Syllabus

Precision Medicine and Health
Understanding the Personal Genome
Fall 2021
PHAR2002
Wednesday and Friday 9:45 to 11:00.
3 Credits

Course Co-Directors: Pamala A. Jacobson, PharmD and William S. Oetting, PhD
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Course information

Course description:
This interprofessional course is for students who want to understand the basic concepts of Precision Medicine. This course will help the student understand how individuality impacts disease predisposition, diagnosis, treatment and health. We will begin with the creation of an individualized full genome sequence and show how this information can be used to predict, diagnose and treatment of disease. We will also talk on the ethical use of this information.

Target students:
This course is intended for first and second year undergraduate non-science majors who are interested in the impact of genetics on different aspects of medicine. However, any undergraduate major may enroll. The course will provide a brief introduction to molecular biology and then introduce different areas of precision medicine with an emphasis on the contribution of genetics for understanding predisposition, disease diagnosis and treatment. An important part will be class exercises which will help the student better understand the concepts presented in the lectures.

Prerequisites: None. The course is directed towards undergraduate non-science majors. However, science major may take the course.

Class time:
Two 75 minute in person lectures per week. Each 75 minute block will be split approximately 50 minutes for lecture and 25 minute for class discussion/exercise. Wednesday and Friday 9:45 to 11:00.

Textbook (Not Required)

Class Format:
This class will be offered as a remote-instructed class by zoom based on University of Minnesota guidance. Exams will be online.

The class format will begin with a traditional lecture format followed by in class discussion of assigned materials, hands on activities using databases and case studies where the discussion in based around a situation (problem) that a clinician may encounter that requires application of the knowledge of precision medicine knowledge.

Class attendance is expected since this class includes live discussions and guest speakers. Attendance will be taken.

Learning Objectives:
At the conclusion of the course, the student will be able to:

1. **Explain** how differences in the DNA sequence of an individual can result in differences in disease susceptibility.
2. **Describe** how genetic testing is used to identify variation in the DNA sequence and then used to prevent or reduce disease and the complex interplay between genetics, environment and lifestyle.
3. **Discuss** how genetic variability in genes encoding drug metabolizing enzymes, drug transporting proteins, and drug receptors (targets) can contribute to variability in drug disposition and action, leading to changes in pharmacokinetics, pharmacodynamics and treatment success.
4. **Discuss** how precision medicine information is used in the clinic to more precisely diagnose and treat patients.
5. **Describe** the differences between germline and somatic mutations and the therapeutic implications of the presence of somatic mutations in cancer.
6. **Explain** how emerging field of gene therapy will be used in precision medicine.
7. **Recognize** the societal and ethical implications of precision medicine and the big business of precision medicine.

Exams and Assignments:

2 exams (covering the 1st half and then 2nd half of semester)	50%
4 writing assignments responding to each discussion topic	40%
Attendance (90% attendance is necessary for full points)	10%
No Final exam	

Tests will vary and may be multiple choice, short answer or essay. Writing assignments for the discussion class periods will be grade individually and submitted on Canvas.

Grading Policy:

Students who have questions regarding the grading of an exam or assignment must submit them in writing to the instructor within one week following the return of the grades.

Grade	% Range	Grade	% Range	Grade	% Range
A	93-100	B-	80-82	D	60-69
A-	90-92	C+	77-79	F	Less than 60
B+	87-89	C	73-76		
B	83-86	C-	70-72		

Make-Up Policy: The makeup of lectures and exams will be done in accordance with University of Minnesota policy.

University policy recognizes that there are a variety of legitimate circumstances in which students will miss coursework, and that accommodations for makeup work will be made. This policy applies to all course requirements. Students are responsible for planning their schedules to avoid excessive conflicts with course requirements. The University policy is located at: https://policy.umn.edu/education/makeupwork

Disability Accommodations: Students with a documented disability (eg. physical, learning, psychiatric, vision, hearing, etc.) already registered with the Disability Resource Center must contact the course director within the first week of class to discuss your accommodations. Accommodations take advance planning to implement. Students who do not present documentation from Disability Services a minimum of one week before an assessment will adhere to original/traditional expectations for that assessment. Please contact Disability Services to quantify and arrange the necessary accommodations: Twin Cities: http://ds.umn.edu/ (612-626-1333). Duluth: http://www.d.umn.edu/access/ (218-726-8217). All discussions concerning this issue will remain confidential. English as a second language is not considered a disability by the College of Pharmacy and this course will not accommodate requests for additional exam time based on this criterion.

