

GENETICS

Courses offered by the Department of Genetics are listed under the subject code GENE on the (<http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=GENE&filter-catalognumber-GENE=on>) Stanford Bulletin's (<http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=GENE&filter-catalognumber-GENE=on>) ExploreCourses web site (<http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=GENE&filter-catalognumber-GENE=on>).

An underlying theme in the department is that genetics is not merely a set of tools but a coherent and fruitful way of thinking about biology and medicine. To this end, the department emphasizes a spectrum of approaches based on molecules, organisms, populations, and genomes. It provides training through laboratory rotations, dissertation research, seminar series, didactic and interactive course work, and an annual three-day retreat of nearly 200 students, faculty, postdoctoral fellows, and research staff.

The mission of the department includes education and teaching as well as research; graduates from our program pursue careers in many different venues including research in academic or industrial settings, health care, health policy, and education. The department is especially committed to increasing diversity within the program, and to the training of individuals from traditionally underrepresented minority groups.

Master of Science in Human Genetics and Genetic Counseling

The University requirements for the M.S. are described in the "Graduate Degrees (<http://www.stanford.edu/dept/registrar/bulletin/4901.htm>)" section of this bulletin.

The Department of Genetics offers an M.S. in Human Genetics and Genetic Counseling, which is accredited by the American Board of Genetic Counseling. This program prepares students to practice in the healthcare profession of genetic counseling. The program is a full time two-year program, and accepts students to begin the program only in Autumn Quarter. Students must be admitted directly into this program, and cannot automatically transfer from the Ph.D. programs within the department, or vice versa. While courses are oriented primarily towards genetic counseling students, they may also be taken by medical students, other graduate students, residents or post-doctoral fellows, and (with permission) undergraduates.

To receive a Master of Science degree in Human Genetics and Genetic Counseling from Stanford University, students must successfully complete the following:

- 84 units, including all of the required coursework as listed below (minimum grades of B- or better, Satisfactory, or Credit)
- Approximately six quarters of rotations and independent study projects in diverse settings
- All required aspects of the Graduate Student Research Project
- All required aspects of the Service and Outreach Requirement
- Formal presentations in Medical Genetics Grand Rounds and Human Genetics Journal Club.

		Units
GENE 271	Human Molecular Genetics	3
GENE 272	Introduction to Medical Genetics	2

GENE 273	Introduction to Clinical Genetics Testing	2
GENE 274A	A Case Based Approach to Clinical Genetics	2
GENE 274B	A Case Based Approach to Clinical Genetics	2
GENE 275	Role Play and Genetic Counseling Observations	2
GENE 276	Genetic Counseling Fieldwork	3-5
GENE 278	Prenatal Genetic Counseling	1
GENE 279	Pediatric and Adult Genetic Counseling	1
GENE 280	Metabolic Genetic Counseling	1
GENE 281	Cancer Genetic Counseling	1
GENE 282A	Genetic Counseling Research Seminar	1
GENE 282B	Genetic Counseling Research Seminar	1
GENE 283	Genetic Counseling Research	1-8
GENE 284	Medical Genetics Seminar	1
GENE 285A	Genetic Counseling Seminar	3
GENE 285B	Genetics Counseling Seminar	3
GENE 285C	Genetic Counseling Seminar	3
GENE 286	Advanced Genetic Counseling Seminar	2
GENE 287	CARDIOVASCULAR GENETICS	1
GENE 288	Neurogenetics	1
GENE 289	Variant Interpretation	1

- There are several additional required courses, including Clinical Embryology, Biomedical Ethics, and Research Ethics. The remaining required units can be completed through elective courses.
- Students are required to take a research elective to support your completion of the program's research project requirements— the number of units is not important (i.e. it could be a 1 unit course or multiple 2-3 units courses). There is "space" in the curriculum to take additional elective courses. We strongly encourage students to sign up for S/NC for any elective courses to ensure that they are able to focus on learning the material rather than earning a specific grade. In the spirit of supporting tailored education, we are also willing to consider any online courses or webinar series in place of or in addition to other electives. Students must submit a 1-page summary of why it would meet your needs, and if approved, you would register for GENE 299 Directed Readings for the appropriate number of units. Your conference funding could be used to cover the cost.

Students are also STRONGLY ENCOURAGED to attend when possible:

- Attendance at the **Genetics Department Retreat** (held yearly, usually in September in Monterey)
- Human Genetics Journal Club** (first Monday of the month, 12:30-1:15pm). Attendance is strongly encouraged unless you have a conflict, as you will all present in your second year, and you will improve your critical thinking skills by attending.
- Current Issues in Genetics** (Fridays 4-5pm, followed by happy hour), Genetics Library M315. This is the Genetics department's version of 'grand rounds,' typically with a more bench-science focus (similar to the talks at the retreat). Great for staying aware of future trends in genomics technology.
- Stanford Center for Biomedical Ethics Seminars** (Brown Bags, Classic Topics, Writing Seminars) (Wednesdays 11-12), SCBE Conf Room
- Other relevant Stanford events** (e.g. occasional guest speakers or film screenings sponsored by the GC program or affiliated groups; events held with our sister genetic counseling program at the University of Manila in the Philippines).

