BOSTON COLLEGE

GRADUATE SCHOOL OF ARTS AND SCIENCES

BIOLOGY

FOCUS ON RESEARCH

Research lies at the heart of the biology experience at Boston College. The department offers a wide array of opportunities for scientific investigation within the areas of molecular cell biology and genetics, cell cycle, neurobiology, developmental biology, structural and cellular biochemistry, vector biology, infectious disease, and bioinformatics. Specific areas of research in the department include the following::

- Nuclear import pathways for Human Papillomavirus proteins
- Fission yeast cAMP signaling and high throughput screening for phosphodiesterase regulators
- Signaling and metabolic pathways controlling B lymphocyte survival and growth
- Structural analysis of amyloids and myelin sheaths
- Chromatin assembly and histone modifications in mammalian cells and fission yeast
- Translational regulation and signal transduction during meiosis and in early animal development
- Regulation of cytokinesis in animal cells
- Genetic and cell biological analysis of Notch-mediated signal transduction in Drosphila
- Computational approaches to comparative genomics, gene regulation, and molecular evolution
- Telomeres, telomerase and chromosome stability
- Secondary and tertiary structure prediction for proteins and RNA
- Genetics and cell biology of the apicomplexan parasite Toxoplasma gondii
- DNA sequence variation, genome data mining and informatics
- Dietary therapies for epilepsy, brain cancer and neurodegenerative lipid storage diseases
- Monocytes/macrophages, CD8 T lymphocytes and viral pathogenesis in the central nervous system

Research Facilities

Our department, in Higgins Hall, is well-equipped for modern molecular, genomic, and proteomic research, biochemistry, imaging, and bioinformatics.

Departmental genomics and proteomics infrastructure includes capacities for Beckman and LiCor DNA sequencing and DNA fragment polymorphism analysis, and Alpha-Innotech two-dimensional gel proteomic analysis. We possess state-of-the-art cell culture and protein purification systems, including the BioCad SPRINT perfusion chromatography system, HPLC, FPLC, and preparative isoelectric focusing.

Our imaging facilities include a Leica confocal microscope, a Phillips transmission electron microscope, departmental and individual laboratory Zeiss and Nikon fluorescence and Nomarski compound microscopes, Molecular Dynamics phosphoimager and densitometer workstations, and x-ray diffraction capability. Our digital graphics and image processing facility includes numerous MacIntosh workstations with multiprocessor CPU configurations, coupled with high-resolution scanners. A large-format poster printer and dye sublimation printers support preparation of high-quality posters and print communications.

We have initiated development of a bioinformatics server platform, to which undergraduates, graduate students, and faculty have access, expanding departmental computing capabilities beyond our MacIntosh, IBM, Sun, and Silicon Graphics workstations. Our bioinformatics server, clavius.bc.edu, is currently comprised of a 20 CPU rack-mount computational cluster, with 1.2 terabytes of fiber-attached network storage. The server is heterogeneous, comprised of dual processor Intel Pentium III/Linux and dual processor Apple/Mac OS X nodes. Research computing time, available free of charge, affords substantial research and educational opportunities for students and faculty.

Programs of Study

The department offers a program of study leading to a Ph.D. degree in biology. Basic areas of study include biochemistry, cellular and developmental biology, genetics, cell cycle, vector biology, and neurobiology.

The Ph.D. degree provides an in-depth training experience. Core course work is provided in cell biology, biochemistry, molecular biology, genetics, and bioinformatics. Advanced electives are available in all areas of faculty expertise. Seminar courses provide students with ongoing training in critical thinking and oral presentation of scientific data. Research experience is provided by working in close cooperation with faculty members, postdoctoral fellows, and senior students in a collaborative, supportive environment.

The Coursework

Core Courses

BI 611 Advanced Genetics.

This course is designed for graduate students who have successfully completed an undergraduate genetics course. Topics include the principles of DNA replication and repair, transmission genetics, microbial genetics, transposition, epistasis and complementation, and gene mapping.

BI 612 Graduate Biochemistry.

This course is designed for graduate students who have successfully completed an undergraduate biochemistry course. The course concentrates on the biochemistry of biologically significant macromolecules and macromolecular assemblies. Topics include the elements of protein structure and folding, principles of protein purification and analysis, enzymology, nucleic acid biochemistry, and the structure and function of biological membranes.

