PROPOSAL FOR NEW UPPER DIVISION UNDERGRADUATE COURSE IN GENOMICS, BIG DATA AND HUMAN HEALTH

Justification:
The Big Data revolution in Biology and health care is here. This upper division 4-unit course reviews how recent advances, particularly in genomics, have the exciting potential to shift medicine from a reactive practice of treating symptoms and diseases, to one where disease risk is diagnosed early or even managed prior to onset. Major topics include the latest developments in genomic technologies and their clinical applications, genomics of human diseases, cancer genomics, targeted immunotherapy, and pharmacogenomics. We also focus on ethical issues surrounding the application and communication of genomic and related health information. These topics are not currently represented with a dedicated course in our undergraduate curriculum.

Title and Description:
Genomics, Big Data and Human Health (4 U).
Imagine a world in which you can input your lifestyle and genomic information into an App to obtain personalized health recommendations. This world is not 30 years in the future but beginning to unfold now. This course reviews how genomic advances are revolutionizing health care. This includes recent developments in personalized medicine, disease screening, targeted immunotherapy, pharmacogenomics, and our emerging understanding of how microbiome and epigenetic factors impact health.

Prerequisites:
BILD1 and [BILD4 or BIMM 101]. This will ensure that students have a baseline of knowledge needed in the course while allowing access to (nearly) all students whether they started our program before or after the BILD 4 requirement was introduced. These prerequisites will also accommodate non-Biology majors who have taken BIMM 101 (e.g. to meet medical school requirements), without incentivizing these students to take BILD 4.

Logistics:
This upper division 4-unit course has a target audience of all Biology students with upper division standing. A familiarity with basic biomedical concepts will be essential (students should have successfully completed BILD1 and BILD4 or BIMM 101). This course can be applied for required upper division electives, and can be considered for a core course for certain majors. It will not be cross-listed in any other department.

The standard lecture format will be used (3 hours lecture, 1 hour discussion with 8 hours outside prep/homework per week). At present, there are no plans to require a textbook; excerpts from selected texts and readings from primary literature will be occasionally assigned. Class time will consist of short lectures interspersed with active learning to develop skills (primarily clicker questions and peer instruction). Homework will consist of reading assignments and problem sets (these will also incorporate group-work in discussion section), and other at-home assignments.

Grades will be based on the following approximate distribution: 20% participation in lecture, 30% assignments (at home and in-class assignments during discussion section), 20% midterm, 30% final exam. The course will require the same resources as other upper division biology electives (classroom with standard projection or screen technology, equipped for podcasting, and Instructional Assistants).

Course scope and syllabus:
This course is comprised of seven major content areas:

- Genomic fundamentals,
- Genomic technology advances,
- Clinical application of genomics,
- Cancer genomics,
- Genomics of human diseases,
- Pharmacogenomics, and
- Ethics and communication of genomic and related health information.

At the end of this course students will be able to: Describe human genome structure and how genomes differ between individuals; Appreciate and be able to describe in general terms the recent rapid advances in sequencing technologies; Understand the process by which genomes are currently sequenced for clinical applications; Develop an understanding of how genomics can inform us about disease risks, allow for more precise diagnosis and prognosis, and more precise recommendations for treatment; Critically evaluate and summarize primary research literature in the genomics area; Discuss major ethical, legal and social implications of advances in clinical applications of genome sequencing.

An outline of major topics is provided below. Case studies and vignettes for each topic will be used to further engage student interest and provide hands-on experience in analyzing genomic data using online bioinformatics tools and databases.

Outline of topics:
Week 1
Review of **genome fundamentals**
Introduction to the course, Overview of major learning objectives and topic areas. Human genome review: What is in a genome? What does the human genome do? How do genomes differ between individuals? How is the genome decoded? Exploring what genetic errors are and what causes them.