- **Work-study position with a genetics service at Stanford** (unless you choose to opt out). All students are expected to work an average of four hours per week, or a total of 40 hours per quarter. You will negotiate the format and timeframes directly with your supervisor.
- **Local, regional, and/or national genetics meetings.** Our hope is that you will choose to attend a combination of events that provide education in both genetic counseling and medical genetics. If frugal, students are often able to attend more than one national conference. We most strongly encourage attending the NSGC Annual Conference during your second year and attending the local conferences (the Northern California Coalition for Genetic Counseling Conference (usually Fall), the Northern California Genetics Exchange (Spring - at Stanford in 2020), and the Western Society for Pediatric Research Annual Meeting (Winter)). Other options include ASHG (Fall) or ACMG (Spring), and various other conferences (with justification submitted to and approved by the program directors in advance). Please refer to the SUGC Program Handbook for details on student conference travel budgets and information on requesting reimbursements.

Faculty members include members of the Stanford faculty from Genetics, Pediatrics, Obstetrics, Pathology, Developmental Biology, Biomedical Ethics, Law, and Psychology, and practicing genetic counselors and clinical geneticists in various medical centers across the Bay Area.

Applications are due in December (see website) for admission in the following Autumn Quarter. Applicants should demonstrate a combination of academic preparation, exposure to genetic counseling, and counseling and/or laboratory experiences. Exposure to persons with disabilities or chronic illness is also helpful. Additional information about the program is available at Stanford's Master's Program in Human Genetics and Genetic Counseling (<http://www.med.stanford.edu/genetic-counseling/>) website.

Doctor of Philosophy in Genetics

University requirements for the Ph.D. degree are described in the "Graduate Degrees (<http://exploreddegrees.stanford.edu/graduatedegrees/>)" section of this bulletin.

The Ph.D. program in the Department of Genetics offers graduate students the opportunity to pursue a discipline that encompasses both a set of tools and a coherent way of thinking about biology and medicine. All major areas of genetics and genomics are represented in the department, including human genetics (molecular identification of Mendelian traits and the pathophysiology of genetic disease, gene therapy, genetic epidemiology, analysis of complex traits, genome functional analysis and human evolution), and application of model organisms such as bacteria, yeast, flies, worms, and mice to basic and translational areas of biomedical research. The department is especially strong in genomic and bioinformatic approaches to genome biology and evolution, and includes several genome-scale databases and Centers such as the Center for Genomics and Personalized Medicine (SCGPM), Saccharomyces Genome Database (SGD), the Stanford Microarray Database (SMD), and the Pharmacogenetics and Pharmacogenomics Knowledge Base (PharmGKB), the ENCODE project, Stanford Genome Technology Center (SGTC), ClinGen, eGTEX, and iPOP.

The Genetics Department works to support new generations of science scholars who reflect the diversity of life experiences, intellectual perspectives, race, abilities, and cultures representing society. The Stanford Genomics Diversity Summer Program is designed to help increase the number of underrepresented scientists pursuing and succeeding in genetics, genomics, or other research careers. The department supports this goal by recruiting highly motivated students from diverse backgrounds and exposing them to cutting-edge research in top and well-resourced laboratories.

Exposure to the intellectual scope of the department is provided by laboratory rotations, dissertation research, advanced courses in genetics and other areas of biomedical science, seminar series, journal clubs, and an annual three-day retreat of faculty, students, postdoctoral fellows, and staff scientists. Emphasis is placed on interactions and collaborations among students, postdoctoral students, and faculty within the department and throughout the campus.

During their first year, graduate students in the department take graduate courses and sample areas of research by carrying out rotations in three or four laboratories. At the end of the first three quarters, students may select a laboratory in which to do their dissertation research. While the dissertation research is generally performed in one laboratory, collaborative projects with more than one faculty member are encouraged. In addition to interacting with their faculty advisor, graduate students receive advice regularly from other faculty members who serve as members of their dissertation committee. Study for the Ph.D. generally requires between four and five years of graduate work, most of which is focused on dissertation research.

Students are primarily enrolled in the program to receive the Ph.D. degree, although a limited number of M.D. candidates can combine research training in genetics with their medical studies. Ph.D. candidates who have passed the qualifying exam in the second year can opt to receive the M.S. as a terminal degree.