BI 614 Graduate Molecular Biology.

This course concentrates on the biochemistry of biologically significant macromolecules and macromolecular assemblies. Topics include the elements of protein structure and folding, principles of protein purification and analysis, enzymology, nucleic acid biochemistry, and the structure and function of biological membranes.

BI 615 Advanced Cell Biology.

Topics include the principles of cellular organization and function, regulation of the cell cycle, and interactions between cells and cellular signaling pathways.

BI 616 Graduate Bioinformatics.

The computer is rapidly becoming an indispensable research tool for the bench Biologist. Mega-scale projects such as genome sequencing, large-scale scale genotyping, expression microarray analysis, and imaging studies have filled public databases with information that is invaluable for the quest to understand Biological function in living organisms. Although some of these resources are available through web portals, it is impossible to realize the full potential of the vast amount of data without more sophisticated, more subtle, custom analyses.

The aim of this course is to develop computer-aided data analysis skills that open the door to Biological information only accessible with Bioinformatics methods. This will be a completely hands-on course where each student works on their own designated UNIX computer. The following will be covered: (1) Using the UNIX environment and its productivity tools e.g. executing programs form the command line, editing and manipulating text files; (2) Programming basics in the PERL computer language; (3) Bioinformatics-specific programming skills acquired via solving realistic and typical data manipulation and analysis problems; (4) Creation of automated data analysis pipelines to perform large-scale and repetitive data analysis tasks; and (5) Special topics such as the creation of management of user databases, and programmed access to web resources.

Electives

BI 506 Recombinant DNA Technology.

This course will describe the theory and practice of recombinant DNA technology, and its application within molecular biology research. Topics will include the cloning of genes from various organisms, plasmid construction, transcriptional and translational gene fusions, nucleic acid probes, site-directed mutagenesis, polymerase chain reaction, and transgenic animals. The goal of the course is to make the research-oriented student aware of the wealth of experimental approaches available through this technology.

BI 509 Vertebrate Cell Biology.

This is an advanced cell biology course focusing on the integration of gene activity, subcellular structure, extracellular signals, and specialized function in vertebrate cells. The course will involve an in-depth study of differentiated cell types, including erythrocytes, nerve and muscle cells, epithelia, and cells of the immune system. The molecular and genetic bases for diseases affecting these cell types will be discussed. The course will also include recent developments in the area of cell cycle control and the transformation of normal cells into cancerous cells.

BI 510 General Endocrinology.

Many tissues (e.g., the brain, heart, kidney) as well as the classical endocrine organs (e.g., adrenal, thyroid) secrete hormones. This course is concerned with normal and clinical aspects of hormone action. The effects of hormones (and neurohormones) on intermediary metabolism, somatic and skeletal growth, neural development and behavior, development of the gonads and sexual identity, mineral regulation and water balance, and mechanisms of hormone action will be considered.

BI 517 Parasitology.

This course is an introduction into the biology and biochemistry of parasites, organisms that live at the expense of other organisms. Parasitology covers a wide range of organisms ranging from protozoa like malaria to roundworms, tapeworms, fleas and ticks. Parasites have an important impact on human health. The course will study the adaptations of parasites to their ecological niches in their infected hosts and the pathology resulting from parasitic infections.

BI 524 Computational Foundations of Bioinformatics.

Bioinformatics concerns an array of problems including proteomics (e.g., prediction of protein structure, function and evolution), metabolomics (e.g., inference of metabolic pathways from protein interaction experiments), functional genomics (e.g., inference of putative gene function from microarray data), transcriptomics (e.g., finding genes for transcribed, noncoding RNA involved in posttranscriptional modification events), etc. In this course, you will learn to design and implement computer programs in a scripting language in order to parse biological data, perform simulations, create web engines, and develop new algorithms in bioinformatics. Additionally you will learn fundamental concepts of probability and statistics as applied to bioinformatics.

BI 533 Cellular Transport and Disease.

