Genomics, Phenomics and Bioinformatics

Department Information

- **Program Director:**
  Phillip McClean, Ph.D.
- **Email:**
  Phillip.McClean@ndsu.edu
- **Department Location:**
  Plant Sciences, Loftsgard Hall
- **Department Phone:**
  (701) 231-8443
- **Application Deadline:**
  International applications are due May 1 for fall semester and August 1 for spring and summer semesters. Domestic applicants should apply at least one month prior to the start of classes.
- **Credential Offered:**
  Ph.D., M.S.
- **English Proficiency Requirements:**
  TOEFL iBT 71, IELTS 6; Duolingo 100

Genomics, Phenomics and Bioinformatics is an interdisciplinary graduate program that involves around 30 faculty from six departments and three colleges. The program initially focused on Genomics and Bioinformatics. In 2021, the program underwent a major change. This was prompted by advances in high-throughput phenotyping, and the growing importance of phenomics data and its direct relationship to genes controlling traits. Based on those relations, phenomics was added as another research track.

Students in the program will perform advanced study, training and research in areas that focus on functional genomics, high-throughput phenotyping, and computation analysis of genomic and phenomic data. This will lead to an understanding of the many -omics fields interact to understand how a phenotype is expressed.

The program is designed to provide both Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) students the necessary skills and intellectual background to work cooperatively with others in a research areas that take systems-wide approach to the study of the organization and expression of the many genes and their products expressed in an organism. Exposure to modern techniques and instrumentation will prepare the student for success in both industrial and academic careers.

Students can obtain a M.S. or Ph.D. in either the functional genomics, bioinformatics, or phenotypics tracks. Comprehensive options are available for all three tracks for M.S. students.

It is the intent of the program to admit students in one of three tracks. The Functional Genomics track will be for students interested in the generation and application of genomic information. The Computational Bioinformatics track is intended for students interested in using computer science and statistical approaches to analyze large amounts of genomic data. The Phenomics track will be attractive to students interested in the application of high-throughput equipment to measure important traits necessary for full expression of the traits necessary for the organism to productively complete its life cycle.

The Genomics graduate program is open to qualified graduates of universities of recognized standing. The Graduate School minimum for the TOEFL examination applies. In addition, the following are the requirements to be admitted with full standing.

Functional Genomics track: a Bachelor of Science (B.S.) degree an introductory biology class emphasizing molecular biology; with courses in genetics, physiology, biochemistry; an upper-division statistics class. A minimum undergraduate GPA of 3.0.

Bioinformatics and Phenomics tracks: a B.S. degree with an introductory biology class emphasizing molecular biology; with courses in calculus, upper-division statistics class, calculus or matrix algebra, and programming language experience. A minimum undergraduate GPA of 3.0.

Students can be accepted conditionally into any track without meeting the course or GPA requirements, but will be required to meet those requirements while in residency.

Adviser and Graduate Committee

During the first year, the student will form a graduate committee and submit the Plan of Study to the Graduate School. The committee must include the student's major adviser, at least one other faculty member of the Genomics, Phenomics, and Bioinformatics program, and a third member from outside the student's home college. For Ph.D. students only, a fourth member of the committee serves as the Graduate School Representative (GSR). The GSR must be a full member of the graduate faculty, AND be either a tenured faculty member outside the committee chair's/co-chairs' home

department(s) OR a faculty member outside the primary college of the committee chair/co-chairs. For this interdisciplinary program, the GSR must ALSO be outside of the program. Additionally, the GSR must be clear of any conflicts of interest with either the student or the committee chair/co-chairs. Examples of possible conflicts of interest may include budgetary relationships, family or financial, personal relationships, or research and/or publication relationships between the GSR and either the student or the committee chair.

Master's Program

Code	Title	Credits
Functional Genomics - Thesis Option		
Core Courses		
PLSC 611	Genomics	3
CSCI/MATH/STAT 732	Introduction To Bioinformatics	3
PLSC 721	Genomics Techniques (BIOC 674 is 3 credits)	2
or BIOC 674	Methods of Recombinant DNA Technology	
796 Current Topics in Genomics (1 credit, 2 semesters)		2
790 Graduate Seminar		1
Electives - At least one course from two of the following elective areas: Physiology, Gene Expression, Genetics and Genomics		9
798 Master's Thesis (6-10)		
Total Credits		30