There are opportunities for graduate students to teach in graduate-level and professional-school courses. In addition, students have the opportunity to participate in educational outreach activities coordinated by the department, which include opportunities to interact with secondary school students and teachers, lay groups, and local science museums.

Students who have recently received a bachelor's, master's, M.D., or Ph.D. degree in related fields may apply for graduate study. Prospective students must have a background in biology, mathematics, physics, and chemistry. Decisions for admission are based on comparison of the relative merits of all the candidates' academic abilities and potential for research and the department's interest in promoting a diverse learning environment. Interviews take place in late February or early March and successful applicants are offered admission by early spring. Students who wish to pursue a combined M.D./Ph.D. degree are considered for admission into the graduate program in the department after they have been admitted to the M.D. program in the School of Medicine.

Students begin graduate studies in Autumn Quarter. Prospective students are encouraged to start the application process early to ensure that they are able to submit a complete application by the December deadline. All students accepted into the Ph.D. program in the Department of Genetics are provided with full tuition and a stipend. Three training grants, two from the National Institutes of Health and one from National Institute for Interdisciplinary Science and Technology, provide major support for the graduate training program in the department. Other student support is provided by departmental funds, the School of Medicine, and from research grants, both federal and private, of the faculty. In addition, a number of graduate students are funded by fellowships, including those from the National Science Foundation and the Stanford Graduate Fellows program.

COVID-19 Policies

On July 30, the Academic Senate adopted grading policies effective for all undergraduate and graduate programs, excepting the professional Graduate School of Business, School of Law, and the School of Medicine M.D. Program. For a complete list of those and other academic policies relating to the pandemic, see the "COVID-19 and Academic Continuity (<http://exploreddegrees.stanford.edu/covid-19-policy-changes/#tempdeptemplatetabtext>)" section of this bulletin.

The Senate decided that all undergraduate and graduate courses offered for a letter grade must also offer students the option of taking the course for a “credit” or “no credit” grade and recommended that deans, departments, and programs consider adopting local policies to count courses taken for a “credit” or “satisfactory” grade toward the fulfillment of degree-program requirements and/or alter program requirements as appropriate.

Graduate Degree Requirements

Grading

The Department of Genetics counts all courses taken in academic year 2020-21 with a grade of 'CR' (credit) or 'S' (satisfactory) towards satisfaction of graduate degree requirements that otherwise require a letter grade provided that the instructor affirms that the work was done at a 'B-' or better level.

The M.S. in Human Genetics and Genetic Counseling program counts all courses taken in academic year 2020-21 with a grade of 'CR' (credit) or 'S' (satisfactory) towards satisfaction of graduate degree requirements that otherwise require a letter grade provided that the instructor affirms that the work was done at a B- or better level. However, the department strongly encourages students to follow grading basis guidelines listed in the curriculum guide to ensure that they maximize opportunities for depth and breadth of performance feedback, while minimizing pressure to achieve high marks.

Graduate Advising Expectations

The Department of Genetics is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the advisor and the advisee. As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both the advisor and the advisee are expected to maintain professionalism and integrity.

Faculty advisors guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

Graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

For a statement of University policy on graduate advising, see the "Graduate Advising (<http://exploreddegrees.stanford.edu/graduatedegrees/#advisingandcredentialstext>)" section of this bulletin.

Emeritus: (Professor) Greg Barsh, Uta Francke

Chair: Michael Snyder

Professors: Russ Altman, Laura Attardi, Julie Baker, Anne Brunet, Carlos Bustamante, Michele Calos, Stanley Cohen, Ronald Davis, Andrew Fire, James Ford, Judith Frydman, Margaret Fuller, Aaron Gitler, Mark Kay, Karla Kirkegaard, Joseph Lipsick, Hiromitsu Nakauchi, Jonathan Pritchard, John Pringle, Julien Sage, Arend Sidow, Tim Stearns, Lars Steinmetz, Hua Tang, Alice Ting, Anne Villeneuve

Professor (Research): Leonore Herzenberg, J. Michael Cherry

Professors (Teaching): Kelly Ormond

Associate Professors: William Greenleaf, Jin Billy Li, Stephen Montgomery, Gavin Sherlock, Douglas Vollrath, Monte Winslow

Associate Professor (Clinical): Mary Ann Campion

Assistant Professors: Maria Barna, Michael Bassik, Ami Bhatt, Le Cong, Christina Curtis, Polly Fordyce, Livnat Jerby-Aron, Anshul Kundaje, Serena Sanulli, Alex Urban

Assistant Professor (Clinical): Andrea Hanon-Kahn

Courses

GENE 104Q. Law and the Biosciences. 3 Units.

Preference to sophomores. Focus is on human genetics; also assisted reproduction and neuroscience. Topics include forensic use of DNA, genetic testing, genetic discrimination, eugenics, cloning, pre-implantation genetic diagnosis, neuroscientific methods of lie detection, and genetic or neuroscience enhancement. Student presentations on research paper conclusions.