The biology of intracellular traffic is in an exciting period of development. New techniques of molecular and cell biology are leading to discoveries of the transport signals and the major carriers. Topics covered in this course include: (1) transport of proteins and different classes of RNAs into and out of the nucleus, (2) transport of proteins into mitochondria and into ER, and (3) vesicular transport. Specific transport deficiencies causing diseases will be discussed. In addition, the course will describe how different viruses (HIV, papillomaviruses, adenoviruses, influenza virus) exploit the intracellular transport pathways of host cells during their life cycle.

BI 540 Immunobiology.

This course focuses on the regulation of immune responses at the molecular level. Topics include: regulation of B and T cell development, functions of B and T lymphocytes in the development of immune responses, generation of antibody and T cell receptor diversity, and antigen processing via MHC I and MHC II pathways. The course emphasizes modern experimental approaches, including the generation of transgenic mice, CRE-mediated conditional deletion, adoptive transfer strategies, and multiparameter FACS. Research literature is used extensively to cover current trends and advances in lymphocyte tolerance, T-regulatory cell function, Th1/th2 cells, immune therapy, TLRs, and innate immune responses.

BI 554 Physiology.

This is a study of the fundamental principles and physicochemical mechanisms underlying cellular and organismal function. Mammalian organ-systems will be studied, with an emphasis on neurophysiology, cardiovascular function, respiratory function, renal function, and gastro-intestinal function.

BI 556 Developmental Biology.

Developmental biology is in the midst of a far-reaching revolution that profoundly effects many related disciplines, including evolutionary biology, morphology, and genetics. The new tools and strategies of molecular biology have

begun to link genetics and embryology and to reveal an incredible picture of how cells, tissues, and organisms differentiate and develop. This course describes both organismal and molecular approaches which lead to a detailed understanding of (1) how it is that cells containing the same genetic complement can reproducibly develop into drastically different tissues and organs; and (2) the basis and role of pattern information in this process.

BI 561 Molecular Evolution.

The amount of available genomic sequence data has increased exponentially in the last decade, revolutionizing our ability to study evolution at the DNA level. This course will provide an introduction to the molecular evolution of genes and genomes, as well as related topics in population genetics. Topics will include genetic variation within and between species, methods for reconstructing the evolutionary history of sequences, and molecular signatures of natural selection. These will be explored through both mathematical and computational methods.

BI 570 Biology of the Nucleus.

This course provides an in-depth treatment of the molecular biology of DNA and RNA, with particular emphasis on the control and organization of the genetic material of eukaryotic organisms. Topics covered include chromatin structure and function, DNA replication, nucleosome assembly, introns, RNA processing, and gene regulation.

BI 572 Neuroscience I.

This course is the first in a two-course sequence that presents an advanced and comprehensive treatment of various topics in the broad field of neuroscience. The emphasis is on the mammalian (including human) brain and the course content is similar to that taught in medical schools. In addition to the text book, readings of current research articles will be assigned. Topics covered in the first semester include: historical foundations of neuroscience; neurocellular anatomy; neurophysiology, synaptic mechanisms, and neurotransmitter systems; neuroanatomy; developmental neurobiology; sensory systems.

BI 573 Neuroscience II.

A continuation of BI 572 Neuroscience I. Topics covered in the second semester include: motor systems; sleep, arousal, and attention; neuroendocrine systems and behavior; neurobiology of motivation and emotion; neurobiology of learning and memory; cognitive neuroscience; mental illness; neural mechanisms of drug addiction.

BI 581 Neuroscience.

This course presents selected topics in the broad field of neuroscience, focusing primarily on the mammalian nervous system. The course text (Neuroscience: Exploring the Brain by Bear, et al.) is designed for future neuroscience researchers and premedical students. Topics include historical foundations of neuroscience, synaptic and neurotransmitter systems, neurocellular anatomy, fundamentals of the nervous system organization, neural development, sensory and motor systems, motivation, and learning and memory. Readings from the text are supplemented with handouts related to current research articles.

Examples of 800 level graduate seminars offered over the past few years:

BI 819 Advanced Topics in Biochemistry

BI 834 Seminar in Translational Regulation

BI 835 Seminar in Structural Neurochemistry

BI 848 Seminar in Cellular Biology: Nuclear Import and Export Pathways

BI 864 Seminar in Developmental Biology

BI 865 Seminar: Cell Motility

BI 867 Current Topics in Chromosome-Microtubule Dynamics

BI 880 Responsible Conduct of Research and Professional Development

INFORMATION

Financial Aid

Graduate assistantships (teaching and research based) are available with full tuition remission. Entry-level stipends are $27,000 per calendar year.

