, CBB Program Director and a Professor of Math and Computer Science.



Annual retreats are one important way that the CBB PhD program maintains close ties amongst graduate students and faculty who otherwise find themselves scattered across research groups all over campus.

“We’re taking what we’ve learned the hard way and training today’s graduate students in an environment where these [interdisciplinary] interactions have become much more seamless.” —Steve Haase

CBB graduate students typically have co-mentors, one in a life science such as biology or molecular genetics and the other in a quantitative science such as math, statistics or computer science. Student research grows out of stable, preexisting collaborations spanning disciplines and departments that would have traditionally been isolated. As the field of computational biology continues to grow, students are poised to grow right along with it.

"So few of us were brought up in this collaborative environment," says CBB Director of Graduate Studies Steve Haase, Associate Professor of Biology in the Duke Center for Systems Biology. "We're taking what we've learned the hard way and training today's graduate students in an environment where these interactions have become much more seamless."

“An Interesting Disaster”

The CBB PhD Program today is its own very flexible and dynamic yet surprisingly cohesive entity. Students in the program choose among faculty representing six, somewhat loosely defined and partially overlapping research areas in various aspects of genomics, computational biology or statistical modeling, but the program has always had its roots in the IGSP.

Harer remembers just how CBB began. It was 1999, the IGSP was little more than a concept, and Harer was then Duke's Vice Provost for Academic Affairs. As a joint effort of the main campus and the medical school, the administration launched an initiative to fund post-doctoral trainees that could bridge the biological and quantitative sciences.

"It was an interesting disaster," Harer says. A successful hire or two were made, but overall very few suitable applicants turned up. "It was clear that we needed to aim earlier: the focus needed to be at the graduate level. The program really grew up out of the IGSP and those beginning efforts to integrate computation and biology."

It is more typical now for CBB students to come in with prior experience on both sides of the aisle. Yet the program is no less vital. "The subject continues to evolve," Harer says. "The Human Genome Project is what initially got us all excited, but there is so much more – genome function, gene networks and applications to medicine and so on. The field keeps changing all the time and the program adapts to fit." ▶





Alumna Highlight Elena Edelman Orlando

Elena first learned about the CBB program when she was a Duke undergraduate majoring in math and biology. As a junior, she conducted research with Tom Kepler, the CBB program's founding director.

When it was time to consider graduate school, "I applied to a bunch of programs," she said. "Ultimately, I really liked the atmosphere at Duke and how collaborative it was. They encourage you to take the time to work in different labs and find out what you really want to do."

As a member of the program's second class, Elena found just what she was looking for. She worked with Sayan Mukherjee in Statistical Science in a collaborative effort aimed to model cancer's progression. The major innovation of the work featured in a 2008 *PLoS Computational Biology* report was the use of gene sets over single genes in following tumors over time, from normal tissue to the beginnings of cancer and on to that cancer's spread.

Today, Elena is a post-doc at Massachusetts General Hospital in Boston, where she lives with husband and fellow CBB alum Dave Orlando. There she is using similar methods to explore cancer's response to drugs. It is work that she says she hopes to continue into her career, perhaps in the biotechnology sector or perhaps not.

"In the CBB field, a lot of doors are open to you and there are so many projects out there," she said. "For someone with these skills, it is no challenge to find work to do." ▶

The CBB Program *By the Numbers*

- 20 The number of Duke alums who now hold a PhD in Computational Biology & Bioinformatics.
- 36 The number of students who are currently working on their doctoral degrees in the CBB program.
- 32 The number of Duke faculty who serve as primary advisers to students in the CBB program, half from the School of Medicine and half from Arts & Sciences.
- 3 The number of core course requirements every CBB student must take. Most students also take a broad set of electives as they define their own paths through the program.
- 19 The number of CBB courses currently being offered, from Responsible Genomics to Genomic Tools and Technologies to Statistical Methods for Computational Biology.
- 18 The number of students in other graduate programs on campus who have chosen to expand their studies by enrolling in the CBB graduate certificate program.
- 57 The number of Duke faculty who are currently contributing, in one way or another, to the interdisciplinary CBB program.

Two of a Kind *University Program in Genetics & Genomics*

In addition to the CBB PhD Program, the IGSP is also closely linked to the University Program in Genetics & Genomics (UPGG). In fact, before the IGSP came into being, UPGG was just UPG. The IGSP's **Beth Sullivan**, now co-director of the UPGG program, recalls that it was IGSP Director Hunt Willard who realized the impact that genomics was having on science, suggested that the graduate training program be expanded to include genomics, and developed and taught the first genomics course for first-year UPGG students.

That link to the IGSP offered students in the program greater opportunities for exposure to the latest in genome research through their first-year rotations. Today, nearly half of all UPGG students have done at least one rotation in an IGSP lab, and about one-third of UPGG students are conducting their PhD research in an IGSP-affiliated lab.

"The combination of UPGG's strength as a degree-granting graduate program and IGSP's focus on research and education creates a rich graduate experience for Duke PhD students who desire to excel in genetics and genomics," Sullivan said. ▶





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“Duke thrives on the ability to pull the undergraduate world and the world of research together. There is no separation between classroom teaching, mentoring and guiding students through research. It is all one and the same.”

—Hunt Willard, IGSP Director

Genome Research & Education Society

Another way to get involved! **GRES** is a student organization dedicated to promoting scholarship and research at Duke and educating others about the genome sciences and their implications.

We've got an event for you!

The IGSP hosts or sponsors a wide selection of regular seminars, special events and workshops throughout the academic year.

Computational Biology Seminar, Mondays @ 11:00

Cancer Genetics & Genomics Seminar, Mondays @ 1:00

UPGG Tuesday Seminar Series, Tuesdays @ 12:30

Systems Biology Seminar, Wednesdays @ 2:00

Genomic & Personalized Medicine Forum, Thursdays @ 9:00

Science & Society Journal Club, the 3rd Friday of the month @ 11:30

Plus, educational workshops, including **Genome Academy, Career Series Dinners** and more. Visit genome.duke.edu for details and the latest updates.