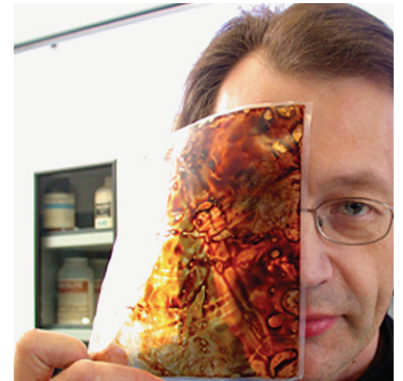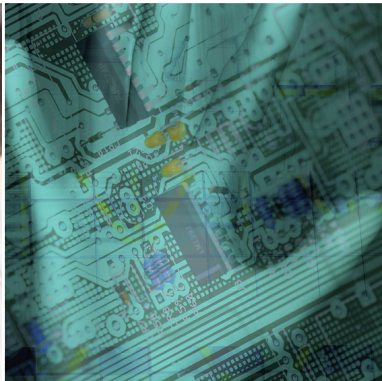# 05/06 CATALOG

OGI SCHOOL OF SCIENCE & ENGINEERING

OHSU

OHSU
OREGON
HEALTH
& SCIENCE
UNIVERSITY

www.ogi.edu/catalog

OGI School of
Science & Engineering

A LETTER FROM THE DEAN

It's about the connections between a healthy environment and a healthy population. It's about computers that think like people do, and are reliable enough to assist in diagnosis and treatment of disease. It's about helping our seniors live longer, more satisfying lives. It's about cultivating business leaders who can guide Oregon's high-technology companies — many of which are focusing their efforts on the biomedical industry — through today's changing markets. At the OGI School of Science & Engineering, it's all about building healthier, better-informed and more secure communities in Oregon and beyond. Virtually everything we do — be it graduate education, research, industrial collaboration, or community outreach — is aimed at solving important human and environmental health problems, and at putting these solutions into the hands of those that need them most.

Are you interested in expanding your science and engineering knowledge in these problem areas? Are you interested in a degree at the cutting-edge of your discipline? As one of four professional schools of Oregon Health & Science University (OHSU), OGI welcomes high-caliber students who are interested in taking advantage of our unique position as the only School of Science & Engineering in the world that is part of an academic health center. At OGI, students have unparalleled opportunities to apply advanced science, computational, and engineering methodologies to the protection of human and environmental health. This electronic catalog is designed to tell you everything you need to

know about the kind of impact you can make by pursuing a graduate degree at OHSU's OGI School of Science & Engineering.

As you scroll through the catalog, you may be surprised at the wide range of programs offered at such a small school. Since OGI's inception more than 40 years ago, the school's small size has been one of its key strengths. We offer an enviable faculty/student ratio of 1/1.8 for Ph.D. students. Despite our size, OGI awards a significant percentage of Oregon's graduate degrees in high-technology fields, and our highly productive faculty generates approximately $12 million in research support each year from government and industrial sources. OGI is small enough to remain responsive to changing needs in the fields we serve, yet large enough to foster collaborative, interdisciplinary research across a broad — yet synergistic — range of human and environmental health issues.

Education at OGI is the formal responsibility of four academic departments: Biomedical Engineering, Computer Science & Electrical Engineering, Environmental & Biomolecular Systems, and Management in Science & Technology. These four departments offer six accredited Masters degrees, including: Biochemistry and Molecular Biology (BMB), Biomedical Engineering (BME), Computer Science and Engineering (CSE), Electrical Engineering (EE), Environmental Science and Engineering (ESE), and Management in Science and Technology (MST). Students can earn accredited doctoral degrees in BMB, BME, CSE, EE, and ESE. Finally, OGI also offers graduate-level certificates in Management in Science and Technology, and Health Care Management.

We are proud of our diverse population of full- and part-time students, who learn in a context where fundamental knowledge is joined with opportunities for clinical and field practice. OGI is committed to following discoveries from concept all the way through to fruition, leveraging the commercial

potential of our technologies wherever possible to serve a wide cross-section of the public.

At OGI, it's all about making a difference. I've tried to give you an idea of how we make a difference in protecting health and well-being in our region and beyond. Now, I invite you to read for yourself how OGI can make a difference to you.