Course evaluation: Students will have an opportunity to complete online course evaluations for course instructors and the overall course. We value your opinion.

Section 1. Why do we need DNA? What does DNA do?

Week 1

1. **Introduction to the course - What is precision/individualized medicine?**
   Drs. Pamala Jacobson and William Oetting
   The first class will be an overall introduction to the different topics presented in this course. We will discuss what precision medicine is, how is it used now and how we expect it be used in the future. This will include the precision medicine ecosystem consisting of patients, doctors, genotypes, phenotypes, outcomes, electronic medical records (EMR), laboratory tests and the use of research databases. We will also discuss the history of the precision medicine initiative and the Human Genome Project.
   Class exercise: Students will comment on what they feel are the most important issues in human genetics and medicine. We will watch the video by Dr. Rick Leach, Vice President of Business Development for Complete Genomics: The Rise of Genomic Medicine. https://www.youtube.com/watch?v=eVjJsNRifBA.

2. **Basic molecular biology part 1 – DNA to RNA to protein to function**
   Dr. William Oetting
   This discussion will focus on the central dogma of molecular biology (DNA→RNA→Protein). We will begin with an introduction to the human genome sequence. We will discuss the history of how the sequence was created and why the human genome DNA sequence is important for a more accurate diagnosis and treatment of disease. We will present the central dogma of molecular biology to explain what information DNA contains, how this information is utilized in the cell and how it is controlled.
   Class exercise: Students will report the comparison of different genes in the human genome using the Human Genome Browser. This shows the diversity and complexity of the human genome.

Week 2

3. **Basic molecular biology part 2 – DNA to RNA to protein to function**
   Dr. William Oetting
   In this lecture we will continue the discussion on the central dogma from DNA sequence to protein function. At the end of days 2 and 3 the student will have an understanding of the role of DNA and be able in later talks to understand how alteration of the DNA sequence results in variation and disease.
   Class exercise: Students will determine the protein sequence based on the DNA/RNA sequence. In part this will show why the reading frame is important.

4. **What is a mutation? - Understanding genetic variation on protein function**
   Dr. William Oetting
   In the previous two lectures we presented how DNA creates specific function in a cell. In this discussion we will show what can happen when the DNA sequence is altered. We will present the different kinds of sequence alterations which can be found in the DNA sequence and their effects on function. From this discussion the student will understand the different types of DNA variation and their impact on function.
   Class exercise: Students will attempt to identify how many different types of variants exist in a given gene using a database of DNA variants (dbSNP).

Week 3

5. **What is normal? What is disease? – Looking at DNA variation**
   De. William Oetting
   Not all DNA sequence variants are the same. The differences between normal variation in the population and variation associated with disease will be contrasted. We will use variants associated with pigmentation and height as examples of normal variation and then show how variants in these same genes can cause the genetic disease albinism or skeletal disorders. This will show how genetic variant can result in normal variation or disease, depending on the type and location of the sequence alteration. From this discussion the student will understand the impact of genetic alteration resulting in normal variation found in the population and variation which causes disease.
   Class exercise. The students will use SIFT and PolyPhen software programs to determine if a variant is predicted to be functional or benign using known functional variants and benign variants in a human gene database containing different types of variants. Understanding functional status of a gene provides clues if it may be associated with disease or poor outcome.

6. **Open classroom discussion**
   Drs. William Oetting and Pamala Jacobson
   This is an opportunity to ask questions and talk about the previous lectures in this section of the class. We will first watch a video by Dr. Francis Collins, Director of the National Institute of Health: We need better drugs – now (https://www.youtube.com/watch?v=2_0aEezKvBE). We will talk about whole genome sequencing and some of the promises and problems. Please bring any question you have on DNA sequencing and disease.