GENE 199. Undergraduate Research. 1-18 Unit.

Students undertake investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

GENE 200. Genetics and Developmental Biology Training Camp. 1 Unit.

Open to first year Department of Genetics and Developmental Biology students, to others with consent of instructors. Introduction to basic manipulations, both experimental and conceptual, in genetics and developmental biology. Same as: DBIO 200

GENE 202. Human Genetics. 4 Units.

Utilizes lectures and small group activities to develop a working knowledge of human genetics as applicable to clinical medicine. Basic principles of inheritance, risk assessment, and population genetics are illustrated using examples drawn from diverse areas of medical genetics practice including prenatal, pediatric, adult and cancer genetics. Practical aspects of molecular and cytogenetic diagnostic methods are emphasized. Existing and emerging treatment strategies for single gene disorders are also covered. Prerequisites: basic genetics. Only available to MD and MOM students.

GENE 205. Advanced Genetics. 3 Units.

For PhD students in any of the Biosciences Departments and Programs at Stanford University. Emphasis on developing the ability to solve problems using genetic ideas and methods, to understand the nature and reliability of genetic inference, and to apply genetic reasoning to biological research. Weekly paper discussions based on original research papers that define or illustrate the ideas and techniques covered in the lecture.

GENE 207. Microfluidic Device Laboratory. 3-4 Units.

This course exposes students to the design, fabrication, and testing of microfluidic devices for biological applications through combination of lectures and hands-on lab sessions. In teams of two, students will produce a working prototype devices designed to address specific design challenges within the biological community using photolithography, soft lithography, and imaging techniques. Same as: BIOE 301D

GENE 208. Gut Microbiota in Health and Disease. 3 Units.

Preference to graduate students. Focus is on the human gut microbiota. Students will receive instruction on computational approaches to analyze microbiome data and must complete a related project. Same as: BIOE 221G, MI 221

GENE 210. Genomics and Personalized Medicine. 3 Units.

Principles of genetics underlying associations between genetic variants and disease susceptibility and drug response. Topics include: genetic and environmental risk factors for complex genetic disorders; design and interpretation of genome-wide association studies; pharmacogenetics; full genome sequencing for disease gene discovery; population structure and genetic ancestry; use of personal genetic information in clinical medicine; ethical, legal, and social issues with personal genetic testing. Hands-on workshop making use of personal or publicly available genetic data. Prerequisite: GENE 202, Gene 205 or BIOS 200. Same as: DBIO 220

GENE 211. Genomics. 3 Units.

The goal of this course is to explore different genomic approaches and technologies, to learn how they work from a molecular biology view point, and to understand how they can be applied to understanding biological systems. In addition, we teach material on how the data generated from these approaches can be analyzed, from an algorithmic perspective. The papers that are discussed are a mixture of algorithmic papers, and technological papers. Finally, the course has a strong programming component, with Python being the language that we teach. All of our problem sets require Python programming - while beginning programmers succeed in our course, it is a steep learning curve, and the problem sets can require a significant time investment. Basic Python knowledge is required.

GENE 212. Introduction to Biomedical Informatics Research Methodology. 3-5 Units.

Capstone Biomedical Informatics (BMI) experience. Hands-on software building. Student teams conceive, design, specify, implement, evaluate, and report on a software project in the domain of biomedicine. Creating written proposals, peer review, providing status reports, and preparing final reports. Issues related to research reproducibility. Guest lectures from professional biomedical informatics systems builders on issues related to the process of project management. Software engineering basics. Because the team projects start in the first week of class, attendance that week is strongly recommended. Prerequisites: BIOMEDIN 210 or 214 or 215 or 217 or 260. Preference to BMI graduate students. Consent of instructor required. Same as: BIOE 212, BIOMEDIN 212, CS 272

GENE 214. Representations and Algorithms for Computational Molecular Biology. 3-4 Units.

Topics: introduction to bioinformatics and computational biology, algorithms for alignment of biological sequences and structures, computing with strings, phylogenetic tree construction, hidden Markov models, basic structural computations on proteins, protein structure prediction, protein threading techniques, homology modeling, molecular dynamics and energy minimization, statistical analysis of 3D biological data, integration of data sources, knowledge representation and controlled terminologies for molecular biology, microarray analysis, machine learning (clustering and classification), and natural language text processing. Prerequisite: CS 106B; recommended: CS161; consent of instructor for 3 units. Same as: BIOE 214, BIOMEDIN 214, CS 274

GENE 215. Frontiers in Biological Research. 1 Unit.