Ed Thompson, Ph.D.
OHSU Vice President and Dean
OGI School of Science & Engineering

WELCOME

HISTORICAL BACKGROUND

The OGI School traces its origins to the early 1960s, when Mark Hatfield, then Oregon's governor, and an advisory committee of industrial and educational leaders recommended creating an independent institution for graduate education and research in the Portland area. In 1963 they established the Oregon Graduate Center for Study and Research. In 1989, the center was renamed the Oregon Graduate Institute of Science and Technology.

Over the next decade, OGI awarded more than 1,000 graduate degrees, offered hundreds of continuing education classes and workshops, and pursued more than $100 million in research, most of it federally funded. Now in its fifth year as a school of Oregon Health & Science University (OHSU), OGI continues as a premier provider of high-quality graduate science and engineering education, with more than 300 students working full- or part-time toward master's or Ph.D. degrees, and more than $12 million in research annually.

OHSU is a health and research university dedicated to graduate education, research and health care. The university educates some 2,500 students each year and in 2003 brought in more than $221 million in research dollars - a figure that is expected to grow by 15 to 20 percent annually. About 1,500 scientists are working on basic and applied research projects throughout OHSU. Its merger with OGI has broadened the mission of the institution to encompass new research frontiers where technology and engineering converge with health care and biomedicine.

The OGI School of Science & Engineering remains committed to its historical purpose: to educate students and conduct high-quality research in science and engineering and to serve as a resource for Oregon's high-technology industry. The merger both strengthens OGI's traditional research-based programs and enables the school to expand in new directions. In 2002, with a $4 million grant from the M.J. Murdock Charitable Trust, the school established a Department of Biomedical Engineering. The merger also

ACADEMIC CALENDAR 2005 | 2006

FALL QUARTER 2005

August 8	Registration begins for Fall Quarter
September 19-23	New student orientation week
September 25*	Last day to register without late fees
September 26	Fall Quarter instruction begins
October 3	Student account balances due
October 7*	Last day to drop a class for 100% refund
October 21*	Last day to drop a class for 50% refund or add a class
November 14	Registration begins for Winter Quarter
November 24-25	Thanksgiving holiday (no classes, OGI offices closed)
December 5-9	Final exams
December 26	Christmas holiday (OGI offices closed)

WINTER QUARTER 2006

November 14	Registration begins for Winter Quarter
January 2	New Year's holiday (OGI offices closed)
January 8*	Last day to register without late fees
January 9	Winter Quarter Instruction Begins
January 16	Martin Luther King Jr.'s Birthday (no classes, OGI offices closed)
January 17	Student account balances due
January 20*	Last day to drop a class for 100% refund
February 3*	Last day to drop a class for 50% refund or add a class
February 13	Registration begins for Spring Quarter
February 20	President's Day (no classes, OGI offices closed)
March 21-24	Final exams (Monday, March 14th will be a regular class day to account for two Monday holidays earlier this quarter)

SPRING QUARTER 2006

February 13	Registration begins for Spring Quarter
April 2*	Last day to register without late fees
April 3	Spring Quarter instruction begins
April 10	Student account balances due
April 14*	Last day to drop a class for 100% refund
April 28*	Last day to drop a class for 50% refund or add a class
May 8	Registration begins for Summer Quarter
May 29	Memorial Day holiday (no classes, OGI offices closed)
June 2	Commencement
June 12-16	Final exams

SUMMER QUARTER 2006

May 8	Registration begins for Summer Quarter
June 25*	Last day to register without late fees
June 26	Summer Quarter instruction begins
July 3	Student account balances due
July 4	Independence Day holiday (no classes, OGI offices closed)
July 7*	Last day to drop a class for 100% refund
July 21*	Last day to drop a class for 50% refund or add a class
September 4	Labor Day holiday (no classes, OGI offices closed)
September 5-8	Final exams

*MST Weekend and Online courses have unique late registration and add/drop deadlines. Please refer to www.ogi.edu/graduate_edu/registration/Information.cfm for detailed information.

facilitates cross-disciplinary collaboration at the interface of science, engineering, health and the environment.

OGI is part of OHSU's West Campus, which also includes the Vaccine and Gene Therapy Institute, the Neurological Sciences Institute and the Oregon National Primate Research Center. The West Campus is about 12 miles from OHSU's central campus on Portland's Marquam Hill.