Week 4

<u>Section 2. What can DNA tell us, what happens when things go wrong and how do we fix DNA?</u>

7. **Who are you anyway? – Ancestry testing and what does race really mean.**
   Dr. David Matthes
   The use of DNA analysis to determine ancestry and health risk is becoming widespread. We will go over how this information is determined and how to interpret it correctly. We will talk about the genetic markers used, the concept of principle components analysis and what are the limitations of this type of analysis. We will also discuss how populations different at the level of the DNA sequence. After this lecture the students will better understand how to read and interpret DNA variation reports. Commercial ancestry testing will be presented.
   Class exercise: Students will be asked to review a genetic ancestry report from a genotyping company and comment on what impact this could have on the family.

8. **What diseases will I get? – Testing for disease producing variants**
   Dr. Charles Billington
   Clinical testing for genetic disease has been ongoing for many decades. We will discuss the history of population and individual DNA screening. This will include the different ways that genetic tests are done. This will include cytogenetic testing, prenatal genetic testing and newborn screening. We will also continue our discussion on determining genetic risk. We

will also have a discussion on next generation DNA sequencing. Adult screening for disease risk is becoming part of clinical care. What will happen in the future? After this discussion, the students will better understand the types of genetic screening done and interpretation of results.
Class exercise: Students will analyze a sequence variation report and determine which diseases are associated with disease risk.

Week 5

9. Using genetics to diagnose and treat single gene disorders.
Dr. Reena Kartha
Single gene disorders are rare for a specific disease but common when all are considered in aggregate. We will discuss how a single nucleotide change in the DNA sequence can have a big effect on our health. We will compare recessive verses dominant genetic conditions. Examples used will be sickle cell disease, phenylketonuria, cystic fibrosis, and osteogenesis imperfecta. We will contrast this type of genetic disease to complex diseases like breast cancer or diabetes which has many genes involved. We will present treatments for cystic fibrosis which are mutation specific. After this lecture, the student will have a better understanding of single gene disorders and their treatment.
Class exercise: Students will use the OMIM and dbSNP databases to identify single gene disease mutations and their frequency in different populations.

10. Gene therapy – Using DNA as a drug
Dr. Scott Mc Ivor
The use of viral vectors and gene editing tools can fix disease causing genes to the normal non-disease version of the gene. We will discuss the history of gene therapy, the successes and the failures. We will talk about different strategies currently being used for changing the DNA sequence using tools such as viral vectors and CRISPR.
Class exercise: Scott, please think of something.

Week 6

11. Open classroom discussion
Drs. Pamala Jacobson and William Oetting
This is an opportunity to ask questions and talk about the previous lectures in this section. We will first watch the documentary Twitch by Kristen Powers (https://www.youtube.com/watch?v=f6BdOnxOA10). In the near future you will be able to test yourself for many genetic based diseases. Do we want to expand this type of testing for as many different diseases as possible? What diseases should we test for? What diseases should we not test for? Should society play a role in this decision? Are there any limits for gene therapy?

<u>Section 3. It is not always yes or no. The complexity of genetics.</u>

12. Pharmacogenomics – What is it? Can it determine which drugs will work, have side effects or are toxic? How is it used in the clinic?
Dr. Pamala Jacobson
In this lecture we will discuss how knowledge of medication related genes and variants help in patient care. We will define what pharmacogenomics (PGx) is and describe the basic

fundamental principles associated with PGx. We will show why pharmacogenomics is important for predicting medication efficacy and determining the risk of side effects and drug toxicity. We will show how knowing an individual's genetic variation in drug metabolism genes allows clinicians chose the appropriate rug dose and predict the response to therapy. After this lecture the student will have an appreciation for the importance of PGx in optimizing precise therapy for the individual.
Class exercise: Students will use the web site PharmGKB to identify variants in genes which impact a specific drug and may alter the response of the patient to that drug. Students will be asked to show how genetic variation may alter the efficacy of a drug based on clinical pharmacogenomics implementation consortium guidelines and how this information may impact drug choice and dosing. Students will evaluate a pharmacogenomic drug report from a real patient.

13. The genetics of neuropsychological diseases – Targeted diagnosis and precision medicine therapies
Dr. Jeffery Bishop
This will be a discussion on the importance of genetics in the diagnosis and treatment of neurological and psychological diseases. The epilepsies are caused by variation in multiple genes and will be used as a model to understand the problem of accurate diagnosis and treatment for affected individuals. We will also discuss other psychiatric disorders such as depression and schizophrenia and describe how genetics can improve diagnosis and aid in the choice of a drug and/or dose for treatment.
Class exercise: Students will be asked to identify the different medications which can be used to treat diseases such as depression or schizophrenia along with what pathways they interact with.

