Genomic Innovation

Open to students from the following NYC-area institutions: Cold Spring Harbor Laboratory (credit transfer), Columbia (CMBS OC6200), CUNY (credit transfer), Einstein (BIOS 4004), Mt. Sinai (BSR 3401), Memorial Sloan Kettering / Rockefeller / Weill Cornell (WCMC TPCM 5003 01), and NYU (BIOL-GA 1140).

Course description
Genomic Innovation is a project-oriented course focused on understanding the current landscape of genome science and on building ideas and organizations to accelerate progress in technology innovation, scientific understanding and industrial applications of genomics. The course will introduce students to cutting-edge technologies and applications in genetics and genomics and their responsible use in science and society. Students from diverse majors and backgrounds (including biology, medicine, engineering, business, sociology, and law) are welcome to participate.

Application and enrollment
The course is designed for graduate students and advanced undergraduates from multiple institutes listed above. Due to the interactive nature of the course, participation is limited to a maximum of 40 students. To apply, please email instructors (info@genomicinnovation.org) two paragraphs: 1) your inventive, scientific, or entrepreneurial aspirations over the coming decade and any special skills or unique experiences, 2) your biggest ambitions of how the human condition can be transformed for the better during our lifetime. Also, please include the university and program you are currently enrolled in. We will admit students on a rolling basis, but will leave some space until the final deadline for applications, August 27. All students will be notified of acceptance by September 2.

Course instructors
- Neville Sanjana, PhD (NYU Biology & NYGC), nsanjana@nygenome.org
- Tuuli Lappalainen, PhD (Columbia Systems Biology & NYGC), tlappalainen@nygenome.org

Teaching fellows
- Margot Brandt, BSc (Columbia & NYGC), mbrandt@nygenome.org
- Gizem Efe, MA (Columbia), ge2215@columbia.edu

Course administrator
- Erica Bertisch, jebertisch@nygenome.org

How to contact the course staff
staff@genomicinnovation.org emails the entire team (Neville, Tuuli, Margot, Gizem & Erica) and is the best way to ensure a quick response to any questions.
Location and time
● New York Genome Center: 101 Avenue of the Americas (6th Ave.), 1st floor auditorium
● NYGC is close to the Canal St. and Spring St. MTA (accessible by 1, A, C, E, 6, R, N, Q)
● Thursdays from 3 - 6pm (Fall 2018, starting September 6th).

Office hours
● Thursdays 2:30p (before class) at the NYGC Auditorium
● By appointment with instructors or TFs – please contact Erica to schedule

Aims and learning objectives
● Introduce students to cutting-edge technologies and applications in genetics and genomics, and their responsible use in science and society. Topics will be presented by domain experts from academia, clinical practice, nonprofits, industry (pharma, startups), technology transfer, and venture capital.
● Provide a broad vision of diverse topics with an emphasis of identifying unmet needs in genomic technologies and developing new ideas to address these needs.
● During the course, students from NYC-area universities will build interdisciplinary teams to foster trans-disciplinary thinking and complete approaches to the development of new ideas. We anticipate that some project teams will result in new ventures and go on to be competitive in NYC-area entrepreneurship competitions.
● Develop skills to think in-depth about current problems in genomics, conceptualize approaches for solving them, and communicate their ideas in academic and nonacademic settings.

Course format
● The course consists of a combination of lectures, classroom and homework assignments alone or in small groups, and a midterm and final project in small groups.
● The class meets once a week on Thursdays at 3 pm - 6 pm. Each meeting will include a guest lecture and discussion with expert guest speaker(s), and typically also discussion of the readings or homework assignments.
● We encourage active participation from the students and peer-to-peer teaching/learning between students with different expertise.
● The web site for the course: http://genomicinnovation.org/.

Prerequisites
● The course is suitable for graduate students and advanced undergraduates.
● Students with diverse majors and backgrounds are welcome to participate, including not only genetics, molecular biology, computational biology and medicine but also for example engineering, business, sociology, and law. We do not expect specific programming skills, advanced statistical skills, or molecular biology laboratory experience, but intellectual curiosity in genomics is essential. For undergraduates, college-level introductory biology is a prerequisite.
Participation is limited, and requires permission of the instructors. See above for Application and Enrollment.

Credits and grading

- 4 credits
- Grading:
  - Homework assignments: 35%
  - Midterm project & presentation: 20%
  - Final project & presentation: 45%
- Some students will receive credit normally at their home university, while some will need to apply for credit transfer based on the transcript. Detailed information will be provided by the end of the course.
- Class attendance is mandatory. If you have a very good reason to skip a class, email staff@genomicinnovation.org in advance to ask for permission, and to receive instructions for an extra assignment to compensate for the missed class.