MISSION

As part of Oregon's only comprehensive public academic health center, OGI shares with OHSU one fundamental purpose: *to improve the health and well-being of people in Oregon and beyond.*

Like the other schools of OHSU, OGI strives for excellence in education, research, and scholarship in a dynamic interdisciplinary environment that stimulates the spirit of inquiry, initiative, and cooperation among students, faculty, and staff. OGI accomplishes its mission by:

- Educating tomorrow's scientists, engineers, and managers in top-tier programs that prepare them for a lifetime of learning, leadership, and contribution;

- Exploring new basic and applied research frontiers in health and biomedical sciences, environmental and biomedical engineering, and information sciences; and

- Emphasizing the creation and implementation of new knowledge and cutting-edge technologies that, wherever possible, will be translated into applications in the health and commercial sectors.

Finally, as the only school of science and engineering in the world that is part of an academic health center, OGI is uniquely well positioned for and committed to *applying advanced scientific, engineering, and computational methodologies to complex problems of human and ecosystem health.*

EQUAL OPPORTUNITY

Oregon Health & Science University and the OGI School of Science & Engineering are firmly committed to a policy of affirmative action and equal opportunity. This

encompasses all employment, education and patient service activities connected with OHSU. No patient, employee, student, trainee, beneficiary or potential beneficiary of the hospitals and clinics or the university shall be unlawfully discriminated against on the basis of race, color, sex, sexual orientation, religion, creed, national origin, age, marital status, disability, veteran status or another applicable basis in law.

ABOUT THIS CATALOG

This catalog is as accurate as possible as of September 1, 2005. Information contained in the catalog may be changed during the course of any academic year, including but not limited to changes in policies, fees, course offerings, course descriptions and program requirements. This document should not be construed as forming the basis of a contract.

Additional student and academic policies are listed in the OGI Student Handbook located at www.ogi.edu/students/studenthandbook.pdf.

OVERVIEW

ACADEMIC DEPARTMENTS

The OGI School of Science & Engineering has four academic departments: Biomedical Engineering (BME), Computer Science and Electrical Engineering (CSEE), Environmental and Biomolecular Systems (EBS) and Management in Science and Technology (MST).

Students benefit from cross-disciplinary research and education as faculty members take part in research projects outside their main department. This encourages the exchange of ideas across related research areas and provides the fullest use of the wide range of instrumentation available at the school.

DEGREE PROGRAMS

The OGI School of Science & Engineering offers M.S. and Ph.D. degrees in:

- Biochemistry and Molecular Biology
- Biomedical Engineering
- Computer Science and Engineering
- Electrical Engineering
- Environmental Science and Engineering
- Management in Science and Technology (M.S. degree only)

CERTIFICATE PROGRAMS

The following certificate programs are available:

Department of Management in Science & Technology

- Health Care Management
- Management in Science and Technology

STUDENTS NOT SEEKING DEGREES

Any qualified student may take courses at OGI, in a part-time capacity, without enrolling in a degree program. Up to 21 credits completed prior to matriculation (admission in a degree program), either taken at OGI or transferred from another institution, may be accepted toward degree requirements. To earn a degree from the OGI School, a student must first be formally admitted to a degree program.

ACCREDITATION

Oregon Health & Science University and the OGI School of Science & Engineering are accredited by the Commission on Colleges of the Northwest Association of Schools and Colleges, an institutional accrediting body recognized by the Council for Higher Education Accreditation and/or the U.S. Department of Education. The address is: Commission on Colleges, NWASC, 8060 165th Avenue NE, Suite 100, Redmond, WA 98052-3981.

ADMISSIONS

ADMISSIONS REQUIREMENTS

The following requirements apply to all Masters and Ph.D. programs at the OGI School, unless otherwise indicated. Individual academic programs may have specific requirements in addition to those shown below and can be found in the department sections of the catalog.

- To apply for any degree program at the OGI School, an applicant must have previously earned a four-year bachelor's degree, although a student may be provisionally admitted prior to that time. An international applicant with a three-year bachelor's degree from a foreign country should have his/her academic credentials evaluated by an external evaluation company in order to

determine equivalency to a four-year, U.S. bachelor's degree.

- The Graduate Record Examination (GRE) may be required. See Departmental sections for specific requirements.

- Official transcripts from each college or university currently and previously attended.

- Three original letters of recommendation. The letters should attest to the student's ability to succeed in a graduate program. Recommendation letters must be signed and preferably mailed directly from the author. If sent in by the student, the recommendation letter must be in a sealed envelope. For guidance, a recommendation form is available at www.ogi.edu/graduate_edu/forms/recommendation_letter.pdf.