Students analyze cutting edge science, develop a logical framework for evaluating evidence and models, and enhance their ability to design original research through exposure to experimental tools and strategies. The class runs in parallel with the Frontiers in Biological Research seminar series. Students and faculty meet on the Tuesday preceding each seminar to discuss a landmark paper in the speaker's field of research. Following the Wednesday seminar, students meet briefly with the speaker for a free-range discussion which can include insights into the speakers' paths into science and how they pick scientific problems. Same as: BIOC 215, DBIO 215

GENE 216. Practical Considerations and Industry Perspective on Academic-Industry Collaborations. 1 Unit.

Provides an overview, fundamentals and practical considerations for different aspects of academic-industry collaborations by inviting current industrial experts to share their views and to answer questions. The different aspects include collaboration models, proposal building, IP right sharing, funding opportunities, sabbatical and internship in industry, industry job searching, etc. This class also serves as a platform to connect with Bay Area biotech and pharmaceutical executives and experts.

GENE 217. Translational Bioinformatics. 3-4 Units.

Computational methods for the translation of biomedical data into diagnostic, prognostic, and therapeutic applications in medicine. Topics: multi-scale omics data generation and analysis, utility and limitations of public biomedical resources, machine learning and data mining, issues and opportunities in drug discovery, and mobile/digital health solutions. Case studies and course project. Prerequisites: programming ability at the level of CS 106A and familiarity with biology and statistics. Same as: BIOE 217, BIOMEDIN 217, CS 275

GENE 218. Computational Analysis of Biological Information: Introduction to Python for Biologists. 2 Units.

Computational tools for processing, interpretation, communication, and archiving of biological information. Emphasis is on sequence and digital microscopy/image analysis. Intended for biological and clinical trainees without substantial programming experience. Same as: MI 218, PATH 218

GENE 219. Current Issues in Genetics. 1 Unit.

Current Issues in Genetics is an in-house seminar series that meets each Academic Quarter for one hour per week (Friday, 4:00-5:00) and features talks by Genetics Department faculty, students, and postdoctoral fellows (with occasional visiting speakers from other Stanford departments). Thus, over the Academic Year, it provides a comprehensive overview of the work going on in the Department. Student attendance at the seminars will be required, with short written assignments (typically three per Quarter) to encourage thinking about the material presented in the talks.

GENE 221. Current Issues in Aging. 2 Units.

Current research literature on genetic mechanisms of aging in animals and human beings. Topics include: mitochondria mutations, insulin-like signaling, sirtuins, aging in flies and worms, stem cells, human progeria, and centenarian studies. Prerequisite: GENE 203, 205 or BIOS 200.

GENE 222. Cloud Computing for Biology and Healthcare. 3 Units.

Big Data is radically transforming healthcare. To provide real-time personalized healthcare, we need hardware and software solutions that can efficiently store and process large-scale biomedical datasets. In this class, students will learn the concepts of cloud computing and parallel systems' architecture. This class prepares students to understand how to design parallel programs for computationally intensive medical applications and how to run these applications on computing frameworks such as Cloud Computing and High Performance Computing (HPC) systems. Prerequisites: familiarity with programming in Python and R. Same as: BIOMEDIN 222, CS 273C

GENE 223. Aging: Science and Technology for Longevity. 2-3 Units.

Is aging another disease that can be ultimately cured? We will look at the biology of aging, transitioning from the molecular level through to the cellular and systems level. What are age-related diseases, can lifespan be extended and are centenarians different? Additionally how can artificial intelligence create robotic and software assistants as we get older and is living forever possible in any form? Topics will include: molecular theories of aging, impact of oxidative stress, age-related diseases, artificial intelligence for longevity, and innovations to improve the quality of life as we age.

GENE 224. Principles of Pharmacogenomics. 3 Units.

This course is an introduction to pharmacogenomics, including the relevant pharmacology, genomics, experimental methods (sequencing, expression, genotyping), data analysis methods and bioinformatics. The course reviews key gene classes (e.g., cytochromes, transporters) and key drugs (e.g., warfarin, clopidogrel, statins, cancer drugs) in the field. Resources for pharmacogenomics (e.g., PharmGKB, Drugbank, NCBI resources) are reviewed, as well as issues implementing pharmacogenomics testing in the clinical setting. Reading of key papers, including student presentations of this work; problem sets; final project selected with approval of instructor. Prerequisites: two of BIO 41, 42, 43, 44X, 44Y or consent of instructor. Same as: BIOMEDIN 224

GENE 230. Genetic Epidemiology. 3 Units.

