Bioinformatics Tracks (for 2023-2024)

Bioinformatics is an interdisciplinary field with several subfields. To help you identify which classes are best for you, we developed several optional tracks to follow. These are examples of classes to take depending on your interests, and are therefore optional to follow. There are 4 main tracks, each divided into two concentrations. You may follow one of these tracks exactly, choose one to modify slightly, or create your own custom set of classes. Contact for this document: sartorma@umich.edu

We have >100 potential bioinformatics mentors in CCMB. Therefore, the example faculty members in each concentration below is not exhaustive, but does include all DCMB primary and joint faculty members.

Summary of the four Tracks and subtracks/concentrations (example lab PIs)

1. Computational Genomics and Multi-omics (aligns with Genome Sciences Training Program)
    a. Genomics/transciptomics/regulomics (e.g. Kim, Athey, Parker, Boyle, Sartor, Burmeister, Welch, Rao, Freddolino, J. Liu, Willer, Rajapakse, Kitzman, Chinnaiyan, Burant, Moran, Au)
    b. Genetics/evolution (e.g. Jun Li, Mills, Kidd, Au, Boehnke, Speliotes, Zoellner, Wittkopp, Dick, J. Zhang)

2. Data Science and Machine Learning (aligns with BIDS-TP)
    a. Machine learning/omics predictions (e.g. Guan, J. Liu, Ye, Baladandayuthapani, Kretzler, Sartor, Dinov, Hero, Draelos, Au)
    b. Signal/image processing (e.g. Najarian, Rao, Srinivasan, Sripada, Athey, Draelos, Au)

3. Protein modeling/proteomics/metabolomics (aligns with Proteomics Training Program)
    a. Proteomics or metabolomics (e.g. Andrews, Nesvizhskii, Karnovsky, Burant)
    b. Protein structure/dynamics/folding modeling (e.g. Y. Zhang, Brooks, Carlson, Freddolino)

4. Biomedical/ Clinical Informatics
    a. Clinical / Health informatics / NLP (e.g. Draelos, Dinov, Nallasamy, Singh)
    b. Electronic Health Records/Genetics/Precision Medicine (e.g. Shi, Hanauer, Taylor, Najarian, Athey)

Important notes:

- Students should take BIOINF 575 fall of year 1 if not already proficient in Python.
- MS students are required to take only 1 statistics class (e.g. BIOSTAT 521), however are recommended to take a full year if hope to transition to the PhD program
- MS students must take either BIOINF 529 (python-based; Winter) or BIOINF 527 (R-based; Fall) in year 1. All PhD students are required to take 529.
- ALL students take **PIBS-503** (1 cr hr) in fall of year 1.
- **BIOINF-504: RTR** (1 cr hr) is required for all students, and is a 1 week workshop in late August.
- The semester when other department's classes are offered may change. Students should double check their schedule.

PIBS 721 – Professional Research Presentation (Winter) - recommended to 3rd year students

I. Computational Genomics and Multi-omics Track (for students starting Fall 2023)

Concentrations: (1) Omics/gene regulation, (2) Genetics/ population genetics

Note: In fall of year 1, you should take a class in the area(s) you are weakest in (stats, biology, or programming).

- Computational Genomics and Multi-omicsTrack – Higher Level Statistics		
Year	**Fall**	**Winter**
1	**BIOINF 575** – Intr. Programming in Bioinf *or* **HUMGEN 545** – Molecular Genetics **BIOSTAT 601** – Prob and Distr Theory **PIBS 503 -** Res Respon & Ethics (1 cr hr) **BIOINF 500** – Skills for Bioinf Grad (1 cr hr)	**BIOINF 529** – Bioinf Concepts & Algorithms **BIOSTAT 602** – Biostatistical Inference **BIOINF 545** – High-throughput Mol Gen and Epi Data Analysis *OR* **BIOINF 665** – Stat Pop Gen
2	**BIOINF 504** - Rigor workshop (1 cr hr) **BIOSTAT 666** - Stat Models and Num Meth in Hum Genetics *OR* **BIOINF 593**– ML in Comp Biol Elective (e.g. **BIOSTAT 615 or BIOINF 540**) **HUMGEN 545** – Molecular Genetics (if not yr 1) **BIOINF 602** – Bioinf Journal Club (listen- 1 cr hr)	**HUMGEN 546** - Molecular Basis of Human Genetic Disease (optional elective) **BIOINF 603** – Bioinf Journal Club (present)

