

Vision Science

The Graduate Program in Vision Science leads to a PhD degree. The program is administered by the Group in Vision Science, representing cross-disciplinary faculty from the School of Optometry and the Departments of Psychology, Computer Science, Molecular and Cell Biology, Neuroscience, and Bioengineering, among others. The faculty is distinguished in their accomplishments and diverse in their areas of expertise. Research facilities available to graduate students in vision science are among the best in the world.

The Graduate Program in Vision Science provides training in a wide variety of topics pertaining to vision. These include the optics of the eye, molecular and cell biology of the eye, anatomy and neurophysiology of the retina and visual pathways, computational vision, clinical aspects of vision, and more. The graduate program is designed to prepare students for academic careers in research and teaching in vision science, optometry, ophthalmology, bioengineering, psychology, biology, and other related disciplines. It also prepares students for research careers in industrial settings in related areas.

Admission to the University

Uniform minimum requirements for admission

The following minimum requirements apply to all programs and will be verified by the Graduate Division:

1. A bachelor's degree or recognized equivalent from an accredited institution;
2. A minimum grade-point average of B or better (3.0);
3. If the applicant comes from a country or political entity (e.g. Quebec) where English is not the official language, adequate proficiency in English to do graduate work, as evidenced by a TOEFL score of at least 570 on the paper-and-pencil test, 230 on the computer-based test, 90 on the iBT test, or an IELTS Band score of at least 7 (note that individual programs may set higher levels for any of these); and
4. Enough undergraduate training to do graduate work in the given field.

Applicants who already hold a graduate degree

The Graduate Council views academic degrees as evidence of broad research training, not as vocational training certificates; therefore, applicants who already have academic graduate degrees should be able to take up new subject matter on a serious level without undertaking a graduate program, unless the fields are completely dissimilar.

Programs may consider students for an additional academic master's or professional master's degree if the additional degree is in a distinctly different field.

Applicants admitted to a doctoral program that requires a master's degree to be earned at Berkeley as a prerequisite (even though the applicant already has a master's degree from another institution in the same or a closely allied field of study) will be permitted to undertake the second master's degree, despite the overlap in field.

The Graduate Division will admit students for a second doctoral degree only if they meet the following guidelines:

1. Applicants with doctoral degrees may be admitted for an additional doctoral degree only if that degree program is in a general area of knowledge distinctly different from the field in which they earned their original degree. For example, a physics PhD could be admitted to a doctoral degree program in music or history; however, a student with a doctoral degree in mathematics would not be permitted to add a PhD in statistics.
2. Applicants who hold the PhD degree may be admitted to a professional doctorate or professional master's degree program if there is no duplication of training involved.

Applicants may only apply to one single degree program or one concurrent degree program per admission cycle.

Any applicant who was previously registered at Berkeley as a graduate student, no matter how briefly, must apply for readmission, not admission, even if the new application is to a different program.

Required documents for admissions applications

1. **Transcripts:** Upload unofficial transcripts with the application for the departmental initial review. Official transcripts of all college-level work will be required **if admitted**. Official transcripts must be in sealed envelopes as issued by the school(s) you have attended. Request a current transcript from every post-secondary school that you have attended, including community colleges, summer sessions, and extension programs. If you have attended Berkeley, upload unofficial transcript with the application for the departmental initial review. Official transcript with evidence of degree conferral **will not** be required if admitted.
2. **Letters of recommendation:** Applicants can request online letters of recommendation through the online application system. Hard copies of recommendation letters must be sent directly to the program, not the Graduate Division.
3. **Evidence of English language proficiency:** All applicants from countries in which the official language is not English are required to submit official evidence of English language proficiency. This requirement applies to applicants from Bangladesh, Burma, Nepal, India, Pakistan, Latin America, the Middle East, the People's Republic of China, Taiwan, Japan, Korea, Southeast Asia, and most European countries. However, applicants who, at the time of application, have already completed at least one year of full-time academic course work with grades of B or better at a U.S. university may submit an official transcript from the U.S. university to fulfill this requirement. The following courses will not fulfill this requirement: 1) courses in English as a Second Language, 2) courses conducted in a language other than English, 3) courses that will be completed after the application is submitted, and 4) courses of a non-academic nature. If applicants have previously been denied admission to Berkeley on the basis of their English language proficiency, they must submit new test scores that meet the current minimum from one of the standardized tests.