Week 7
14. The complexity of complex disease – How we can tell who is at risk
Dr. James Pankow
Complex diseases are a result of inherited variants in multiple genes which increase the risk for disease. We will discuss how we determine if a variant in a gene(s) will predispose us to disease. This will include a discussion of what a genome wide association study (GWAS) is and how it can it be used to identify important variants in disease risk. We will focus on type 2 diabetes as an example. This will provide the student with an understanding of the genetic components of a complex disease. Knowing if an individual is predisposed to a specific disease may provide interventions to prevent the disease from occurring. We will discuss what the polygenic risk score is, how you create it and what it can be used for. We will further discuss different interventions which will help predisposed individuals avoid disease and how genetics can influence this. With this lecture the student will understand the concept of risk and how it can be used to tailor disease prevention.

Class exercise: There will be a review for Exam 1. Students will be given an opportunity to ask questions.

15. Open classroom discussion

Drs. Pamala Jacobson and William Oetting

This is an opportunity to ask questions and talk about the previous lectures in this section. This will also include an exam review. We will first watch a video by Dr. Russ Altman of Stanford University: Personalized prescriptions (https://www.youtube.com/watch?v=X1iKibDqtck). We will look at the PharmGKB and CPIC databases. How do genetic variants associated with single gene disorders compare to variants associated with complex diseases?

Week 8

16. Exam 1 - in class

<u>Section 4. Cancer and genetics</u>

17. What is cancer and the role of genetic variants in risk and formation

Dr. Christopher Pennell

In this lecture we will describe what cancer is and the genes which are involved in causing cancer. We will show how cancer is a disease of a cellular pathway and not necessarily of a specific tissue. The progression of a normal cell to cancer through the accumulation of somatic mutations will be discussed. We will also show how cellular mutations can be used to diagnosis cancer risk, treatment and prognosis.

Class exercise: The student will asked to match up mutations in genes associated with cancer and determine if these mutations affect the same cellular pathway or a different pathway.

Week 9

18. Precision medicine in cancer – Using genetics to determine an individual's risk of cancer, for diagnosis and targeted anticancer therapies

Dr. Pamala Jacobson

We will discuss the difference between inherited (germline) and somatic (cancer tissue) mutations and their role in cancer formation. We will discuss the role germline mutations play in determining cancer risk and show how this information can be used to reduce the risk of cancer from occurring or determine the optimal treatment for the patient. After lecture 10 and 11, the student will understand the biology of cancer and the role genetics play in the formation and treatment of cancers.

Class exercise: The student will be asked to match up a specific treatment for cancer with the mutations associated with the cancer. We will use specific genes and variants associated with breast and ovarian cancer.

Week 10

19. Tumor immunology and immunotherapy

Dr. Christopher Pennell

An individual's immune system is a powerful form of precision medicine and can be harnessed to fight cancer. Immunotherapies release the brakes on the bodies own immune system to kill cancer cells that have become tolerant to natural mechanisms of elimination. Although immunotherapies are effective, serious toxicities may occur when the immune

system attacks normal cells. Using cell engineering, immunotherapies are the ultimate of designer therapies.

Class exercise: Students will learn how to determine if a drug or cellular product is an immunotherapy and what the toxicities might occur.

20. Cases in the clinic – Oncology precision medicine in the real world

Dr. David Stenehjem

This will be a presentation of clinical cases focusing on oncology. We will show how clinicians utilize genetic information to help identify the pathways which are altered, how the type of treatment is decided and the outcomes. This will include chemotherapy and anti-body mediated therapy. This lecture will provide the student with 'real world' examples of precision medicine.

Class exercise: Using genetic variant oncology related reports, the student will use them to understand the impact of specific genetic variants on cancer diagnosis and treatment.

Week 11

21. Open classroom discussion

Drs. Pamala Jacobson and William Oetting

This is an opportunity to ask questions and talk about the previous lectures in this section. We will watch the TED talk by Dr. Lincoln Nadauld of Precision Medicine and Precision Genomics at Intermountain Healthcare. https://www.youtube.com/watch?v=aO3O9rfUMT4. How has our knowledge of what cancer is changed our treatment of cancer? What role can non-genetic elements play in the treatment of cancer?