- Computational Genomics and Multi-omics Track – Lower Level Statistics		
Year	**Fall**	**Winter**
1	**BIOINF 575** – Intr. Programming in Bioinf **BIOSTAT 521** – Applied Biostatistics **BIOINF 500** – Skills for Bioinf Grad (1 cr hr) **PIBS 503** - Res Respon & Ethics (1 cr hr)	**BIOINF 529** – Bioinf Concepts & Algorithms **BIOSTAT 522** – Biostat Anal for Health Studies **BIOINF 545** - High-throughput Mol Gen and Epi Data Analysis **BIOINF 602** – Bioinf Journal Club (listen; 1 cr hr)
2	**BIOINF 504** - Rigor workshop (1 cr hr) **HUMGEN 541** – Molecular Genetics **BIOSTAT 523** – Stat Meth for Epidemiology *or* BIOSTAT 615**–**Stat Computing (elective) **BIOINF 593 –** ML in Comp Bio *or* EECS 453	**BIOINF 547 –** Mathematics of Data *or* other Adv Bioinf (if not taken in fall) **HUMGEN 546** - Molecular Basis of Human Genetic Disease (optional elective) **BIOINF 603** – Bioinf Journal Club (present)

Computational Genomics and Multi-omics Track Suggested Courses to Fulfill Requirements		
	Fall Classes	**Winter Classes**
Basic required (need all)	BIOINF 602/ BIOINF 603; PIBS 503 BIOINF 500; BIOINF 504 BIOINF 527 (if not 529; MS only)	BIOINF 602/ BIOINF 603 BIOINF 529 (all PhD; optional MS)
Statistics (PhD take 2; MS see website)	BIOSTAT 601 STATS 425 BIOSTAT 521	BIOSTAT 602 STATS 426 BIOSTAT 522
Programming/computing (take 1)	BIOINF 575 (if not proficient in python) BIOSTAT 615; EECS 453	EECS 453, EECS 545
Biology (take at least 3 cr hrs)	HUMGEN 545; CDB 530; BIOINF 523 BIOLCHEM 650 (2 cr hrs)	HUMGEN 546; BIOLCHEM 640 (2 cr hrs)
Advanced Bioinformatics (take 2; at least 1 has to be BIOINF)	BIOINF 593; BIOINF 590 BIOSTAT 666 (requires 601/2) BIOINF 540; BIOINF 580	BIOINF 545; BIOINF 547; BIOINF 665 (every other yr?)
Other suggested electives	BIOSTAT 615 BIOSTAT 523 CDB 530	BIOSTAT 682; HUMGEN 542 BIOSTAT 685 CANCBIO 554

II. Data Science and Machine Learning (for students starting Fall 2023)

Concentrations: (1) image/signal processing or (2) Machine learning/omics predictions

Note: If have not had linear algebra or needs a review, BIOINF 501 (or potentially MATH 417) is recommended in year 1.

- Data Science and Machine Learning Track - Imaging/signal processing concentration		
Year	**Fall**	**Winter**
1	**BIOINF 500** – Skills for Bioinf Grad (1 cr hr) **PIBS 503** - Res Respon & Ethics (1 cr hr) **BIOSTAT 601** – Prob and Distr Theory **BIOINF 501 –** Math Fnds (if needed) *or* **BIOINF 575** – Intro Program (if needed)	**BIOINF 529** – Bioinf Concepts & Algorithms **BIOSTAT 602** – Biostatistical Inference **EECS 453** -Comp Data Sci & ML or **BIOINF 603** – Bioinf Journal Club (present) **BIOINF 602** – Bioinf Journal Club (listen- 1 cr hr)
2	**BIOINF 504** - Rigor workshop (1 cr hr) **PHYSIOL 502** – Human Physiology **BIOINF 590**- Img Proc & ML for Canc Bioinf *or* **HS 650** - Data Science & Pred Analytics **BIOINF 580** –Intro Signal Proc & Mch Lrn **BIOINF 603** – Bioinf Journal Club (present)	**EECS 545** - Machine Lrn *or* alternative elective **(BIOINF 520** Comp Systems Bio in Phys *or* **BIOINF 585** – Deep Learning (if not 590))

- Data Science and Machine Learning Track - Machine learning/omics predictions Concentration		
Year	**Fall**	**Winter**
1	**BIOINF 575** – Intr. Programming (if needed) *or* **BIOINF 580** **BIOSTAT 601** – Prob and Distr Theory **BIOINF 500** – Skills for Bioinf Grad (1 cr hr) **PIBS 503** - Res Respon & Ethics (1 cr hr)	**BIOINF 529** – Bioinf Concepts & Algorithms **BIOSTAT 602** – Biostatistical Inference **BIOINF 603** – Bioinf Journal Club (present) **BIOINF 602** – Bioinf Journal Club (listen; 1 cr hr)
2	**BIOINF 504** - Rigor workshop (1 cr hr) **HUMGEN 545** – Molecular Genetics **BIOINF 590 -** Image Proc & ML for Cancer Bioinf *or* **HS 650**-Data Science & Pred Analytics *or* **BIOINF 593** – ML in Comp Biol **BIOINF 580** –Intro Signal Proc & Mch Lrn	**BIOINF 545 –** High-throughput genomics analysis *OR* **EECS 545** – Machine Learning (or other elective)