Weeks 2 & 3
Recent **advances in genomic technologies** and their **clinical applications**
How are genomic technologies currently impacting the practice of medicine? What recent and future advances in genomic technologies have the potential for major clinical impact? What other 'omes' are useful for medicine? Can the transcriptome, proteome and metabolome be useful? How deeply can a person be analyzed? The promise and hype of personalized medicine. Open discussion of how genomics can inform on disease risks and some of the challenges associated with the use and management of genomic and related health information. We will also learn about major international genomics projects, including the 100,000 Genome project, and where genomic medicine could take us next.

Week 4 & 5

Genomics and **cancer** treatment
What has been learned from genome sequencing of cancer? How many genes have been implicated in cancer? How can sequencing advance cancer treatment? Why do some anticancer drugs fail and how might genomic approaches help address the issue? Can genomic approaches help detect early cancer and monitor treatment effectiveness? What is immunotherapy? Can genomics be used to help harness a patient's own immune system to fight cancer?

Week 6
Genomics and **human diseases**
How are genes responsible for genetic disorders identified? How useful are genomic approaches for solving mystery genetic diseases? Why can't most Mendelian diseases be solved? What is a complex genetic disease? Examples from neurological and metabolic diseases including type 2 diabetes and schizophrenia. Correlation and truth claims and issues surrounding interpretations of GWAS results.

Week 7 & 8
Pharmacogenomics and the design of treatment based on a patient's genome
How can genomics help guide drug treatments for treating diseases? The use of sequencing in the drug development process. Are there sex and race differences in drug effects? Avoiding adverse drug reactions (e.g. Abacavir and HLA-B5701, Statin drugs). Cytochrome P450s and notable drug examples including Warfarin and Tamoxifen. Computer assisted drug design and the promise and hype of RNA-based drugs and CRISPR.

Weeks 9 & 10
Ethics and the communication of genomic and related health information
Key ethical and communication principles relating to genomics, Can your genetic information be used against you? Who controls your genomic and other health information? What is the role of the physician and what are the implications of direct-to-consumer genomic testing? What are the major risks that must be considered when using genomic data? Can genomics be antiracist? We also consider the issues surrounding the use of genetic information prenatally (e.g. in sperm banks).

Please comment on any overlap with existing courses:
Content in this new course is complementary, but non-overlapping, with that in the existing courses:

- BIMM 134 *Biology of Cancer* (Bennett),
- BIMM 118 *Pharmacology* (David),
- BIMM 172 *Genome Science* (Briggs),
- BIEB 143 *Genome Diversity and Dynamics* (Petrie), and
- BIMM 110 *Molecular Basis of Human Disease* (Day, Tour and others).

This complementarity, discussed in detail below, is purposeful and deliberate. Science is about connecting ideas and disciplines and the more we can stress this to students the better.

BIMM 134 ("Biology of Cancer") takes an overall molecular focus to introducing cancer biology. Our new courses "cancer genomics" segment focuses on how sequencing of multiple types can advance cancer treatment. We also have a unique focus on the new and rapidly

advancing field of cancer immunotherapy and the bioinformatics basis for identification and prioritization of cancer specific variants for clinical applications.

BIMM 118 ("Pharmacology") introduces the molecular basis of drug action with a focus on select classes of currently available drugs, their pharmacokinetics (drug absorption, distribution and elimination) and pharmacodynamics (action on physiological and biochemical levels). In contrast, our "pharmacogenomics" content segment focuses on how genomic information can help guide drug treatments, avoid potential adverse reactions, and assist the design of new therapeutic strategies for treating diseases.

BIEB 143 ("Genome Diversity and Dynamics") and BIMM 172 ("Genome Science") both introduce modern next generation sequencing methods as we do in week one of the proposed new course. Beyond that are content diverges as we focus on human genomics and implications for human health. These are topics that do not feature in either BIEB 143 or BIMM 172.

BIMM 110 ("Molecular Basis of Human Disease") focuses on our current molecular and cellular level understanding of selected major human diseases including Cystic Fibrosis, Mitochondrial Myopathies, Colorblindness and Breast Cancer. The proposed new course has no substantial overlap in these areas.