Curriculum

Courses Required

VIS SCI 201A Seminar in Vision Science

VIS SCI 299	Research in Vision Science (two required lab rotations)	1-12
Select five of the following Proseminars:		10
VIS SCI 212A	Optics and Dioptrics of the Eye	
VIS SCI 212B	Visual Neurophysiology and Development	
VIS SCI 212D	Anatomy and Vegetative Physiology of the Eye	
VIS SCI 212E	Color Vision and Visual Sensitivity	
VIS SCI 212F	Spatial and Binocular Vision, Eye Movements, and Motion Perception	
VIS SCI 212G	Molecular Genetics of Vertebrate Eye Development and Diseases	
VIS SCI 298	Group Studies, Seminars, or Group Research (sect 1) (year 1-2)	1-6
VIS SCI 298	Group Studies, Seminars, or Group Research (sect 3) (year 1-2)	1-6
VIS SCI 230	Ethics in Scientific Research	2
VIS SCI 300	Teaching Methods in Vision Science	1
Electives per approved individualized study list		

Vision Science

VIS SCI 201A Seminar in Vision Science 2 Units
Graduate seminar in vision science.

Rules & Requirements

Prerequisites: Consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of seminar per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 201B Seminar in Vision Science 2 Units
Graduate seminar in vision science.

Rules & Requirements

Prerequisites: Consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of seminar per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 203A Geometric Optics 4 Units

Geometrical methods applied to the optics of lenses, mirrors, and prisms. Thin lens eye models, magnification, astigmatism, prism properties of lenses, thick lenses.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 2 hours of laboratory per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Formerly known as: 101

VIS SCI 203B Optical System and Physical Optics 4 Units

Principles of optical systems, principles and clinical applications of apertures and stops, aberrations and optical instruments. Optics of the eye. Selected topics in physical optics, diffraction, interference, polarization.

Rules & Requirements

Prerequisites: 203A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 2 hours of laboratory per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Formerly known as: 102

VIS SCI 205 Visual Perception Sensitivity 4.5 Units

Psychophysical basis for clinical tests in acuity, perimetry, and color vision. The visual stimulus and photometry. Visual receptors. Psychophysical method and visual threshold. Light sensitivity. Contrast sensitivity. Light and dark adaptation. Temporal and spatial properties of visual function. Color vision and abnormalities. Changes with age and disease. Visual illusion. Basis for advanced diagnostic procedures.

Hours & Format

Fall and/or spring: 15 weeks - 3.5 hours of lecture and 2 hours of laboratory per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Formerly known as: 104

VIS SCI 206A Anatomy and Physiology of the Eye 2 Units

This course focuses on the anatomy and physiology of the eyeball.

Overview of the gross anatomy of the eye followed by eye-relevant cellular and molecular biology. Cellular and molecular details of structure and function of each of the various non-neural components.

Hours & Format

Fall and/or spring: 7.5 weeks - 4 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Instructors: Gong, Fleiszig

VIS SCI 206B Anatomy and Physiology of the Eye and Visual System 3 Units

Structure and function of the tissues of the eye, ocular appendages, and the central visual pathways. Basic concepts of physiological, neurological, embryological, and immunological processes as they relate to the eye and vision. Foster an appreciation of the pathophysiology of various disease processes. Convey the importance of anatomy and physiology in the medical approach to ocular disease processes.

Rules & Requirements

Prerequisites: VIS SCI 206A

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2.5 hours of lecture and 0.5 hours of laboratory per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 206C Anatomy and Physiology of the Eye and Visual System 2 Units

Problem-based learning approach using clinical case examples. Continuation of 206A-206B.

Rules & Requirements

Prerequisites: 206A-206B

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 7.5 weeks - 4 hours of seminar per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Formerly known as: 106C

VIS SCI 206D Neuroanatomy and Neurophysiology of the Eye and Visual System 2 Units

Structure and function of the neurosensory retina, photoreceptors, RPE including blood supply. Current concepts of etiology and management of major retinal conditions. Overview of diagnostic techniques in retinal imaging, electrophysiologic testing and new genetic approaches. Structure and function of the early visual pathway including retinal ganglion cells, optic nerves, lateral geniculate nucleus and visual cortex. Pupillary responses. Specialization in the visual cortex.

Rules & Requirements

Prerequisites: 206A (must be taken concurrently)

Hours & Format

Fall and/or spring: 7.5 weeks - 4 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Instructors: Flannery, Freeman

Formerly known as: half of 206A

VIS SCI 212A Optics and Dioptrics of the Eye 2 Units

Introduction for graduate students to basic principles of classic and modern geometric optics (thick lens systems, mirrors, prisms, apertures, and stops) and physical optics (interference, diffraction, and polarization) with emphasis on dioptrics of the human eye (including schematic eyes, aberrations, and entoptic phenomena).