Code	Title	Credits
Functional Genomics Comprehensive Study Option		
PLSC 611	Genomics	3
CSCI 732	Introduction To Bioinformatics	3
PLSC 721	Genomics Techniques (or)	2
BIOC 674	Methods of Recombinant DNA Technology	3
796 Current Topics (1 credit, 2 semesters)		2
790 Graduate Seminar		1
Electives - At least one course from each of the following elective areas: Physiology, Gene Expression, Genetics and Genomics		
797 Master's Paper		4
Total Credits		**30**

Code	Title	Credits
Bioinformatics - Thesis Option		
PLSC 611	Genomics	3
CSCI 732	Introduction To Bioinformatics	3
CSCI 859	Computational Methods in Bioinformatics	3
796 Current Topics (1 credit, two semesters)		2
790 Graduate Seminar		1
Electives - Computer Science, Statistics, Computational Biology		9
798 Master's Thesis		6-10
Total Credits		**30**

Code	Title	Credits
Bioinformatics Comprehensive Study Option		
PLSC 611	Genomics	3
CSCI 732	Introduction To Bioinformatics	3
CSCI 859	Computational Methods in Bioinformatics	3
796 Current Topics (1 credit, 2 semesters)		2
790 Graduate Seminar		1
Electives - From the Computer Science, Statistics, Computational Biology elective areas		15

Code	Title	Credits
797 Master's Paper		4
Total Credits		**30**

Code	Title	Credits
Phenomics Thesis Option		
CSCI 679	Introduction to Data Mining	3
ABEN 747	Numerical Modeling of Environmental and Biological Systems	3
Physiology Elective		3
796 Special Topics (1 credit, 2 semesters)		2
790 Graduate Seminar		1
Electives - At least one course from the Modling and Sensing and Computer Science, Statistics, and Computational Biology elective areas		9
798 Master's Thesis		6-10
Total Credits		**30**

Code	Title	Credits
Physiology Electives		
ANSC 663	Physiology of Reproduction	3
BIOL 660	Animal Physiology	3
BIOL 662	Physiological Ecology	3
BIOL 664	Endocrinology	3
BIOL 683	Cellular Mechanisms of Disease	3
BIOL 825	Biology of Aging	3
BIOL 861	Advanced Physiology - Physiology of Extremes	3
MICR 650	Infectious Disease Pathogenesis	3
MICR 680	Microbial Physiology	3
PPTH 751	Physiology Of Plant Disease	3
PLSC 686	Applied Crop Physiology	3
PLSC 750	Crop Stress Physiology	3
PSCI 747	Cardiovascular Pharmacology	3
PSCI 762	Advanced Biopharmaceutics	2
PSCI 765	Cancer Cell Biology	2
Gene Expression		
BIOC 660	Foundations of Biochemistry and Molecular Biology I	3
BIOC 683	Cellular Signal Transduction Processes and Metabolic Regulation	3
BIOC 719	Molecular Biology of Gene Expression and Regulation	3
BIOC 723	Structural Basis of Membrane Transport and Signaling	3
BIOL 682	Developmental Biology	3
BIOL 820	Advanced Cell Biology	
MICR 775	Molecular Virology	3
PLSC 731	Plant Molecular Genetics	3
Genetics and Genomics Electives		
ANSC 657	Genetic Improvement of Livestock	3
ANSC 750	Quantitative Genetics Applications of Matrix Algebra	1
ANSC 751	A Primer to Quantitative Genetics	1
ANSC 752	Selection Index Theory and Application	1
BIOL 679	Biomedical Genetics and Genomics	3
BIOL 859	Evolution	3
BIOL 860	Evolutionary Ecology	3
BIOL 862	Environment and Adaptation	3
MICR 681	Microbial Genomics with Computational Laboratory	3
MICR 682	Microbial Genetics	3
MICR 783	Advanced Bacterial Genetics and Phage	3