ADDITIONAL REQUIREMENTS FOR INTERNATIONAL STUDENTS

To be considered for admission to the OGI School for a full course of study, international students must also provide documentation to show that they meet the following requirements:

- Evidence of adequate financial resources to pay for their OGI education and their cost of living.

- Written TOEFL scores for all applicants whose native language is not English, except for those who have earned a degree from a U.S. institution. The OGI School will accept either the paper-based test or the computer-based test. Required scores for individual programs are discussed in the department sections of this catalog. For more information on the TOEFL please visit www.toefl.org.

APPLICATION PROCEDURES

For degree programs, the following items must be submitted:

- Completed OGI School of Science & Engineering application form available online at http://www.ogi.edu/admissions/apply/. The application is valid for one year from date of submission.

- $ 65 nonrefundable application fee, which is valid for one year and cannot be waived or deferred.

- Official transcripts from each current and prior college or university attended. The transcripts must arrive in a sealed envelope and should be mailed directly to the Department of Graduate Education.

- Three letters of recommendation.

- Official GRE scores (if applicable, see Department sections). The institutional code for OGI is 4592.

- TOEFL scores (if applicable, see above).

For certificate programs, the following items must be submitted:

- Completed OGI certificate program application form available at http://www.ogi.edu/admissions/apply/.

- $ 25 nonrefundable application fee, which is valid for one year and cannot be waived or deferred.

Please send completed applications, transcripts and other application materials to:

Department of Graduate Education
OGI School of Science and Engineering
20000 N.W. Walker Road
Beaverton, Oregon 97006-8921
Phone: 503 748-1382
Toll-free: 800 685-2423
Fax: 503 748-1285
E-mail to: admissions@admin.ogi.edu

Due dates: Applications are considered on a year-round basis. It is highly recommended that domestic students submit their applications 10 weeks prior to the quarter in which they would like to begin, 15 weeks for international students. Priority is given in the admission and financial support processes to those applications received by March 1.

Start date: The academic year formally begins in September and students are encouraged to start the academic program at that time. However, mid-year admissions may be offered. Generally, Ph.D. students are admitted for Fall quarter and as full-time students.

STUDENT VISAS

Information on student visas and other immigration services can be found on the Web site for OHSU's Office of International Services, www.ogi.edu/admissions/immigration/.

TUITION AND FINANCES

TUITION AND FEES

For the 2005-2006 academic year, tuition and fees are as follows:

Non-degree students, Masters students and Ph.D. students:

Credits	Tuition & Fees
1	$625
2	$1250
3	$1875
4	$2500
5	$3139
6	$3766
7	$4393
8	$5020
9	$5690
10-12	$625/credit (Non-degree students) No additional charge for Masters and Ph.D. students.
13 +	$625/credit (Non-degree and Master's Students) No additional charge for Ph.D. students.

The above tuition and fee amounts include OHSU's activity, building, and incidental fees. These fees are mandatory and cannot be reduced for students who do not intend to use a specific resource or service.

- The International Student Fee is $30/quarter and applies to all F-1 or J-1 students.
- A lab fee of $300 per quarter applies to all MS students in the Environmental and Biomolecular Systems Department.

DEPOSITS

Upon acceptance as a master's student into the Biochemistry and Molecular Biology or Environmental Science and Engineering programs, applicants must pay a $100 deposit to reserve a place in the program. Deposits will be applied toward tuition and are nonrefundable.

HEALTH INSURANCE

Full-time, matriculated students are required to either enroll in OGI's student medical insurance or provide proof of other acceptable medical insurance coverage. The student is responsible for the full cost of OGI's insurance coverage and may purchase additional coverage for family members. Contact the Graduate Education Department for current premium rates. Part-time students are not eligible for OGI's student insurance.

FINANCIAL AID

Generally, entering full-time Ph.D. students are eligible for financial support through a combination of tuition scholarships, OGI scholarships, and graduate research assistantships. Offers of support are initiated by the individual academic departments. Part-time Ph.D. students may be eligible for some of the above. Partial tuition scholarships may be awarded by the school or individual academic departments to entering full-time master's students. No additional application is required.

Subsidized and Unsubsidized Federal Stafford Loans are available to eligible students who are formally admitted to a master's or Ph.D. program at the OGI School of Science & Engineering. Students must be enrolled for at least five credits each quarter and must be either U.S. citizens or eligible non-citizens. For application materials and additional information, contact the Financial Aid Office at OHSU at 503-494-7800 or 800-775-5460 or e-mail to: finaid@ohsu.edu. Information about financial aid may also be found on OHSU's Web site at www.ohsu.edu/finaid/.