Biomedical Data Science Track Suggested Courses to Fulfill Requirements		
	Fall Classes	**Winter Classes**
Basic required (need all)	BIOINF 602/603/500; PIBS 503; BIOINF 504; BIOINF 527 (if not 529; MS only)	BIOINF 602/ BIOINF 603 BIOINF 529 (all PhD; optional MS)
Statistics (PhD take 2; MS see website)	BIOSTAT 601; STATS 425 BIOSTAT 521	BIOSTAT 602; STATS 426 BIOSTAT 522
Programming/computing (take at least 1, more recommended)	BIOINF 575 (if not proficient in python) BIOSTAT 615; EECS 551 or 453	EECS 453?; EECS 545; EECS 556; EECS 595
Biology (take 1, at least 3 cr hrs)	PHYSIOL 502; BIOINF 523 PHARM 601; CDB 530; HUMGEN 545	HG 546
Advanced Bioinformatics (take 2; at least 1 has to be BIOINF)	BIOINF 590; BIOINF 593 BIOINF 463; BIOINF 540; BIOINF 580	LHS 712 ; BIOINF 547; BIOINF 585 BIOINF 520; BIOINF 545
Other suggested electives	BIOSTAT 680; HS 650 EECS 584; EECS 595 BIOINF 501 (if no previous Lin Alg)	MATH 562/IOE 511 CANCBIO 554; HUMGEN 542

III. Proteins/Proteomics/Metabolomics Track (for students starting Fall 2023)

Concentrations: (1) Protein structure/modeling; (2) Proteomics/metabolomics

Note: In fall of year 1, you should take a class in the area(s) you are weakest in (stats, biology, or programming).

- Protein/ Proteomics Track – Proteomics/Metabolomics concentration		
Year	**Fall**	**Winter**
1	**BIOINF 575** – Intr. Programming in Bioinf (*if needed*) **BIOSTAT 601** – Prob and Distr Theory *or* BIOSTAT 521 (or could do stats next year) **BIOINF 551** – Proteome and Metab Inform **BIOINF 500** – Skills for Bioinf Grad (1 cr hr) **PIBS 503** - Res Respon & Ethics (1 cr hr)	**BIOINF 529** – Bioinf Concepts & Algorithms **BIOSTAT 602** – Biostatistical Inference **BIOINF 602** – Bioinf Journal Club (listen; 1 cr hr)
2	**BIOINF 504** - Rigor workshop (1 cr hr) **BIOLCHEM 550 -** Macromol Struct & Fcn **CHEM 647** – Mass Spectrometry *OR* BIOLCHEM 660 (elective)	**BIOINF 603** – Bioinf Journal Club (present) **BIOINF 545**- High-throughput genomic analysis (*if not taking BIOINF 528*) CANCBIO 554 – Cancer Biology (*optional elective*)

- Protein/ Proteomics Track – Protein modeling concentration		
Year	**Fall**	**Winter**
1	**BIOINF 575** – Intr. Programming in Bioinf **STATS 425** – Intro to Probability **BIOINF 500** – Skills for Bioinf Grad (1 cr hr) **PIBS 503** - Res Respon & Ethics (1 cr hr)	**BIOINF 529** – Bioinf Concepts & Algorithms **STATS 426** – Intro to Theoretical Stats **BIOINF 528** – Structural Bioinf *(if offered*) **BIOINF 602** – Bioinf Journal Club (listen; 1 cr hr)
2	**BIOINF 504** - Rigor workshop (1 cr hr) **BIOLCHEM 550 -** Macromolecular Structure and Function **BIOINF 528** - Structural Bioinf **BIOINF 463** – Mathematical Modeling in Biology *OR* **EECS 484** – Database Mgt Syst	**BIOINF 603** – Bioinf Journal Club (present) **CMPLXSYS 510** – Intro Adaptive Dynamics *or* other elective