Cost of Study

In 2009-10, the tuition and fees for a full-time student are $1,182 per credit, 100 percent of which is covered by tuition remission for students receiving financial aid.

Living and Housing Costs

The Housing Office provides an extensive list of off-campus housing options. Most graduate students rent rooms or apartments near Chestnut Hill; many biology students share apartments with other students in the program. Average monthly expenses (rent, food, utilities) are $1,420 for students.

Student Group

The enrollment at Boston College is 14,500, including 4,200 students enrolled in the various graduate schools. There are 44 Ph.D. students in the department. The graduate students are geographically and ethnically diverse.

Location

Boston College is located in the Chestnut Hill section of Newton, an attractive residential area about 6 miles from the heart of Boston, with easy access to the city by public transportation. The Boston area, with its numerous educational and biomedical research institutions, offers countless outstanding seminars, lectures, colloquia, and concerts throughout the year. A wide variety of cultural and recreational opportunities can be found close to the campus.

The College

Founded in Massachusetts in 1863, Boston College currently includes the Graduate School of Arts and Sciences and Graduate Schools of Law, Social Work, Management, Nursing, and Education. Its expanding campus is graced with many attractive Gothic buildings. Boston College has a strong tradition of academic excellence and service to the community.

Applying

Preference is given to completed applications received prior to January 2. This deadline is especially important for those seeking financial aid. Admission is granted on the basis of academic background and demonstrated aptitude in biology and related disciplines. A year of organic chemistry, physics, and mathematics and a solid background in biology are highly recommended for admission. Scores on the Graduate Record Examinations General Test are required for consideration. The Subject Test in biology is strongly recommended. For information on how to apply, please visit www.bc.edu/gsas.

THE FACULTY AND THEIR RESEARCH

ANTHONY T. ANNUNZIATO, PROFESSOR

Ph.D., University of Massachusetts, Amherst, 1979

Chromatin assembly and histone modifications in human cells and fission yeast. Benson, L.J., Gu, Y., Yakovleva, T., Tong, K., Barrows, C., Strack, C., Mizzen, C., Cook, R.A., and Annunziato, A.T. 2006. Modifications of H3 and H4 during Chromatin Replication, Nucleosome Assembly, and Histone Exchange. J. Biol. Chem. 281:9287-96. Biochemical and genetic analysis of histone modifying enzymes. Benson, L.J., Phillips, J.A., Gu, Y., Parthun, M.R., Hoffman, C.S., and Annunziato, A.T. 2007. Properties of the Type B Histone Acetyltransferase Hat1: H4 tail interaction, site preference, and involvement in DNA repair. J. Biol. Chem. 282: 836-42.

DAVID R. BURGESS, PROFESSOR

Ph.D., California, Davis, 1974

Spatial and temporal regulation of cytokinesis; role of the actin- and microtubule-based cytoskeletons in early development. Ng M F Chang, Burgess DR. 2005. Movement of Membrane Domains and Requirement of Membrane Signaling Molecules for Cytokinesis. Dev. Cell. 9: 1-10.

HUGH P. CAM, ASSISTANT PROFESSOR

Ph.D., Harvard, 2003

Epigenetic control of higher-order genome organization and chromatin structures. Cam, H. P., Noma, K., Ebina, H., Levin, H.L., Grewal, S.I.S. 2008. Host genome surveillance for retrotransposons by transposon-derived proteins. Nature 451, 431-6.

THOMAS C. CHILES, PROFESSOR AND CHAIRMAN OF BIOLOGY

Ph.D., Florida, 1988

Cell biology, signal transduction; cell-cycle control, gene regulation in mature B lymphocytes. Mataraza, J.M., J. Tumang, M.R Gumina, S.M. Gurdak, T.L. Rothstein, and T.C. Chiles. 2006. Disruption of cyclin D3 blocks proliferation of B-1a cells but loss of cyclin D3 is compensated by cyclin D2 in mutant animals. *J. Immunol*. 177:787-795.