This course presents fundamental concepts and methods in genetic epidemiology, with examples on genetic studies of chronic diseases, including cancer, cardiovascular disease, metabolic conditions, and autoimmune diseases. It will provide an overview of various study designs, including family studies, and it covers fundamental analyses, inferences, and their strengths and limitations. It will include topics such as assessing genetic influences on disease; advances in genomics technology; family based study designs for linkage, exome sequencing and case-parent trios; candidate gene and genome-wide association studies of both common and rare genetic variants; gene-environment interactions, epistasis and non-Mendelian genetics; software and web-based data resources; ethical issues in genetic epidemiology; and applications of genetic epidemiology to clinical practice and public health. Guest speakers will discuss these concepts through the lens of various chronic diseases. Prerequisite: introductory biostatistics or epidemiology, biology, and genetics. Biostatistics (intro) or epidemiology (intro), biology, genetics (intro). Same as: EPI 224

GENE 232. Advanced Imaging Lab in Biophysics. 4 Units.

Laboratory and lectures. Advanced microscopy and imaging, emphasizing hands-on experience with state-of-the-art techniques. Students construct and operate working apparatus. Topics include microscope optics, Koehler illumination, contrast-generating mechanisms (bright/dark field, fluorescence, phase contrast, differential interference contrast), and resolution limits. Laboratory topics vary by year, but include single-molecule fluorescence, fluorescence resonance energy transfer, confocal microscopy, two-photon microscopy, microendoscopy, and optical trapping. Limited enrollment. Recommended: basic physics, basic cell biology, and consent of instructor. Same as: APPPHYS 232, BIO 132, BIO 232, BIOPHYS 232

GENE 235. C. Elegans Genetics. 2 Units.

Genetic approaches to *C. elegans*, practice in designing experiments and demonstrations of its growth and anatomy. Probable topics include: growth and genetics, genome map and sequence, mutant screens that start with a desired phenotype, reverse genetics and RNAi screens, genetic duplications, uses of null phenotype non-null alleles, genetic interactions and pathway analysis, and embryogenesis and cell lineage. Focus of action, mosaic analysis, and interface with embryological and evolutionary approaches.

GENE 236. Deep Learning in Genomics and Biomedicine. 3 Units.

Recent breakthroughs in high-throughput genomic and biomedical data are transforming biological sciences into "big data" disciplines. In parallel, progress in deep neural networks are revolutionizing fields such as image recognition, natural language processing and, more broadly, AI. This course explores the exciting intersection between these two advances. The course will start with an introduction to deep learning and overview the relevant background in genomics and high-throughput biotechnology, focusing on the available data and their relevance. It will then cover the ongoing developments in deep learning (supervised, unsupervised and generative models) with the focus on the applications of these methods to biomedical data, which are beginning to produce dramatic results. In addition to predictive modeling, the course emphasizes how to visualize and extract interpretable, biological insights from such models. Recent papers from the literature will be presented and discussed. Students will be introduced to and work with popular deep learning software frameworks. Students will work in groups on a final class project using real world datasets. Prerequisites: College calculus, linear algebra, basic probability and statistics such as CS 109, and basic machine learning such as CS 229. No prior knowledge of genomics is necessary. Same as: BIODS 237, BIOMEDIN 273B, CS 273B

GENE 242. Genetics of Viral Emergence and Emerging Viruses. 2 Units.

This course will cover genetic and complementary approaches toward understanding and mitigating the emergence of new viral epidemics. Topics are: nI. Viral Emergence ('Viral life in prebiotic soup', 'emergence in cellular contexts', 'viruses from viruses', 'viruses and their non-viral cousins'), nII. Emergent Virology ('tracking the virome', 'genomics of recent viral pandemics', and 'the spectrum of viral malevolence'), and nIII. The Virome Interface ('environmental influences on viral epidemics', 'viruses, genes, and human behavior', 'big data in the service of controlling epidemics', and 'genetic approaches to viral treatment').

GENE 247. Genomic approaches to the study of human disease. 3 Units.

This course will cover a range of genetic and genomic approaches to studying human phenotypic variation and disease. We will discuss the genetic basis of Mendelian and complex diseases, as well as clinical applications including prenatal testing, and pediatric and cancer diagnostics. The course will include lectures as well as critical reading and discussion of the primary literature. Prerequisite: BIO 82 or equivalent. Open to advanced undergraduate students. Same as: BIO 247

GENE 260. Supervised Study. 1-18 Unit.

Genetics graduate student lab research from first quarter to filing of candidacy. Prerequisite: consent of instructor.

GENE 267. Molecular Mechanisms of Neurodegenerative Disease. 4 Units.

The epidemic of neurodegenerative disorders such as Alzheimer's and Parkinson's disease occasioned by an aging human population. Genetic, molecular, and cellular mechanisms. Clinical aspects through case presentations. This class is open to both graduate and undergraduate students, but requires sufficient backgrounds in college level genetics, cell biology and biochemistry. Undergraduates who are interested are required to contact the course director first. Same as: BIO 267, NENS 267

GENE 268. Biology and Applications of CRISPR/Cas9: Genome Editing and Epigenome Modifications. 1 Unit.