Rules & Requirements

Prerequisites: Consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 212B Visual Neurophysiology and Development 2 Units
Introduction for graduate students. Visual pathways will be considered from retina to lateral geniculate to visual cortex. Basic organization at each stage will be covered. Primary focus will be studies of receptive field characteristics and associated visual function. Development and plasticity of the same visual pathways will also be covered. Evidence and implications will be explored from controlled rearing procedures and studies of abnormal visual exposure.

Rules & Requirements

Prerequisites: Consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 212D Anatomy and Vegetative Physiology of the Eye 2 Units
Introduction for graduate students to a general survey of the orbit, anterior and posterior segment of the eye, extraocular muscles, and neuroanatomy of the eye. Vegetative physiology of the cornea and tear film, aqueous humor, crystalline lens, vitreous humor, epithelial tissue (iris, ciliary body and retina), and photochemistry.

Rules & Requirements

Prerequisites: Consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 212E Color Vision and Visual Sensitivity 2 Units
Introduction for graduate students to sensory aspects of light and color vision including: psychophysical methods, spectral response of the eye, mechanisms of sensitivity control, dark adaptation, color discrimination, mechanisms of normal and defective color vision.

Rules & Requirements

Prerequisites: Consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 212F Spatial and Binocular Vision, Eye Movements, and Motion Perception 2 Units

Introduction for graduate students to human spatial vision including contrast sensitivity, visual acuity, and spatial localization. Introduction to eye movements, motion perception, and motor and sensory aspects of binocular vision including pursuit, vergence, and saccadic eye movements, accommodation, stereopsis, and binocular space perception. Perception of real and apparent motion.

Rules & Requirements

Prerequisites: Consent of instructor

Hours & Format

Fall and/or spring: 6 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Instructors: Banks, Malik, Schor

VIS SCI 212G Molecular Genetics of Vertebrate Eye Development and Diseases 2 Units

The primary focus of this course is to teach the molecular basis of vertebrate eye development and related disease. This course will cover some of the basic principles of molecular and cell biology, commonly used techniques and experimental approaches, as well as the biological mechanisms for vertebrate eye development and related eye diseases. Recent progress in identifying important ocular genes and the approaches used to identify them will be discussed.

Rules & Requirements

Prerequisites: Graduate student in vision science or consent of instructor in charge

Hours & Format

Fall and/or spring: 5 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Instructor: Gong

VIS SCI 215 Visual System Development 2 Units

Development of the eye and visual system. Normal development of the eye, retina, and central visual pathways. Effects of visual deprivation. Assessment of optical and visual function in human infants. Refraction and refractive error in infants and children. Development of visuomotor function, spatial vision, color vision, binocular vision, and depth perception.

Rules & Requirements

Prerequisites: 206B

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Formerly known as: 115

VIS SCI 217 Oculomotor Functions and Neurology 2 Units

Neuro-anatomical pathways for the control of eye position and movement; gaze holding, image stabilization and tracking eye movement systems; oculomotor signs of disorders of the central nervous system (palsies, nystagmus, oculomoplegia, cog-wheel pursuits, saccadic dysmetria); the near visual-motor response and the synergistic coupling of accommodation and convergence; binocular misalignment (heterophoria and fixation disparity); and presbyopia.

Rules & Requirements

Prerequisites: 203B or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 1.5 hours of lecture and 10 hours of laboratory per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Formerly known as: 117

VIS SCI 219 Binocular Vision and Space Perception 2 Units

Perception of space, direction, and distance. Binocular retinal correspondence, horopters, differential magnification effects and anomalies of binocular vision development. Sensory vision, local stereopsis, static and dynamic stereopsis, binocular depth cues.

Rules & Requirements

Prerequisites: 203A-203B

Hours & Format

Fall and/or spring: 15 weeks - 1.5 hours of lecture and 10 hours of laboratory per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Formerly known as: 118

VIS SCI 230 Ethics in Scientific Research 2 Units

This seminar will examine a range of ethical issues that arise in the process of doing science. Beginning with the philosophical and social foundations, we will consider the pathogenesis of fraud, statistics and deception, the ethics of authorship and publication, research with human subjects, the use of animals, the definition(s) of misconduct and the difference between misconduct and questionable research practices, the relationship between industry and science, and finally, the responsibilities and obligations of the scientist in society.