The "Free Application for Student Aid" (FAFSA) forms may be found at www.fafsa.ed.gov/. Use Federal School Code 004883 when completing the FAFSA form.

REFUND POLICY

To receive a refund, a student must drop a course within the available timeframes listed below:

Quarter-long Courses: A 100% tuition refund will be given if a student drops a quarter-long course by the end of the second week of the quarter. Dropping before the end of the fourth week of the quarter will result in a 50% refund. No refunds will be provided for dropping a course after the fourth week of the quarter.

MST Compressed Weekend Courses: A 100% refund will be given if an MST weekend course is dropped by the Friday following the first weekend of class. Dropping by the Friday following the second weekend of class will result in a 50% refund. After that, there is no refund for dropping a compressed weekend course.

Online Courses: Dropping an online course by the end of the second week following the beginning of the course will result in a 100% refund. There is no 50% refund timeframe for online courses. No refund will be issued for dropping an online course after two weeks.

ACCESS AND DISABILITIES SERVICES

OHSU/OGI believes that a diverse student body enhances the educational opportunities for all students and is beneficial to the graduate experience at large. If you are a student with a documented disability or you think you might experience a disability and believe you will need accommodations while at OHSU/OGI, we encourage you to contact the Director of the Office for Student Access. The Office for Student Access provides accommodations, information, support, advice and resources institution-wide. The Office for Student Access works in conjunction with the Program Accommodation Liaison (PAL) designated from each individual school to ensure equal access to all the programs and services offered by that individual school.

Graduate programs are extremely rigorous and fast-paced. Accommodations that may have worked in your undergraduate program may no longer be effective in this environment. For further assistance or information, please contact the Director of the Office for Student Access at 503-494-0082 or the OGI PAL in the Graduate Education office at 503-748-1581. All information regarding a student's disability is kept in accordance with relevant state and federal laws.

COURSE NUMBERS

Courses listed as 5xx/6xx are applicable to both a master's program as well as a doctoral program. Master's, certificate and non-degree students should register for the 5xx class and doctoral students should register for the 6xx class when available.

5xx Graduate courses offered primarily in support of master's programs. May be used towards a doctoral program as appropriate.

6xx Graduate courses offered primarily in support of doctoral programs. May be used towards a master's program as appropriate.

The following standard course numbers may be included in each program's course offerings. Refer to the individual program for further details.

501/601	Master's Non-Thesis Research/PhD Pre-qualifying Research
502/602	Independent Study
503/603	Master's Thesis Research/PhD Dissertation Research
504/604	Internship
505/605	Reading and Conference
506/606	Special Topics Courses
507/607	Seminar
508/608	Workshop
509/609	Practicum

400-LEVEL COURSES

Occasionally, OGI will offer a 400-level course for personal or academic development. Courses designated by a 400-series number are not considered graduate level courses and will not satisfy any degree requirements. These courses will appear on the transcript.

ACADEMIC POLICIES

The following is a list of selected OGI School of Science & Engineering academic policies. A more comprehensive listing can be found in the OGI School Student Handbook at www.ogi.edu/students/studenthandbook.pdf.

AUDITING A COURSE

OGI courses are offered for graded graduate credit hours or ungraded audit units. Students may register to audit a course on a space available basis. Students taking a course for credit have priority over students auditing a course. Audits are recorded on the student's transcript at the discretion of the instructor, based upon a reasonable expectation of attendance and minimal participation determined by the instructor. Audits are charged at the standard tuition rate. Audit units do not count toward a student's fulltime status. Instructors have final discretion over allowing audits of their classes and defining their academic expectations. Management in Science and Technology (MST) courses may not be audited.

Any request to change credit/audit status must be submitted in writing to the Graduate Education Office. Requests received during the first six weeks of the quarter do not need the instructor's approval. Students may change status after the first six weeks and before the final exam (or last class meeting for classes without exams) by submitting a request that includes the instructor's written permission. Status cannot be changed after the final exam (or last class meeting for classes without exams).