PLSC 631	Intermediate Genetics (required for Functional Genomics Option)	3
PLSC 741	Cytogenetics	4
PLSC 751	Advanced Plant Genetics	3
PLSC 782	Population and Quantitative Genetics	
PPTH 755	Population Biology of Plant Pathogens	3
PPTH 759	Host-Parasite Genetics	3
PSCI 617	Pharmacogenomics	2
Computer Science, Statistics, and Computational Biology Electives		
ANSC 850	Linear Models in Animal Breeding	1
ANSC 851	Genetic Prediction	1
ANSC 852	Applied Variance Component Estimation	1
ANSC 856	Prediction and Control of Inbreeding in Breeding Programs	1
BIOL 842	Quantitative Biology	3
BIOL 877	Analysis of Population and Demographic Data	3
CSCI 679	Introduction to Data Mining	3
CSCI 724	Survey of Artificial Intelligence	3
CSCI 736	Advanced Intelligent Systems	3
CSCI 765	Introduction To Database Systems	3
CSCI 879	Advanced Data Mining	3
MATH 630	Graph Theory	3
MATH 636	Combinatorics	3
MATH 684	Mathematical Methods of Biological Processes	3
MATH 830	Graph Theory	3
MATH 839	Topics in Combinatorics and Discrete Mathematics	3
MATH 867	Topics in Applied Mathematics	3
MICR 724	Applied Epidemiology and Biostatistics	3
PLSC 749	Applied Plant Molecular Breeding	3
PH 674	Epidemiology	3
PH 706	Essentials of Epidemiology	3
PH 731	Biostatistics	3
PH 750	Epidemiologic Methods I	2
PH 752	Epidemiologic Methods II	2
PLSC 724	Field Design I	3
STAT 650	Stochastic Processes	3
STAT 661	Applied Regression Models (required for Bioinformatics Ph.D. option)	3
STAT 711	Basic Computational Statistics using R	3
STAT 712	Applied Statistical Machine Learning	3
STAT 713	Introduction to Data Science	3
STAT 714	Statistical Big Data Visualization	3
STAT 725	Applied Statistics	3
STAT 764	Multivariate Methods	3
STAT 840	Introduction to Statistical Design and Analysis of Gene Expression Experiments	3
STAT 851	Bayesian Statistical Inference	3
STAT 860	Statistical Machine Learning	3
Modeling and Sensing Electives		
ABEN 747	Numerical Modeling of Environmental and Biological Systems	3
ABEN 758	Applied Computer Imaging and Sensing for Biosystems	3
CE 725	Biomaterials-Materials in Biomedical Engineering	3
CSCI 628	Spatial Data Science	3
GEOG 655	Introduction to Geographic Information Systems	4
GEOG 656	Advanced Geographic Information Systems	3
GEOG 670	Remote Sensing	3

GEOG 680	Geographic Information Systems Pattern Analysis and Modeling	3
PAG 654	Applications of Precision Agriculture	3

Doctoral Program

Code	Title	Credits
Functional Genomics		
PLSC 611	Genomics	3
CSCI 732	Introduction To Bioinformatics	3
PLSC 721	Genomics Techniques (or)	2
or BIOC 674	Methods of Recombinant DNA Technology	
796 Current Topics (1 credit, 3 semesters)		3
790 Graduate Seminar (1 credit, 2 semesters)		2
Requested Core Courses (unless in M.S. transcript)		
PLSC 631	Intermediate Genetics	3
STAT 726	Applied Regression and Analysis of Variance	3
Graduate Evolution Course		
Electives - At least one course from each of the following elective areas: Physiology, Gene Expression, Genetics and Genomics		15
899 Doctoral Dissertation		up to 90

Code	Title	Credits
Bioinformatics Option		
PLSC 611	Genomics	3
CSCI 732	Introduction To Bioinformatics	3
CSCI 859	Computational Methods in Bioinformatics	3
796 Current Topics (1 credit, 3 semesters)		3
790 Graduate Seminar (1 credit, 2 semesters)		2
Required Core Courses (unless in M.S. transcript)		
CSCI 679	Introduction to Data Mining	3
CSCI 765	Introduction To Database Systems	3
STAT 661	Applied Regression Models	3
Electives - From the Computer Science, Statistics, Computational Biology elective areas		15
899 Doctoral Dissertation		up to 90

Code	Title	Credits
Phenomics Option		
CSCI 679	Introduction to Data Mining	3
ABEN 747	Numerical Modeling of Environmental and Biological Systems	3
Physiology Course		3
796 Current Topics (1 credit, 3 semesters)		3
790 Graduate Seminar (1 credit, 2 semesters)		2
STAT 726	Applied Regression and Analysis of Variance	3
CSCI 765	Introduction To Database Systems	3
Electives - At least one course from the Modling and Sensing and Computer Science, Statistics, and Computational Biology elective areas		15
899 Doctoral Dissertation		up to 90

