

Dear Academic Senate Committee,

The Biology Department is submitting a proposal to establish a new Genomics and Bioinformatics track within the Biology major. This new track in the major will allow students to gain training in this new and rapidly-growing field of genomics and bioinformatics and broaden students' options to obtain a major in Biology.

Since the Human Genome Project in 2000, the amount of genomic information generated each year has been increasing exponentially, and the trend is not only accelerating but expected to continue into the next few decades. The traditional approach of studying biology has been revolutionized by this new access to genomic information, and the ability to handle, manipulate, and calculate genomic data has become paramount for biologists in this post-genome sequencing era. In addition to conventional training and coursework in biology, biologists who intend to work in genomics are also required to learn multitudes of skills in computer science, statistics, and mathematics in order to handle the amount of data and perform a genome-scale calculation. Hence, a handful of colleges and universities have started undergraduate programs related to genomics and/or bioinformatics. The idea of establishing a Genomics and Bioinformatics track was first brought to the Biology Department by Eileen McQuade. After discussing this idea in departmental meetings, Yi-Fan Lu investigated this possibility by comparing the resources we currently have at Westmont and the curriculums from several comparable undergraduate programs with a focus on genomics and/or bioinformatics. The department then assessed the possibility of combining the resources at Westmont and establishing a new track that focuses on this fast-developing field.

After receiving inputs from Don Patterson in Computer Science and Russ Howell in Mathematics, we have put together a plan that utilized the interdisciplinary resources for students to obtain essential skills in biology, mathematics, and computer science that allow students to enter a career related to this exciting field.

In addition to the core biology courses, the students in the Genomics and Bioinformatics track are also required to take the following MA and CS courses to establish their fundamental quantitative and computational skills.

MA 005 Introduction to Statistics (4)

MA 015 Discrete Mathematics (4)

MA 009 Elementary Calculus I (4)

CS 010 Design and Implementation of Solutions to Computational Problems (4)

CS 030 Abstract Models for Concrete Problems Using Java (4)

Furthermore, the students will also have the option to take upper-division CS or MA courses in their third or fourth years for advanced knowledge and skills in specialized fields, such as

MA 019 Multivariable Calculus (4)

CS 116 Artificial Intelligence and Machine Learning (4)

CS 128 Information Retrieval and Big Data (4)

PHY 40 Differential Equations (4)

These courses will build foundations for students to acquire essential skills of solving problems quantitatively and/or using computer programming to facilitate the calculation. In the core upper-division courses within the biology discipline, students are required to take Genetics (4), Genomics and Bioinformatics (4), Evolution (4), and one additional upper-division lab course. Genomics and Bioinformatics (4) and Evolution (4) both have a heavy focus on solving real-world biological questions quantitatively and computationally. Often, the solution requires handling and manipulating a large dataset and involves using computer software and/or statistics to get the answer. These two courses are great opportunities for students to put their previous quantitative training into practice and solve biological questions from the two fields that heavily rely on computational and quantitative skills.

BIO 114 Genetics (4)

BIO 117 Genomics and Bioinformatics (4)

BIO 131 Evolution (4)

One course from the following: (4)

BIO 113 Biochemistry (4)

BIO 110 Microbiology (4)

BIO 130 Cell Biology (4)

BIO 132 Molecular Biology (4)

In addition to interdisciplinary training, the students are also required to take faith-integrated courses such Biology and Faith (4) or Bioethics Seminar (1) and have the opportunity to conduct research with faculty members from either Biology and Computer Science Departments.

The post-graduate career outlook of students from this new track includes employment in biotechnology or pharmaceutical companies with a position such as biostatisticians, bioinformaticians, pipeline managers, or pursuing a graduate degree (MS or PhD) in relevant fields. Most common advanced degrees are MS or PhD in biostatistics, genomics, or bioinformatics. Bioinformaticians in the employment market are especially in high demand right now, and are expected to grow in a foreseeable future, thanks to the enormous amount of data generated through whole-genome sequencing. We believe this new track will provide adequate preparation for students who would like to enter the workforce after graduation and those who plan to pursue further education.