Hours & Format

Fall and/or spring: 15 weeks - 30 hours of seminar per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 262 Visual Cognitive Neuroscience 3 Units

The course will provide an overview of visual cognitive neuroscience, drawing from neuroanatomy, neurophysiology in humans and animal models, psychophysics, neuroimaging, neuropharmacology, neuropsychology, and computational models of vision and cognition. Topics will include basic anatomy and physiology of the mammalian visual system, motion perception and processing, depth perception and representation of visual space, brightness and color, object and face recognition, visual attention, developmental and adult plasticity, perceptual learning, multisensory integration, and visual awareness.

Rules & Requirements

Prerequisites: Consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Instructor: Silver

VIS SCI 265 Neural Computation 3 Units

This course provides an introduction to the theory of neural computation. The goal is to familiarize students with the major theoretical frameworks and models used in neuroscience and psychology, and to provide hands-on experience in using these models. Topics include neural network models, supervised and unsupervised learning rules, associative memory models, probabilistic/graphical models, and models of neural coding in the brain.

Rules & Requirements

Prerequisites: Calculus, differential equations, basic probability and statistics, linear algebra, and familiarity with high level programming languages such as Matlab

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Instructor: Olshausen

VIS SCI C265 Neural Computation 3 Units

This course provides an introduction to the theory of neural computation. The goal is to familiarize students with the major theoretical frameworks and models used in neuroscience and psychology, and to provide hands-on experience in using these models. Topics include neural network models, supervised and unsupervised learning rules, associative memory models, probabilistic/graphical models, and models of neural coding in the brain.

Rules & Requirements

Prerequisites: Calculus, differential equations, basic probability and statistics, linear algebra, and familiarity with high level programming languages such as Matlab

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Instructor: Olshausen

Also listed as: NEUROSC C265

VIS SCI C280 Computer Vision 3 Units

Paradigms for computational vision. Relation to human visual perception. Mathematical techniques for representing and reasoning, with curves, surfaces and volumes. Illumination and reflectance models. Color perception. Image segmentation and aggregation. Methods for bottom-up three dimensional shape recovery: Line drawing analysis, stereo, shading, motion, texture. Use of object models for prediction and recognition.

Rules & Requirements

Prerequisites: Knowledge of linear algebra and calculus. Mathematics 1A-1B, 53, 54 or equivalent

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

Instructor: Malik

Also listed as: COMPSCI C280

VIS SCI 298 Group Studies, Seminars, or Group Research 1 - 6 Units
Group studies of selected topics. Advanced studies in various subjects through special seminars on topics to be selected each year, informal groups studying special problems, group participation in experimental problems and analysis.

Hours & Format

Fall and/or spring: 15 weeks - 4 hours of lecture per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 299 Research in Vision Science 1 - 12 Units
Research.

Rules & Requirements

Prerequisites: Consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Summer:

6 weeks - 1-16 hours of independent study per week

8 weeks - 1-12 hours of independent study per week

Additional Details

Subject/Course Level: Vision Science/Graduate

Grading: Letter grade.

VIS SCI 300 Teaching Methods in Vision Science 1 Unit
Instruction in teaching methods and materials, in vision science and optometry; practice teaching in classrooms and laboratory.

Rules & Requirements

Prerequisites: Graduate standing in vision science

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of lecture per week

Additional Details

Subject/Course Level: Vision Science/Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

Instructor: Silver

VIS SCI 601 Individual Study for Master's Students 1 - 6 Units
Individual study for the comprehensive requirements in consultation with the adviser in vision science.

Rules & Requirements

Prerequisites: Consent of instructor

Credit Restrictions: Course does not satisfy unit or residence requirements for master's degree.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Additional Details

Subject/Course Level: Vision Science/Graduate examination preparation

Grading: Offered for satisfactory/unsatisfactory grade only.

VIS SCI 602 Individual Study for Doctoral Students 1 - 6 Units
Individual study in consultation with the adviser in vision science, intended to provide an opportunity for qualified students to prepare themselves for the various examinations required for the Ph. D.

Rules & Requirements

Prerequisites: Consent of instructor

Credit Restrictions: Course does not satisfy unit or residence requirements.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Additional Details

Subject/Course Level: Vision Science/Graduate examination preparation

Grading: Offered for satisfactory/unsatisfactory grade only.