Code	Title	Credits
Physiology Electives		
ANSC 663	Physiology of Reproduction	3
BIOL 662	Physiological Ecology	3
BIOL 664	Endocrinology	3
BIOL 683	Cellular Mechanisms of Disease	3
BIOL 825	Biology of Aging	3
MICR 650	Infectious Disease Pathogenesis	3
MICR 680	Microbial Physiology	3
MICR 785	Pathobiology	3
PPTH 751	Physiology Of Plant Disease	3
PLSC 686	Applied Crop Physiology	3
PLSC 750	Crop Stress Physiology	3
PSCI 747	Cardiovascular Pharmacology	3
PSCI 762	Advanced Biopharmaceutics	2
PSCI 765	Cancer Cell Biology	2
Gene Expression Electives		
BIOC 660	Foundations of Biochemistry and Molecular Biology I	3
BIOC 683	Cellular Signal Transduction Processes and Metabolic Regulation	3
BIOC 719	Molecular Biology of Gene Expression and Regulation	3
BIOC 723	Structural Basis of Membrane Transport and Signaling	3
BIOL 682	Developmental Biology	3
BIOL 820	Advanced Cell Biology	
MICR 775	Molecular Virology	3
PLSC 731	Plant Molecular Genetics	3
Genetics and Genomics Electives		
ANSC 657	Genetic Improvement of Livestock	3
ANSC 750	Quantitative Genetics Applications of Matrix Algebra	1
ANSC 751	A Primer to Quantitative Genetics	1
ANSC 752	Selection Index Theory and Application	1
BIOL 679	Biomedical Genetics and Genomics	3
BIOL 859	Evolution	3
BIOL 860	Evolutionary Ecology	3
BIOL 862	Environment and Adaptation	3
MICR 681	Microbial Genomics with Computational Laboratory	3
MICR 682	Microbial Genetics	3
PPTH 755	Population Biology of Plant Pathogens	3
PPTH 759	Host-Parasite Genetics	3
PLSC 631	Intermediate Genetics	3
PLSC 741	Cytogenetics	3
PLSC 751	Advanced Plant Genetics	3
PLSC 782	Population and Quantitative Genetics	
PSCI 617	Pharmacogenomics	2
Computer Science, Statistics, and Computational Biology Electives		
ANSC 850	Linear Models in Animal Breeding	1
ANSC 851	Genetic Prediction	1
ANSC 852	Applied Variance Component Estimation	1
ANSC 856	Prediction and Control of Inbreeding in Breeding Programs	1
BIOL 842	Quantitative Biology	3
BIOL 877	Analysis of Population and Demographic Data	3
CSCI 679	Introduction to Data Mining	3
CSCI 724	Survey of Artificial Intelligence	3

CSCI 736	Advanced Intelligent Systems	3
CSCI 765	Introduction To Database Systems	3
CSCI 879	Advanced Data Mining	3
MATH 630	Graph Theory	3
MATH 636	Combinatorics	3
MATH 830	Graph Theory	3
MATH 839	Topics in Combinatorics and Discrete Mathematics	3
MATH 864	Calculus Of Variations	3
MATH 867	Topics in Applied Mathematics	3
MICR 724	Applied Epidemiology and Biostatistics	3
PLSC 749	Applied Plant Molecular Breeding	3
PH 674	Epidemiology	3
PH 706	Essentials of Epidemiology	3
PH 731	Biostatistics	3
PH 750	Epidemiologic Methods I	2
PH 752	Epidemiologic Methods II	2
PLSC 724	Field Design I	3
STAT 650	Stochastic Processes	3
STAT 661	Applied Regression Models	3
STAT 711	Basic Computational Statistics using R	3
STAT 712	Applied Statistical Machine Learning	3
STAT 713	Introduction to Data Science	3
STAT 714	Statistical Big Data Visualization	3
STAT 725	Applied Statistics	3
STAT 726	Applied Regression and Analysis of Variance	3
STAT 764	Multivariate Methods	3
STAT 840	Introduction to Statistical Design and Analysis of Gene Expression Experiments	3
STAT 851	Bayesian Statistical Inference	3
STAT 860	Statistical Machine Learning	3
Modeling and Sensing Electives		
ABEN 747	Numerical Modeling of Environmental and Biological Systems	3
ABEN 758	Applied Computer Imaging and Sensing for Biosystems	3
CE 725	Biomaterials-Materials in Biomedical Engineering	3
CSCI 628	Computational Techniques for Environmental Sustainability	3
GEOG 655	Introduction to Geographic Information Systems	4
GEOG 656	Advanced Geographic Information Systems	3
GEOG 665	Remote Sensing of the Environment	3
GEOG 670	Remote Sensing	3
GEOG 680	Geographic Information Systems Pattern Analysis and Modeling	3
PAG 654	Applications of Precision Agriculture	3

Examinations

1. **Qualifying Exam (Ph.D. only):** This exam consists of written and oral portions. The student will complete a written exam that emphasizes the application of materials presented in the core courses. The members of the genomics graduate program will submit these questions. The oral exam will be administered by the student's graduate committee and will focus on material beyond the core courses that are specific to the research of the student. Upon completion of the qualifying exam, the student will be accepted as a Ph.D. candidate.