If this proposal is approved, this track will be the 4<sup>th</sup> track within the major. The previous three tracks in biology are Evolution and Natural History track, Molecular and Cell Biology track, and General Biology Track. If this program is approved, Yi-Fan Lu will be willing to serve as the academic advisor for those students who have potential interests in this track and those who are already committed to this track.

Here we also attached a proposed four-year schedule and the curriculum (64 units total) for the senate committee to review. We appreciate your time and look forward to hearing your input soon.

Sincerely,  
Biology Department

### Genomics and Bioinformatics Track Recommended Schedule

Year	Fall	Spring
1 <sup>st</sup>	CHM 005 General Chemistry I (4) MA 005 Introduction to Statistics (4) MA 009 Elementary Calculus I (4)	BIO 005 General Biology I (4) CHM 006 General Chemistry II (4) CS 010 Design and Implementation of Solutions to Computational Problems (4)
2 <sup>nd</sup>	BIO 006 General Biology II (4) MA 015 Discrete Mathematics (4) One supporting course from CHM, CS, PHY, or MA* (4)	BIO 114 Genetics (4) CS 030 Abstract Models for Concrete Problems Using Java (4)
3 <sup>rd</sup>	BIO 117 Genomics and Bioinformatics (4) Upper-Division BIO (4)	BIO 131 Evolution (4)
4 <sup>th</sup>	Integrative Course (1-4) Upper-Division CS or MA* (4) Research in BIO or CS (optional)	Upper-Division major electives in BIO, CS or MA (4) Research in BIO or CS (optional)

\*Additional two supporting science courses in Chemistry, Computer Science, Mathematics, or Physics to be taken within any of the four years.

### Genomics and Bioinformatics Track Recommended Courses

\*Recommended courses are not required to graduate. However, we strongly recommend that students who are interested in these fields take these courses to be more prepared for a graduate degree or in the workforce.

Future interest	Course list
<b>Genome technology</b>	BIO 113 Biochemistry (4), BIO 132 Molecular Biology (4), CS 128 Information Retrieval and Big Data (4), CS 116 Artificial Intelligence and Machine Learning (4)
<b>Structural biology (i.e., protein or RNA structures)</b>	BIO 113 Biochemistry (4), CHM 115 Advanced Biochemistry (4), BIO 132 Molecular Biology (4), CS 128 Information Retrieval and Big Data (4)
<b>Ecology and conservation</b>	BIO 125 General Ecology (4)

## **Genomics and Bioinformatics Track: 64 units**

### **Interdisciplinary Science Courses: 36 units**

CHM 005 General Chemistry I (4)

CHM 006 General Chemistry II (4)

MA 005 Introduction to Statistics (4)

MA 015 Discrete Mathematics (4)

MA 009 Elementary Calculus I (4)

CS 010 Design and Implementation of Solutions to Computational Problems (4)

CS 030 Abstract Models for Concrete Problems Using Java (4)

*Additional courses in physical or other cognate sciences (8) to be selected from the following:*

CHM 101 Organic Chemistry (4)

CHM 102 Organic Chemistry II (4)

MA 010 Elementary Calculus II (4)

MA 019 Multivariable Calculus (4)

CS 116 Artificial Intelligence and Machine Learning (4)

CS 128 Information Retrieval and Big Data (4)

PHY 011 Physics for Life Sciences I (4)

PHY 013 Physics for Life Sciences II (4)

PHY 021 General Physics I (4)

PHY 023 General Physics II (4)

PHY 40 Differential Equations (4)

### **Required Biology Courses: 24 units**

BIO 005 General Biology I (4)

BIO 006 General Biology II (4)

Upper-division Biology Courses (12)

BIO 114 Genetics (4)

BIO 117 Genomics and Bioinformatics (4)

BIO 131 Evolution (4)

*One course from the following: (4)*

BIO 113 Biochemistry (4)

BIO 110 Microbiology (4)

BIO 130 Cell Biology (4)

BIO 132 Molecular Biology (4)

*One integrative course from the following: (1-4)*

BIO 196 Bioethics Seminar (1)

BIO 197 Biology and Faith (4)

**Major electives from the following for a total of 64 units**

Upper-division BIO

Upper-division CS

Upper-division MA

No more than 2 units of Practicum: BIO 190, 191, or 192

No more than 4 units Research: BIO 198, CS 198