<u>Section 5. Jobs in Precision Medicine – Who are the professionals using genetics?</u>

22. Genetic counseling – Why this is important in precision medicine

Dr. Heather Zierhut

We will discuss the role of genetic counselors in the treatment of patients. Specifically, what goes on in a genetic counseling session and how complex genetic information is explained to a patient. We will also discuss some of the limitations to genetic counseling. After this, students will have a better understanding of genetic counseling and its role in medical treatment of individuals with genetic associated disease.

Class exercise: Students will be given cases and be asked how the patient should be counseled about their genetic findings.

Week 12

23. Genetics in pharmacy – How do we help individualize drug treatment using genetics?

Dr. David Gregornik

A pharmacist will talk about the use of genetic information to determine the best way to provide drug treatment to a patient. The impact of an individual's genetic makeup and its impact on drug impact and toxicity will be discussed.

24. Genetics in medicine – How has genetics changed clinical practice?

Dr. William Dobyns

A medical doctor will talk about how new genetic findings have changed the practice of medicine. What promises have come true and which ones have not.

Week 13

25. Genetics in industry – genetics and precision medicine jobs in the commercial sector
TBD

Individuals within industry will talk about what new technologies have been developed and what will be the new directions.

<u>Section 6. The impact of new genetic findings on society</u>

26. Current topics in the news. Topics may include COVID-19 and precision medicine, big business of precision medicine, and the false claims.
Dr. Brian Van Ness

This will be a presentation of different aspects of precision medicine in the news focusing on COVID-19 related drugs. We will discuss how to recognize hype from valid opportunity.
Class exercise: Students will be asked in the previous week to look for and bring to class articles that include different aspects of precision medicine. These will be discussed in class.

Week 14

27. Ethics – Precision medicine problems in the clinic
Dr. Brian Van Ness

With new technologies, there are always unexpected findings. Clinicians need to work with ambiguity in testing results and how to provide that information to the patient. Additionally, identical data can be presented in multiple formats making interpretation difficult. It also needs to be acknowledged that the clinician is testing a family, not just an individual (who is your patient). After this discussion the student will have a greater appreciation that genetic findings are not always clear in their interpretation.
Class exercise: The American College of Medical Genetics and Genomics recommends that incidental findings, found through genomic sequencing, be given to the patient. Students will be asked to present some of the possible consequences of this recommendation. (see Genetics in Medicine. 2017;19:249–255)

28. Ethics – Precision medicine problems in society
Dr. Brian Van Ness

As genetic sequencing becomes more available, there are societal issues which need to be considered. We will discuss the impact of genetic information including eugenics (whether it still exists), potential cultural issues (gay gene, god gene) and genetic discrimination. Other topics include human/animal chimeras for transplantation and the creation of transgenic humans.
Class exercise: Students will be asked to provide commentary on the production of transgenic humans and comment on what characteristics they would want to improve and which genes would you need to alter to make a positive change.

30. Exam 2 in class during finals week

Precision Medicine (PHAR2002) - Course Schedule Fall 2021
Wednesday and Friday 9:45 to 11:00.
Semester is from September 7 to December 15, 2021 (Last day of class for U of M is 12/15)
Finals week is December 16-22, 2021

Lecture	Date	Title	Instructor
Section 1		**Why do we need DNA? What does DNA do?**	
1	W 9/8	Introduction to the course - What is precision/individualized medicine?	Pamala Jacobson William Oetting
2	F 9/10	Basic molecular biology part 1 – DNA to RNA to protein to function	William Oetting
3	W 9/15	Basic molecular biology part 2 – DNA to RNA to protein to function	William Oetting
4	F 9/17	What is a mutation? - Understanding genetic variation on protein function	William Oetting
5	W 9/22	What is normal? What is disease? – Looking at DNA variation	William Oetting
6	F 9/24	Video and open discussion with breakout sessions	Pamala Jacobson William Oetting
Section 2		**What can DNA tell us, what happens when things go wrong and how do we fix DNA?**	
7	W 9/29	Who are you anyway? – Ancestry testing and what does race really mean	David Matthes
8	F 10/1	What diseases will I get? – Testing for disease producing variants	Charles Billington
9	W 10/6	Using genetics to diagnose and treat single gene disorders	Reena Kartha
10	F 10/8	Gene Therapy: Using DNA as a Drug	Scott McIvor
11	W 10/13	Video and open discussion with breakout sessions	Pamala Jacobson William Oetting
Section 3		**It is not always yes or no. The complexity of genetics and health**	
12	F 10/15	Pharmacogenomics – What is it? Can it determine which drugs will work, have side effects or cause adverse effects? How is it used in the clinic?	Pam Jacobson
13	W 10/20	The genetics of neuropsychologic diseases - targeted diagnosis and precision medicine therapies	Jeff Bishop
14	F 10/22	The complexity of complex disease – How we can tell who is at risk	Jim Pankow
15	W 10/27	Video and open discussion with breakout sessions and Exam 1 review	Pamala Jacobson William Oetting
16	F 10/29	Exam 1	Pamala Jacobson William Oetting