Academic integrity

We will not tolerate cheating or plagiarism, and active and fair contribution in group assignments is expected from all students. When academic dishonesty is suspected, it will be dealt with seriously in adherence to the official guidelines of New York University and Columbia University. The guidelines on academic integrity, which all students should read, are available online at http://gsas.nyu.edu/about-gsas/policies-and-procedures/gsas-statement-on-academic-integrity.html and https://gsas.columbia.edu/student-guide/research/academic-integrity-and-responsible-conduct-research.

Schedule

Week 1 | Sep 6 | Introduction, goals and expectations for Genomic Innovation
- Discussion of aims and themes of the course
- Lecture on basic concepts in genomics
- Defining innovation: Innovation in the last century and the last decade
- Tour at the New York Genome Center
- Introduction of students
- Hand out homework assignments 1 & 2

Week 2 | Sep 13 | New frontiers and applications in genome sequencing
- Sequencing technologies, gaps in our knowledge, and future opportunities
- Guest speaker: Mike Zody (NYGC)
- Hand-in homework assignment 1 & lightning talks

Week 3 | Sep 20 | Mining genomic data from our environment and health records
- The revolution of metagenomic sequencing our everyday environment: advances, challenges and future prospects
- Big data in healthcare: How to harness electronic health records
○ Guest speaker: Chris Mason (Weill-Cornell), Nick Tatonetti (Columbia)

**Week 4 | Sep 27 | Technology transfer and intellectual property**
- How to build and protect intellectual property
- How to make commercial products of research innovations?
- Guest speaker: Andrew Whitely (CSHL), Sadhana Chitale (NYU)
- Hand-in homework assignment 2
- Hand out homework assignment 3

**Week 5 | Oct 4 | Funding of genomic ventures**
- Funding of genomic ventures via venture capital
- Guest speakers: Barbara Dalton (Pfizer), Angela Tran Kingyens (Version One)
- Midterm assignment: Form teams and discuss topics
- Hand in homework assignment 3

**Week 6 | Oct 11 | Genomics in cancer research, diagnosis, and treatment**
- The genomic revolution in cancer research
- Cancer genomics as example of one of the first clinical applications of genome sequencing
- Guest speaker: Marcin Imilienski (NYGC/Weill-Cornell)
- Finalize midterm topic

Oct 18: No class (American Society for Human Genetics conference). Work independently on midterm.

**Week 7 | Oct 25 | The revolution of portable sequencers**
- The technology, applications, and future vision of small portable sequencers
- Guest speaker: Eoghan Harrington (Oxford Nanopore Technologies)
- Presentation and hand in of midterm assignments

**Week 8 | Nov 1 | Founders’ Day: Launching and running a biotech startup**
- Personal stories from founders of biotech startups
- The basics of writing a business plan
- Guest speakers: Joe Pickrell (Gencove), Miriam Boer (Sonify Biosciences), Frank Rimalovski (NYU eLab)
- Hand out homework assignment 4
- Hand in midterm peer reviews
- Select final project teams & topics

**Week 9 | Nov 8 | Genetic variation in humans: From research to applications**
- Integrating genomics data sets to understand molecular mechanisms of disease
- Human genetic data as a game changer in drug development and clinical practice
- Speakers: Tuuli Lappalainen (Columbia & NYGC), Noura-Abul-Husn (Mt Sinai)
Week 10 | Nov 15 | New frontiers in genetic diagnosis
  ○ The advances and challenges in genetic diagnosis of severe diseases
  ○ Speaker: Wendy Chung (Columbia)

Nov 22: Thanksgiving, no class.

Week 11 | Nov 29 | Genome editing and CRISPR
  ○ Innovation in biotechnology: the discovery and applications of the CRISPR technology
  ○ Neville Sanjana (NYU & NYGC), Sam Sternberg (Columbia)

Week 12 | Dec 6 | Single cell technology: Innovation and applications
  ○ Experimental and computational revolution of single cell analysis
  ○ Single cell applications in biotech and medicine
  ○ Rahul Satija (NYU & NYGC), Ian Peikon (Kallyope)

Week 13 | Dec 13 | Final presentations
  ○ Final project presentation from all groups with Q & A
  ○ Hand-in final 2 pg executive summary

Homework assignments

Assignment 1: Setting goals.
Describe a goal that you want to accomplish in the next 10 years? Goals could range from developing a necessary technology or solving a scientific problem to developing a transformative products or therapeutic. Write 1 page about why this goal is important, what solving this problem would accomplish, and why you are passionate about it. Be as specific as possible. Prepare a 1 minute, no slides presentation about the goal for the next class. This presentation should provide other class members with a clear idea of your interests for forming teams for the midterm and final projects.