2. **Final Exam:** The final exam will be an oral defense of the student's research results. The student's graduate committee will administer the exam.

Samat Amat, Ph.D.
University of Calgary, Canada, 2019
Department: Microbiological Sciences
Research Interests: Animal Microbiome

Nonoy Bandillo, Ph.D.
University of Nebraska-Lincoln, 2016
Department: Plant Sciences
Research Interests: Pulse Breeding, Genetics

Samiran Banerjee, Ph.D.
University of Saskatchewan, 2012
Department: Microbiological Sciences
Research Interests: Agriculture Microbiomes; Plant-Microbe Interactions

Michael J. Christoffers, Ph.D.
University of Missouri-Columbia, 1998
Department: Plant Sciences
Research Interest: Weed Molecular Genetics

Anne Denton, Ph.D.
University of Mainz, 1996
Department: Computer Science
Research Interest: Data Mining, Bioinformatics

Justin D. Faris, Ph.D.
Kansas State University, 1999
Department: Plant Sciences
Research Interest: Wheat Molecular Genetics

Jason Fiedler, Ph.D.
The Scripps Research Institute, 2012
Department: Plant Sciences
Research Interests: Bioinformatics, High-throughput Genotyping, Small Grains Genetics

Paulo Flores, Ph.D.
Federal University of Rio Grande do Sul, 2008
Department: Agricultural and Biosystems Engineering
Research Interests: Precision Agriculture, Applications of UASs/Drones in Agriculture, UASs/Drone Imagery Analysis, GIS Applications for Precision Agriculture

Timothy Friesen, Ph.D.
North Dakota State University, 2001
Department: Plant Pathology
Research Interest: Host-Pathogen Interactions of Cereals

Barney Geddes, Ph.D.
University of Manitoba, Canada, 2014
Department: Microbiological Sciences
Research Interests: Plant Microbe Interactions

Upinder Gill, Ph.D.
Washington State University, 2012
Department: Plant Pathology
Research Interests: Host-Microbe Interactions, Genetics and Genomics of Plant Disease Resistance

Rich Horsley, Ph.D.
North Dakota State University, 1988
Department: Plant Sciences
Research Interests: Barley Breeding, Genetics

David P. Horvath, Ph.D.
Michigan State University, 1993
Department: Plant Sciences
Research Interest: Perennial Weed Physiology

Rick Jansen, Ph.D.
University of Minnesota, 2009
Department: Public Health

Research Interest: Molecular and Genomic Epidemiology

Xuehui Li, Ph.D
University of Georgia, 2009
Department: Plant Sciences
Research Interests: Statistical Genomics

Zhaohui Liu, Ph.D.
North Dakota State University, 2006
Department: Plant Pathology
Research Interest: Host-Parasite Interactions of Wheat

Phillip E. McClean, Ph.D.
Colorado State University, 1982
Department: Plant Sciences
Research Interest: Plant Molecular Genetics

Steven W. Meinhardt, Ph.D.
University of Illinois, Champaign-Urbana, 1984
Department: Biochemistry and Molecular Biology
Research Interest: Protein Structure/Function

Carrie Miranda, Ph.D.
University of Missouri, 2018
Department: Plant Sciences
Research Interests: Legume Molecular Genetics and Bioinformatics

Juan Osorno, Ph.D.
North Dakota State University, 2006
Department: Plant Sciences
Research Interests: Legume Genetics/Genomics and Synteny

Birgit Pruess, Ph.D.
Ruhr-Universitat Bochum, 1991
Department: Veterinary and Microbiological Sciences
Research Interest: Microbial Physiology and Gene Regulation

Jack B. Rasmussen Ph.D.
Michigan State University, 1987
Department: Plant Pathology
Research Interest: Molecular Plant/Microbe Interactions

Katie Reindl, Ph.D.
North Dakota State University, 2006
Department: Biological Sciences
Research interest: Cancer cell biology

Saeed Salem, Ph.D.
Rensselaer Polytechnic Institute, 2009
Department: Computer Science
Research Interest: Bioinformatics Analysis of Biological Networks

Sarah Signor, Ph.D.
University of California-Davis, 2013
Department: Biological Sciences
Research Interests: Insect Evolutionary Genomics

Vasant A. Ubhaya, Ph.D.
University of California-Berkeley, 1971
Department: Computer Science and Operations Research
Research Interest: Algorithm Analysis, Operations Research

Changhui Yan, Ph.D.
Iowa State University, 2005
Department: Computer Science

Research interest: Computational Bioinformatics