Section 4		**Why do we get cancer? Precision Medicine in cancer**	
17	W 11/3	What is cancer and the role of genetic variants in risk and formation	Chris Pennell
18	F 11/5	Precision Medicine in cancer. Using genetics to determine an individual's risk of developing cancer, for diagnosis and targeted anticancer therapies	Pam Jacobson
19	W 11/10	Tumor immunology and immunotherapy	Chris Pennell
20	F 11/12	Patient cases in oncology – using precision medicine in the real world	David Stenehjem
21	W 11/17	Video and open discussion with breakout sessions	Pamala Jacobson William Oetting
Section 5		**Jobs in Precision Medicine – What are the professions in this field?**	
22	F 11/19	Genetic counseling – Why this is important in precision medicine	Heather Zierhut
23	W 11/24	Pharmacy – How do we individualize drug treatment using genetics?	David Gregornik
		Thanksgiving	
24	W 12/1	Medicine – How has genetics changed clinical practice?	Bill Dobyns
25	F 12/3	Industry – genetics and precision medicine jobs in the commercial sector	TBD
Section 6		**The impact of new precision medicine findings in the clinic and society**	
26	W 12/8	Current topics in the news. COVID-19 and precision medicine, big business of precision medicine and the false claims	Brian Van Ness
27	F 12/10	Precision Medicine problems in the clinic	Brian Van Ness
28	W 12/15	Precision Medicine problems in society	Brian Van Ness
29	F 5/7	Exam 2 during finals week on Friday May 7	William Oetting

Instructor Bios - PHAR 2002

Pam Jacobson, PharmD,
Dr. Jacobson is a professor and associate department head in the Department of Experimental and Clinical Pharmacology in the College of Pharmacy and holds a joint appointment in the Medical School's Division of Hematology, Oncology and Transplantation. She received her PharmD from the University of Nebraska and completed residencies, including a specialty residency in infectious disease, at the University of Michigan. Dr. Jacobson joined the University of Minnesota in 1998. Her research has focused on the clinical pharmacology of immune suppressants and anticancer agents, specifically studying pharmacokinetics, pharmacodynamics, and pharmacogenetics of these agents to increase drug efficacy and decrease toxicity. Her primary work is with patients undergoing stem cell transplantation for cancer and kidney transplant. She directs the Institute of Personalized Medicine, is co-PI of the Minnesota Precision Medicine Collaborative, and is a member of the Masonic Cancer Center, University of Minnesota.

William Oetting, PhD
Dr. Oetting is a professor in the Department of Experimental and Clinical Pharmacology in the College of Pharmacy. He received his PhD in Genetics from the University of Nebraska-Lincoln. The focus of his research is to identify genetic variants associated with complex human phenotypes and disease. Part of his research is on the identification of genetic variation associated with various outcomes in kidney allograft recipients, including pharmacogenomic related outcomes. This work includes creating a large cohort of DNA samples from both kidney allograft recipients and living kidney donors, collecting clinical outcomes, genotyping variants and associating these variants with different phenotypes. He also works on identifying genetic variation associated with defects in pigmentation, specifically in regards to the genetic disorder albinism. Additional research in complex disease includes identification of variants associated with behavioral phenotypes, asthma, and novel single gene disorders.