The bioenergetics of B lymphocyte activation and survival: Doughty, C.A., B.F. Bleiman, D.J. Wagner, F.J. Dufort, J.M. Mataraza, M.F. Roberts, and T.C. Chiles. 2006. Antigen receptor-mediated changes in glucose metabolism in B lymphocytes: role of phosphatidylinositol 3-kinase signaling in the glycolytic control of growth. *Blood*. 107:4458-4465.

JEFFREY H. CHUANG, ASSISTANT PROFESSOR

Ph.D., Massachusetts Institute of Technology, 2001

Computational biology and bioinformatics; comparative genomics, gene regulation, molecular evolution. Imamura H, Persampieri JH, Chuang JH..2007. Sequences conserved by selection across mouse and human malaria species. BMC Genomics. 8:372-385.

PETER G. CLOTE, PROFESSOR

Ph.D., Duke, 1979

RNA secondary and tertiary structure prediction: folding, kinetics, pointwise mutations, partition function, 3-dimensional motif detection. Protein structure and function: disulfide bonds, machine learning, time warping, functional genomics. Boltzmann probability of RNA structural neighbors and riboswitch detection. , Eva Freyhult; Vincent Moulton; Peter Clote, Bioinformatics. 2007 Aug 15;23(16):2054-62. Epub 2007 Jun 14.

MARC-JAN GUBBELS, ASSISTANT PROFESSOR

Ph.D., Utrecht University, the Netherlands, 2000

Genetics and cell biology of the apicomplexan parasite Toxoplasma gondii. Gubbels, M.-J., C.F. Brooks, M. Muthalagi, T. Szatanek, J. Flynn, B. Parrot, B. Striepen and M.W. White . 2008. Forward Genetic Analysis of the Apicomplexan cell and division cycle in Toxoplasma gondii. PLoS Pathogens, 4(2): e36

LAURA E. HAKE, ASSOCIATE PROFESSOR

Ph.D., Tufts, 1992

Translational regulation and signal transduction during meiosis and in early animal development. Keady, B.T., Kuo, P., Martinez, S.E., Yuan, L. and Hake, L.E. (2007). MAPK interacts with XGef and is required for CPEB activation during meiosis in *Xenopus* oocytes. Journal of Cell Science, 120:1093-1103.

CHARLES HOFFMAN, PROFESSOR AND GRADUATE PROGRAM DIRECTOR

Ph.D., Tufts Sackler School, 1986

High throughput drug screening for cyclic nucleotide phosphodiesterase regulators; cAMP signaling in fission yeast. Ivey FD, Wang L, Demirbas D, Allain C, and Hoffman CS 2008. Development of a fission yeast-based high throughput screen to identify chemical regulators of cAMP phosphodiesterases. J Biomol Screen 13:62-71.

DANIEL KIRSCHNER, PROFESSOR

Ph.D., Harvard, 1972

Structural biochemistry of amyloids and myelin sheath; neurodegenerative diseases; peripheral demyelinating neuropathies. Kirschner DA, Gross AAR, Hidalgo M, Inouye H, Gleason K, Abdelsayed G, Castillo GM, Snow AD, Pozo-Ramajo A, Petty SA, Decatur (2008) Fiber diffraction as a screen for amyloid inhibitors. *Curr Alz Res* 5:288-307. Luo XY, Cerullo J, Dawli T, Priest C, Haddadin Z, Kim A, Inouye H, Suffoletto BP, Avila RL, Lees JPB, Sharma D, Xie B, Costello CE, Kirschner DA (2008) Peripheral myelin of *Xenopus laevis*: Role of electrostatic and hydrophobic interactions in membrane compaction. *J Structural Biol*, 162:170-183. (DOI: 10.1016/j.jsb.2007.10.012)

GABOR T. MARTH, ASSISTANT PROFESSOR

D.Sc., Washington (St. Louis), 1994

DNA sequence variation, genome data mining and informatics. Quinlan AR, Stewart DA, Strömberg MP, Marth GT. Pyrobayes: an improved base caller for SNP discovery in pyrosequences. Nature Methods. 2008;5:179-81.