This course is designed to provide a broad overview of the biology and applications of the revolutionary CRISPR/Cas9 system, with detailed exploration of several areas: / / –Basic biology of the CRISPR/Cas9 system / –High-throughput screening using CRISPR/Cas9 / –Epigenetic modifications and transcriptional regulation using dCas9 / –Therapeutic applications of gene editing with CRISPR / –Disease modeling with CRISPR / –Ethical considerations of the use of CRISPR/Cas9 / / The course will be geared toward advanced undergraduates and graduate students, and will assume a basic background in molecular biology and genetics. The course will be lecture-based, with frequent opportunities for discussion and questions.

Same as: BIOS 268

GENE 271. Human Molecular Genetics. 3 Units.

For genetic counseling students, graduate students in genetics, medical students, residents, and postdoctoral fellows interested in the practice of medical genetics and genomics. Gene structure and function; the impact of mutation and polymorphism as they relate to developmental pathways and human disease; mitochondrial genetics; approaches to the study of complex genetic conditions; GWAS and genome sequencing technologies; variant interpretation; gene therapy, stem cell biology, and pharmacogenetics. Undergraduates require consent of instructor and a basic genetics course. Non-GC students: Please contact the instructor when you enroll.

Same as: CHPR 271

GENE 272. Introduction to Medical Genetics. 2-3 Units.

For genetic counseling students, graduate students in human genetics, medical students, residents, and fellows; undergraduates with consent of instructor. Principles of medical genetics practice, including taking a family history, modes of inheritance and risk assessment, and mathematical principles of medical genetics (Bayes theorem, population genetics). An additional problem set is required for 3 units.

Same as: CHPR 272

GENE 273. Introduction to Clinical Genetics Testing. 2 Units.

For genetic counseling students, medical students, residents, and fellows. Uses a combination of case based assignments, laboratory observation and didactic lectures to introduce techniques and technology used in cytogenetics, molecular genetics and biochemical genetic testing, and to introduce clinical features of common genetic conditions that are commonly diagnosed through genetic testing. Non-GC students: Please contact the instructor when you enroll.

GENE 274A. A Case Based Approach to Clinical Genetics. 2 Units.

For genetic counseling students and medical genetics residents and fellows. Case-based scenarios and guest expert lectures. Students learn skills in case preparation, management, and presentation, as well as content around common genetic disorders.

Same as: CHPR 274A

GENE 274B. A Case Based Approach to Clinical Genetics. 2 Units.

For genetic counseling students and medical genetics residents and fellows. Case-based scenarios and guest expert lectures. Students learn skills in case preparation, management, and presentation, as well as content around common genetic disorders. This course is a continuation of GENE 274A, but may be taken individually with instructor permission.

Same as: CHPR 274B

GENE 275. Role Play and Genetic Counseling Observations. 2 Units.

For genetic counseling students only. Students role play aspects of genetic counseling sessions and learn through clinical observations and personal reflection. Observation includes genetic counseling sessions in prenatal, pediatric, and specialty settings.

GENE 276. Genetic Counseling Fieldwork. 1-7 Unit.

For genetic counseling students only. Supervised clinical experiences. May be repeated for credit. Prerequisite: GENE 275.

GENE 278. Prenatal Genetic Counseling. 1 Unit.

Online course for genetic counseling students, graduate students in genetics, medical students, residents, fellows, and nurses interested in prenatal genetics. Genetic counseling students should take this course in conjunction with their initial prenatal genetics rotation. Topics include: prenatal screening and diagnostic testing, ultrasound, genetic carrier screening, teratology, fetal treatment and intervention, perinatal loss, termination, and infertility. Non-GC students: Please contact the instructor when you enroll.

Same as: CHPR 278

GENE 279. Pediatric and Adult Genetic Counseling. 1 Unit.

Internet based course for genetic counseling students, graduate students in genetics, medical students, residents, and fellows; genetic counseling students should take this course in conjunction with their initial general genetics rotation. Topics include: clinical reasoning in medical genetics, techniques to prepare for the medical genetics visit, assessment of child development and medical history in the context of a genetic workup, dysmorphology, development of a differential diagnosis, and resources for case management and family support. Non-GC students: Please contact the instructor when you enroll.

Same as: CHPR 279

GENE 280. Metabolic Genetic Counseling. 1 Unit.

Internet based course for genetic counseling students, graduate students in genetics, medical students, residents, and fellows. Genetic counseling students should take this course in conjunction with their metabolic genetics rotation. Topics include: overview of metabolic diseases; common pathways; diagnosis, management, and treatment of metabolic disorders; and newborn screening. Non-GC students: Please contact the instructor when you enroll.

Same as: CHPR 280

GENE 281. Cancer Genetic Counseling. 1 Unit.