David Matthes, PhD
Dr. Matthes is a teaching professor in the Department of Biology Teaching and Learning and the Department of Genetics, Cell Biology and Development. His courses include the award-winning Foundations of Biology course, a senior-level, team-based learning-format section of Cell Biology, a project-based bioinformatic analysis course in which students characterize human genes of unknown function, and a personal genome analysis course in which students analyze their own genome variations while learning about the connections between the genome and many aspects of the human condition. He received the Horace T. Morse-University of Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education in 2018 and the College of Biological Sciences' Stanley Dagley-Samuel Kirkwood Undergraduate Education Award in 2015. Dr. Matthes joined the CBS faculty in 2008.

Charles Billington, Jr., MD, PhD
Dr. Billington is an assistant professor in the Department of Pediatrics and a faculty member of the Division of Genetics and Metabolism. Dr. Billington's research looks at variable phenotypes of genetic conditions. In the past he has done research on Williams Syndrome and on animal models of brain and facial malformations and now is interested in working to develop work around the variability of brain and vascular differences in other genomic syndromes. Clinically he is also interested in care for patients with inborn errors of metabolism, particularly urea cycle disorders and maple syrup urine disease.

Reena Kartha, MS, PhD
Dr. Kartha is associate director of translational pharmacology for the Center for Orphan Drug Research. She holds a PhD in cellular and molecular biology from the Indian Institute of Science, Bangalore. She completed her post-doctoral training in translational research at Stanford University and the University of Minnesota. Dr. Kartha's research interests are in deciphering the pathophysiological role of oxidative stress in disease conditions such as neurodegenerative disorders and ischemia/reperfusion injury. Her research involves understanding the molecular pharmacology of antioxidants and other drugs used to treat these conditions using cell culture and animal models and identification of novel protein- or miRNA-based biomarkers for early diagnosis of these conditions and as markers of response to therapy using patient derived samples.

R. Scott McIvor, PhD
Dr. McIvor is a professor in the Department of Genetics, Cell Biology and Development. The general research interest of Dr. McIvor's laboratory is genetic therapy for inherited diseases and cancer. Specific research activities include: the use of recombinant lentiviral vectors for gene transfer into hematopoietic stem cells in the treatment of cancer and inherited disorders such as immunodeficiency diseases and lysosomal storage diseases; the use of adeno-associated virus for treatment of storage diseases and as a vector for gene transfer into the central nervous system in the treatment of neurological disorders; the adaptation of an active vertebrate transposon ("Sleeping Beauty") in the development non-viral genetic therapies; and the chromosomal site-directed correction of mutations in hematopoietic stem cells and other target tissues for the treatment of immunodeficiencies and other inherited disorders.

Jeffrey Bishop, PharmD, MS, BCPP, FCCP
Dr. Bishop is an associate professor in the Department of Experimental and Clinical Pharmacology and an adjunct associate professor in the Department of Psychiatry. He conducts psychopharmacology and pharmacogenomics research with a focus on examining genetic relationships with symptom improvement, side effects, and cognitive effects of medications. Dr. Bishop also provides clinical and didactic education to pharmacy and medical trainees. He earned a degree in biology at Luther College and went on to complete his Doctor of Pharmacy degree at the University of Iowa. Subsequently he completed a fellowship in clinical psychopharmacology and pharmacogenetics at the University of Iowa College of Pharmacy as well as a master's degree in Clinical Investigation through the University of Iowa College of

Medicine. His research work has been supported through local, foundation, and NIH funding mechanisms.

Jim Pankow, PhD, MPH
Dr. Pankow is a professor in the Division of Epidemiology and Community Health in the School of Public Health. He is an epidemiologist whose long-term research goal is to identify and characterize risk factors for cardiovascular disease, type 2 diabetes, and other chronic conditions of aging. During his career he has helped assemble large genetic epidemiologic cohorts of cardiovascular disease, investigated genetic determinants of proteins involved in inflammation, hemostasis, and cellular adhesion, researched novel risk factors for type 2 diabetes, including genetic and epigenetic determinants, and evaluated new methods and approaches in statistical genetics in collaboration with faculty in biostatistics.

Christopher Pennell, PhD
Dr. Pennell is associate director of education for the Masonic Cancer Center and an associate professor in the Medical School's Department of Laboratory Medicine and Pathology. He is the co-director of the Inspire Program in the Institute for Engineering in Medicine and was just named an inaugural Abbott Professor for Innovative Education. Dr. Pennell's laboratory is investigating novel strategies for immunotherapy, drawing on the immune system's inherent specificity as part of a personalized medicine approach for treating cancer. His team is using the tools of immunology, molecular biology, genetic engineering, and transgenic animals in two research areas that have potentially synergistic applications: the development of DNA-based cancer vaccines; and the development of T-cell chimeric antigen receptors engineered to recognize and bind specific tumor cell-surface antigens, activating T-cell cytotoxicity.