Hillier LW, Marth GT, Quinlan AR, Dooling D, Fewell G, Barnett D, Fox P, Glasscock JI, Hickenbotham M, Huang W, Magrini VJ, Richt RJ, Sander SN, Stewart DA, Stromberg M, Tsung EF, Wylie T, Schedl T, Wilson RK, Mardis ER. Whole-genome sequencing and variant discovery in C. elegans. Nat Methods. 2008;5:183-8.

JUNONA MOROIANU, ASSOCIATE PROFESSOR

Ph.D., Rockefeller, 1996

Nuclear import pathways for human papillomavirus (HPV) proteins and genomic DNA.

Bordeaux, J., Forte, S., Darshan, M.S., Harding, E., Klucevsek, K., and Moroianu, J. (2006) The L2 minor capsid protein of low risk human papillomavirus type 11 interacts with host nuclear import receptors and viral DNA. Journal of Virology 80(16): 8259-8262.

MARC A. T. MUSKAVITCH, PROFESSOR AND DELUCA CHAIR

Ph.D., Stanford, 1981

Subcellular trafficking and ubiquitylation in developmental signaling and host-pathogen interactions. Parks. A.L., Stout, J.R., Shepard, S.B., Klueg, K.M., Dos Santos, A.A., Parody, T.R., Vaskova, M., and Muskavitch, M.A.T. 2006. Structure-function analysis of Delta trafficking, receptor binding, and signaling in Drosophila. Genetics. 174:1947-1961.

THOMAS N. SEYFRIED, PROFESSOR

Ph.D., Illinois, 1976

Dietary therapies for epilepsy, brain cancer, and neurodegenerative lipid storage diseases. Zhou, Z., Mukherjee, P., Kiebish, M.A.,Markis, W.T.,Mantis, J.G., and Seyfried, T.N. 2007. The calorically restricted ketogenic diet, an effective alternative therapy for malignant brain cancer. Nutrition & Metabolism 2007, 4:5 doi:10.1186/1743-7075-4-5.

KENNETH C. WILLIAMS, ASSOCIATE PROFESSOR

Ph.D., McGill University, 1993

Kenneth Williams studies monocytes/macrophages, CD8 T lymphocytes and viral pathogenesis in the central nervous system. Williams K, Westmoreland S, Greco J, Ratai E, Lentz M, Kim W-K, Fuller R, Kim JP, Autissier P, Sehgal PK, Schinazi R, Bischofberger N, Piatak M, Lifson J, Masliah E, González RG. Magnetic resonance spectroscopy reveals a role of activated blood monocytes contributing to neuronal injury in simian immunodeficiency neuroAIDS J Clin Invest, Published online August 18, 2005. J. Clin. Invest. 2005, 115: 2534-2545. Kim WK, Alvarez X, Fisher J, Bronfin B, Westmoreland S, McLaurin J, Williams K. CD163 identifies perivascular macrophages in normal and viral encephalitic brains and potential precursors to perivascular macrophages in blood. Am. J. Pathol. 2005, 168: 822-834.

Faculty No Longer Accepting Graduate Students:

KATHLEEN DUNN, ASSOCIATE PROFESSOR AND ASSOCIATE CHAIR

Ph.D., North Carolina at Chapel Hill, 1982

Sociology of Science: science policy and career development; female scientists at midcareer; institutional and personal factors associated with research activity. Previously: plant molecular biology; cloning and characterization of genes induced during alfalfa nodulaltion. Zucchero, JC, Caspi, M and Dunn, K. 2001. *ngl* 9: a third MADS box gene expressed in alfalfa root nodules. Mol. Plant-Microbe Interact. 14:1463-7

CLARE M. O'CONNOR, ASSOCIATE PROFESSOR

Ph.D., Purdue, 1977

O'Connor CM. 2006. Protein L-isoaspartyl/D-aspartyl O-methyltransferases: Catalysts for Protein Repair. In Protein Methyltransferases, Vol. 24, The Enzymes (Eds. F. Tamanoi, S. G. Clarke), pp. 383-431.

WILLIAM H. PETRI, ASSOCIATE PROFESSOR

Ph.D. Berkeley, 1972

Molecular, developmental, and genetic aspects of development in Drosophila. Jin J, Petri WH. 1993. Localization of developmental enhancers in the 26A vitelline membrane gene of Drosophila. Dev. Biol. 156:557-64.

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