CODE OF CONDUCT

OHSU's Code of Conduct guides the behavior and performance of all members of the Oregon Health & Science University community. As members of that community, all OGI students, matriculated and non-matriculated, must comply with the Code of Conduct and all other OHSU policies. It is incumbent on the student to be familiar with the Code of Conduct and to abide by the guidelines and expectations therein. An electronic version of the Code of Conduct is available at http://www.ohsu.edu/cc/codeofco.pdf. Hard copies of the document are available from the OGI Department of Graduate Education, Paul Clayton Building, phone 503-748-1382, email: grad_ed@admin.ogi.edu. Questions about the OHSU Code of Conduct can be directed to the OHSU Integrity Office at 503-494-8849.

CONFIDENTIALITY OF STUDENT RECORDS

With the passage of the Federal Family Educational Rights and Privacy Act (FERPA) of 1974, Oregon Health & Science University adopted rules to govern the collection, use and disclosure of student records with the goal of ensuring their privacy. Students have the right to inspect their educational records that are maintained by OGI/OHSU, the right to a hearing to challenge the contents of those records when they allege the records contain misleading or inaccurate information, and the right to give their written consent before their records are released to any person, agency or organization other than OGI/OHSU officials and certain authorized federal and state authorities.

Directory Information. OGI/OHSU can release certain public domain information, known as directory information, unless a student has filed a written request in the OHSU Registrar's Office to restrict his/her directory information.

Each student has the right to designate directory information as not being subject to release without his or her consent, except as otherwise permitted by law. OHSU's Registrar's Office shall provide to each student a form entitled "Request to Restrict Directory Information" to be used by the student to designate that directory information may not be released without the student's consent. If the student does not submit the completed form by the date indicated, OHSU may release directory information pertaining to that student. This form, including the list of OHSU's designated directory information items, is available at http://www.ohsu.edu/registrar/reqtorestricdirinfo.pdf.

CONTINUOUS ENROLLMENT

Unless on approved leave of absence, a Ph.D. or master's student who has begun work on his/her thesis/dissertation must register and pay for at least one research credit per quarter, in addition to any other registered course credits, in order to maintain matriculated status. A student is considered to have begun work on his or her thesis/dissertation when he or she first registers for 503 - Master's Thesis Research (for master's students) or 603 - Ph.D. Dissertation Research (for Ph.D. students). Continuous enrollment is not required of master's students not pursuing a thesis, or of master's or Ph.D. students who have not initially registered for 503 or 603 research (as appropriate). If a Ph.D. or master's thesis student graduates (including EPC approval) before the last day to register in a term, continuous enrollment for that term is not required.

CREDIT LOAD PER QUARTER

Twelve credits per quarter are considered a normal course load for full-time, degree-seeking students, although nine or more is considered full time status. Academic departments may require students to carry more than nine credits per quarter as a condition of eligibility for a stipend and/or tuition scholarship. A student may not register for more than 12 credits in a quarter without his or her academic department's approval. Audit credits do not count towards full-time status. Students registering for fewer than 9 credit hours are considered part time and are not eligible for student benefits, such as health insurance.

DROPPING A COURSE

To drop a course a student must officially modify his/her registration by either dropping the course online or by contacting the Department of Graduate Education in writing. *Notifying the instructor of the intention to drop or withdraw from a course is not sufficient and may result in a failing grade and full responsibility for the tuition.* Refunds and transcripts are based on the date the registration is officially modified, not the date of last attendance. Courses dropped during the designated refund period (see Refund Policy under Tuition and Fees) will not appear on the transcript. Courses dropped outside of the refund period will be listed on the transcript as a withdrawal.

Students may withdraw from OGI courses at any time before the final exam or the last class meeting for classes without final exams.

GRADING/SATISFACTORY ACADEMIC PROGRESS

Most OGI School courses are graded with a letter grade. Research work may be graded with either a Pass/No Pass or letter grade as determined by each academic program.

Transfer credits and Pass/No Pass grades are not counted in students' Grade Point Averages (GPAs). The GPA is a weighted average of all eligible credits and grade value points.

The following value point scale is employed at the OGI of Science & Engineering:

A = 4.00   B = 3.00   C = 2.00
A- = 3.67   B- = 2.67   C- = 1.67
B+= 3.33   C+ = 2.33   F = 0.00

The grading system is defined as:

A = Excellent
B = Satisfactory
C = Below graduate standard
F = Failure

The following marks are also used:

AU = Audit, no credit
P   = Satisfactory completion
NP = No credit, unsatisfactory
I   = Incomplete
PI = Permanent Incomplete
W = Withdrawn (after the add/drop period)
X   = No basis for grade

Matriculated students must maintain a cumulative GPA of 3.0. Failure to do so will result in academic probation, and if the GPA is not improved, may lead to dismissal. A minimum cumulative GPA of 3.0 is required to graduate.