David Stenehjem, PharmD, BCOP
Dr. Stenehjem is an associate professor and associate department head in the Department of Pharmacy Practice and Pharmaceutical Sciences at the University of Minnesota, College of Pharmacy. His outcomes-based research agenda is centered around assessing the role and value of oncology therapeutics and precision oncology in improving outcomes for cancer patients. His research strategy uses real world data collected from major cancer centers across the nation to assess clinical and economic outcomes of cancer patients treated with specific therapeutic agents. This approach allows for the molecular stratification of patients while assessing meaningful outcomes to demonstrate the value of precision oncology and specific cancer treatments. Additionally, translational research is supported by assessing the implications of novel biomarkers with treatment response. He is also a co-director of a pharmacogenomic implementation fellowship program in partnership with Essentia Health in Duluth.

Heather Zierhut, PhD, MS, CGC
Dr. Zierhut is an associate professor in the Department of Genetics, Cell Biology, and Development in the College of Biological Sciences and the program director of the Graduate Program of Study in Genetic Counseling. Her major area of interest focuses on the education and clinical preparation of genetic counseling professionals as well as the implications of genetics

and genetic counseling on public health. Dr. Zierhut is also interested in the psychosocial and public implications involved with the provision of genetic counseling services. Her previous research has focused on decision making of parents of children with Fanconi Anemia. Dr. Zierhut's current research is focused on genetics in public health screening programs and outcomes of genetic counseling. She is an active member in the National Society of Genetic Counseling and has been recognized by her peers as a recipient of the New Leader Award in 2009, Outstanding Volunteer and Janus Series speaker in 2014, and Strategic Leader in 2017.

David Gregornik, PharmD

David Gregornik is an Adjunct Associate Professor in the Department of Experimental and Clinical Pharmacology in the College of Pharmacy. He is the Pharmacogenomics Program Director at Children's Minnesota. Dr. Gregornik earned his PharmD at the University of Minnesota College of Pharmacy and completed a specialty residency in Pediatric Pharmacotherapy at St. Jude Children's Research Hospital in Memphis TN where he was part of the St. Jude Pharmaceutical Department for 18 years providing advanced clinical pharmacy care to children with cancer and undergoing bone marrow transplant. From 2009-2013 David moved to Memorial-Sloan Kettering Cancer Center where he served as Manager of Pediatric Clinical Pharmacy Programs. Dr. Gregornik joined Children's Minnesota in August 2016 where he established a Pharmacogenomics Clinical Service and ambulatory clinic. His research areas include clinical pharmacogenomics implementation and evaluating pharmacogenomic determinants of response and toxicity in children with cancer.

Bill Dobyns, MD

Dr. Dobyns is a professor of Pediatrics and director of the Division of Genetics and Metabolism at the University of Minnesota. He joined the faculty in June 2020 for his second tour at the U, having worked in the Division of Pediatric Neurology from 1992-1998. Dr. Dobyns is a physician-scientist trained in both pediatric neurology and medical genetics, and director of a molecular genetics laboratory that studies the nature and causes of numerous developmental brain disorders in children. While best known for studies of lissencephaly, his work has involved many different disorders including early childhood epilepsy, intellectual disability, autism, microcephaly and macrocephaly, many malformations of cortical development, malformations of the corpus callosum, brainstem and cerebellum, vascular malformations both in the brain and elsewhere, childhood stroke, and mosaicism as a mechanism of disease.

Brian Van Ness, PhD

Dr. Van Ness is a professor in the Department of Genetics, Cell Biology and Development; the director of the Precision Medicine Seminar Series for the Minnesota Precision Medicine Collaborative; and a member of the Institute of Personalized Medicine. The research in the Van Ness lab is directed at defining genetic deregulation that contributes to lymphoid malignancies, particularly multiple myeloma. Research techniques include gene profiling (expression arrays, SNPs); transfections; flow cytometry; transgenic mice; PCR.