Protein/Proteomics Track Suggested Courses to Fulfill Requirements		
	Fall Classes	**Winter Classes**
Basic required (need all)	BIOINF 602/ BIOINF 603; PIBS 503 BIOINF 500; BIOINF 504 BIOINF 527 (if not 529; MS only)	BIOINF 602/ BIOINF 603 BIOINF 529 (all PhD; optional MS)
Statistics (PhD take 2; MS see website)	BIOSTAT 601 STATS 425 BIOSTAT 521	BIOSTAT 602 STATS 426 BIOSTAT 522
Programming/computing (take 1)	BIOSTAT 615; BIOINF 575 EECS 587; EECS 484; EECS 453	EECS 402; EECS 453?; EECS 545
Biology (take at least 3 cr hrs)	BIOLCHEM 550; BIOLCHEM 515 BIOLCHEM 660; CDB 530	BIOLCHEM 515 CANCBIO 554 (proteomics conc)
Advanced Bioinformatics (take 2; at least 1 has to be BIOINF)	BIOINF 528 (protein modeling conc) BIOINF 551 (proteomics conc) BIOINF 463 (protein modeling)	BIOINF 545 (proteomics conc) CMPLXSYS 510 (protein modeling) BIOINF 585
Other suggested electives	CHEM 647; EECS 484	STATS 503

IV. Biomedical/Clinical Informatics Track (for students starting Fall 2023)

Concentrations: (1) Clinical/Health Informatics; (2) Electronic Health Records/Precision Medicine

Note: In fall of year 1, you should take a class in the area(s) you are weakest in (stats, biology, or programming).
Note for math modeling concentration: If no previous linear algebra, take BIOINF 501 (or MATH 417) in year 1.

- Biomedical/Clinical Informatics Track - Clinical / Health Informatics Concentration		
Year	**Fall**	**Winter**
1	**BIOINF 575** – Intr. Prog in Bioinf (if needed) *or* **LHS 660 –** Eval&Res Meth. Health Info & Learning Syst **BIOSTAT 521** – Applied Biostatistics **BIOINF 500** – Skills for Bioinf Grad (1 cr hr) **PIBS 503** - Res Respon & Ethics (1 cr hr)	**BIOINF 529** – Bioinf Concepts & Algorithms **BIOSTAT 522** – Biostat Anal for Health Studies **BIOINF 602** – Bioinf Journal Club (listen; 1 cr hr)
2	**BIOINF 504** - Rigor workshop (1 cr hr) **PHYSIOL 502** – Human Physiology *or* other bio **LHS 668 –** Introduction to Health Informatics **BIOINF 580** –Intro Signal Proc & Mch Lrn	**LHS 610** – Expl Data Analysis for Health **LHS 712** – NLP on Health Data **BIOINF 603** – Bioinf Journal Club (present)

- Biomedical/Clinical Informatics Track - Electronic Health Records/Precision Medicine concentration		
Year	**Fall**	**Winter**
1	**BIOSTAT 521** – Applied Biostatistics **BIOINF 575** – Intro Program in Bioinf (if needed) *or* **LHS 660 –** Eval&Res Meth. Health Info & Learn Syst **BIOINF 500** – Skills for Bioinf Grad (1 cr hr) **PIBS 503** - Res Respon & Ethics (1 cr hr)	**BIOINF 529** – Bioinf Concepts & Algorithms **BIOSTAT 522** – Biostat Anal for Health Studies **LHS 610** – Expl Data Analysis for Health **BIOINF 602** – Bioinf Journal Club (listen- 1 cr hr)
2	**BIOINF 504** - Rigor workshop (1 cr hr) **HUMGEN 545** – Molecular Genetics *or* other bio **BIOINF 540** – Math of Biol Networks *or* **EECS 453 –** Principles of Mch Lrn (if not yr 1) **LHS 668** – Intro to Health Informatics	**BIOINF 545** – High-throughput genomics analysis *or* **BIOSTAT 666** – Stat Model Hum Gen **BIOINF 603** – Bioinf Journal Club (present)

Biomedical/Clinical Informatics Track Suggested Courses to Fulfill Requirements		
	Fall Classes	**Winter Classes**
Basic required (need all)	BIOINF 602/ BIOINF 603; PIBS 503 BIOINF 500; BIOINF 504 BIOINF 527 (if not 529; MS only)	BIOINF 602/ BIOINF 603 BIOINF 529 (all PhD; optional MS)
Statistics (PhD take 2; MS see website)	BIOSTAT 601 STATS 425 BIOSTAT 521	BIOSTAT 602 STATS 426 BIOSTAT 522
Programming/computing (take 1)	BIOINF 575; BIOSTAT 615 EECS 453; BIOINF 580	LHS 610; EECS 545 EECS 453?
Biology (take at least 3 cr hrs)	CDB 530; PHYSIOL 502 HUMGEN 545; BIOINF 523	MCDB 428; HUMGEN 546
Advanced Bioinformatics (take 2; at least 1 has to be BIOINF)	BIOINF 540; BIOINF 593 BIOINF 580; BIOINF 590	LHS 712; BIOINF 545 BIOSTAT 666
Other suggested electives	LHS 668; LHS 660	BIOSTAT 620