Assignment 2: Reporting from the front lines
Find 2 scientists, engineers or entrepreneurs that are active in the general areas you are interested in, and interview them. In addition to understanding their work and scientific achievements, ask them about how they work. What motivated them to work on a particular problem? How do they choose problems and what strategies do they use to solve problems? What are pressing needs and important problems in their field? Write a 1 page summary of your interviews that focuses on the most interesting insights and lessons.
Assignment 3: Beginning the process of innovation.
This assignment is about figuring out the path to reach your goal – the one that you described in Assignment 1, or a different one. Create a Zwicky-Boyden tiling tree to outline all possible routes to the goal, including those that might not be feasible, have competition from others working on the problem, etc. What is the lowest-risk path towards this goal? Visualize and describe the key milestones. Think of the expertise that is needed from a team trying to reach your goal. Write a 1 page summary of your chosen path, and the earliest test you can perform to see if this path will work. Include your tiling trees as an appendix.

Assignment 4: Finding and listening to the experts.
Find and follow on Twitter 10 domain experts or leaders in one of the areas from your group’s midterm project. These can be leaders in science, medicine, engineering or business. Read over the tweets from the previous month for each of these experts. Be prepared to discuss with the class the following:
- Who did you follow and why?
- What topics did they mention most frequently in their tweets?
- What did you learn that might be difficult to get from reading papers or popular press articles?
- Summarize 3 insightful or surprising things that you’ve learned from the online conversations.
Write a 150-word summary of the last two points.

Midterm and final projects
The main assignment of Genomic Innovation is to analyze an opportunity, and build a project around it. Students will work in teams of 3-4 people. The topic is chosen by the team, and approved by the instructors or TFs. The typical topic would be a research spin-off idea for a product or service that could become the foundation of a startup company, but it could also be for example a new nonprofit organization, or a research project to pursue in an academic or corporate environment. During the semester, each team will formulate and analyze the goal and practical execution of their project.

Midterm
The midterm is about innovation and brainstorming, and exploring opportunities and ideas before settling on a single direction for the final. The teams will identify as many ideas as they have members in the team. The team should identify unmet needs – these can be unsolved problems and needs e.g. in health, medicine, or environment – and propose a potential solution to each of them. Alternatively, they can focus on a single unmet need and propose multiple solutions. These will be presented to the class with a focus on 1) the problem that you are trying to solve, 2) why it is important, 3) who are your target users or customers. Based on the feedback, one of these ideas will be developed further in the final project. There, the focus shifts to practical solution and execution of the idea.
The Midterm deliverables:
1. The team gives a presentation of about 10 minutes, followed by a short Q&A that the team should be prepared for. Focus on the problem that you are trying to solve, and the demand for the solution.
2. The team provides a short written summary of the ideas, focusing on the same points as in the presentation. About 150 words per idea (i.e. a team of three people with three ideas should provide 450 words altogether).
3. Each team member provides a 150-word written feedback of another team’s presentation including their answers in the Q&A, focusing on constructive feedback on their ideas (rather than presentation performance).

Final
For the final project, the team will choose one of the ideas analyzed and presented for the midterm, and develop it further. The teams can continue to refine the importance of the problem that they are going to solve, but the final project needs to include details of the proposed solution. This includes research into technology, previous solutions, identification of unique benefits and challenges of different solutions, and justification why the proposed solution is superior and innovative. Additionally, the teams should think about the business side of their project: detailed analysis of the market, the IP, funding, and the roles and expertise of the ideal team.

The Final deliverables:
1. The team gives an elevator pitch in the class (~15 mins), followed by a longer Q&A that the team should be prepared for. Describe the problem that you are trying to solve, the product that you’re going to provide, details of how you are going to get there, the funding model and IP, and the team that you are going to build.
2. The team provides a write-up of the executive summary of a business plan (about 2-3 pages)
3. Each team member provides a 150-word written feedback of another team’s presentation including their answers in the Q&A, focusing on constructive feedback on their project (rather than presentation performance).

Detailed instructions will be provided during the course.

Class discussion
Each lecture will be followed by a group discussion with the speaker that should ideally extend beyond normal Q&A, led by 3 students who have been selected to prepare questions in advance. In addition to other emerging topics and questions, the students are encouraged to think during the talk, ask the speaker, and discuss after the talk the following topics:
- When and how did this topic even become a thing? What enabled that?
- What are the bottlenecks in advancing future discovery? What would be the dream technology to have?
- What are the key advances and unsolved questions on the basic research side? What about the practical applications?
- Ask each lecturer:
  - Examples of missteps and successes along the path
  - What excites you most in your work?

Reading list
Before each class, students will be required to read a couple of articles, provided on the course website, in order to become familiar with the topic. The material will typically be discussed in the class before the guest lectures.