Internet based course for genetic counseling students, graduate students in genetics, medical students, residents, and fellows; genetic counseling students should take this course in conjunction with their initial cancer genetics rotation. Topics include: cancer biology and cytogenetics; diagnosis and management of common cancer genetic syndromes; predictive testing; psychology of cancer genetic counseling; and topics recommended by ASCO guidelines. Non-GC students: Please contact the instructor when you enroll.

Same as: CHPR 281

GENE 282A. Genetic Counseling Research Seminar. 1 Unit.

For genetic counseling students only. Facilitated discussions on identifying a topic and mentor for genetic counseling departmental research projects.

GENE 282B. Genetic Counseling Research Seminar. 1 Unit.

For genetic counseling students only. Lectures and facilitated discussions on research methodology for genetic counseling departmental research projects. Prerequisite: GENE 282A.

GENE 283. Genetic Counseling Research. 1-8 Unit.

Genetic counseling students conduct clinical research projects as required by the department for graduation. May be repeated for credit. Pre- or corequisite: GENE 282.

GENE 284. Medical Genetics Seminar. 1 Unit.

Presentation of clinical and research topics in human genetics, followed by case presentations from the medical genetics and biochemical genetics services. Course may be completed online or in-person. Non-GC students: Please contact the instructor when you enroll.

Same as: CHPR 284

GENE 285A. Genetic Counseling Seminar. 3 Units.

Year-long seminar primarily for genetic counseling students. Fall: An introduction to genetic counseling principles, techniques, and professional development.

GENE 285B. Genetics Counseling Seminar. 3 Units.

Year-long seminar primarily for genetic counseling students. Winter: The impact of chronic illness and genetic disease across the lifespan.

GENE 285C. Genetic Counseling Seminar. 3 Units.

Year-long seminar primarily for genetic counseling students. Spring: The application of counseling theories, models, and therapy to the practice of genetic counseling.

GENE 286. Advanced Genetic Counseling Seminar. 2 Units.

For genetic counseling students only. This course will enhance students' advanced counseling skills through formal case presentations, observations of community resources, and a variety of presentations on professional issues. Must be taken for 3 quarters. Prerequisites: GENE 285 A,B,C and 276.

GENE 287. CARDIOVASCULAR GENETICS. 1 Unit.

Online course for genetic counseling students, graduate students in genetics, medical students, residents, fellows, and nurses interested in inherited cardiovascular conditions. Genetic counseling students should take this course in conjunction with their cardiovascular genetics rotation. Topics include: Basic cardiology principles, including relevant anatomy and physiology; diagnosis, management and genetic testing as it relates to common inherited cardiovascular conditions in both the pediatric and adult setting; predictive genetic testing issues specific to inherited cardiovascular conditions; psychological issues related to sudden death conditions. Non-GC students: Please contact the instructor when you enroll.

Same as: CHPR 287

GENE 288. Neurogenetics. 1 Unit.

Internet-based course for genetic counseling students, graduate students in genetics, medical students, residents, and fellow; genetic counseling students should take this course in conjunction with their neurogenetics rotation. Topics include: introduction to neurology for beginners, including an overview of neurologic exam and localization, to provide non-neurologist trainees a foundation for understanding the differential diagnosis process in neurology; common and exemplary neurogenetics disorders spanning the adult and pediatric neurologic sub-specialties; key genetic concepts such as triple repeat disorders and FSHD; ethical and psychological topics as well as gene-targets therapeutics. Medical students and graduate students outside of genetic counseling should obtain permission from instructor prior to enrollment. No prerequisite for genetic counseling students, genetics or neurology residents/fellows or post-docs. Non-GC students: Please contact the instructor when you enroll.

GENE 289. Variant Interpretation. 1 Unit.

Internet-based course for genetic counseling students, graduate students in genetics or bioscience, medical students, residents, and fellows. Genetic counseling students should take this course in conjunction with their variant interpretation rotation. Topics include a review of the types of genetic variants, HGVS nomenclature and standards, and technical aspects of variant calling, filtering, and prioritization. Attendees will become familiar with the types of evidence to support or refute pathogenicity and the standards in doing so, and will develop skills to critically assess the literature and existing databases for variant classification. Non GC-students: Please contact the instructor once you enroll.

GENE 299. Directed Reading in Genetics. 1-18 Unit.

Prerequisite: consent of instructor.

GENE 346. Advanced Seminar in Microbial Molecular Biology. 1 Unit.

Enrollment limited to PhD students associated with departmental research groups in genetics or molecular biology.
Same as: BIO 346, CSB 346

GENE 399. Graduate Research. 1-18 Unit.

Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

GENE 801. TGR Project. 0 Units.

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GENE 802. TGR Dissertation. 0 Units.

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