Incompletes. An Incomplete must be completed by the end of the quarter following the quarter in which the Incomplete was awarded. In cases where the Incomplete is not completed, the instructor has the choice of assigning a grade or converting the Incomplete into a Permanent Incomplete. The grade may be an "F" but instructors have the option of assigning another grade if they feel quality and quantity of work accomplished warrants it. If a student

wants an extension of this one quarter deadline, the student may petition the Educational Policy Committee (EPC) showing the instructor's support of the extension (a separate letter, e-mail or signature on the petition will suffice). The petition should be specific, include a date by which the grade will be assigned and submitted to the Graduate Education Department in writing.

LEAVE OF ABSENCE

Approved Leave: A student matriculated in a degree program and in good academic standing may apply for a leave of absence from school. A leave of absence must be approved by the student's academic department and documented with the Graduate Education Department. Approved leave status is granted for a specific period of time and an extension to the leave must be re-approved. While on leave of absence a student may not use university resources, such as the library, computing facilities, advisor or department services. The time a student spends on approved leave will not be included in the time limits to complete a degree.

Unapproved Leave: Students failing to notify OGI of their leave will be placed on inactive status following 4 consecutive quarters of not completing a class. At that point matriculated students will be notified of their status and asked to clarify their intentions regarding the completion of their degrees. If a student has not enrolled in classes or requested an approved leave within four additional quarters that student will be administratively withdrawn from the program. Once withdrawn, if the student wishes to resume his/her work towards a degree, he/she must reapply to the program, submitting a new application and paying a new application fee. Reapplication will be subject to the admissions requirements in place at that time and department review and acceptance in accordance with the department's current admissions practices. If readmitted, the student will be subject to the degree requirements in effect at time of re-matriculation. The time a matriculated student spends on unapproved leave will

be included in the time limits to complete a degree.

Important Note: Students must be aware that other requirements, regulations or restrictions (such as but not limited to: visa status, department scholarships, financial aid and health insurance eligibility) may impose different enrollment requirements than those allowed under OGI's Leave of Absence policy. It is the student's responsibility to register for the appropriate number of credits that may be required in accordance with their particular situation.

MATRICULATED VS. NON-MATRICULATED

A matriculated student is formally admitted and enrolled in a degree program. A non-matriculated student has not applied and been admitted to a degree program. In order to receive a degree from the OGI School of Science & Engineering, a student must be matriculated into a degree program. Students are encouraged to matriculate prior to completing 21 credits since no more than 21 credits taken as a non-matriculated student will be applied towards degree requirements (see Pre- Matriculation Credits Applied Towards a Degree policy below).

ON-SITE (RESIDENCY) PH.D. REQUIREMENTS

The OGI School has a two-year on-site residency requirement for Ph.D. programs. Full-time Ph.D. students usually meet this requirement by an on-site dissertation project under the advisement of an OGI faculty member. Part-time Ph.D. students can satisfy the first year of the on-site requirement by attendance in classes on the OGI campus. Because part-time Ph.D. students, by definition, are not on campus full time, the student's academic department will determine residency requirements for the second year.

In exceptional circumstances (e.g., dissertation topics requiring access to special facilities only available elsewhere), other arrangements may be proposed to the student's academic department for written approval. There is no on-site program requirement for M.S. or certificate programs at OGI.

PRE-MATRICULATION CREDITS APPLIED TOWARD A DEGREE

A maximum of 21 credits earned before acceptance to a degree program at OGI may be applied toward degree requirements. This maximum may include a combination of up to 12 transfer credits (18 from Portland State University, University of Oregon and Oregon State University) and credits taken at OGI. Individual departmental regulations may be more restrictive. The academic program determines which pre-matriculation credits will be accepted towards degree requirements. Exceptions to the 21 credit maximum are the sole discretion of the academic program.

REGISTRATION

Anyone may register for classes at OGI, regardless of their admissions status into a degree program. Each quarter, a class schedule is published listing the courses being offered with their dates, times and locations. To access a current class schedule online, visit www.ogi.edu/schedule/. All students attending a class must be registered for that class.

A student will not earn a grade or credits for the class if he or she is not registered for that class. A student may register for classes online at http://www.ogi.edu/graduate_edu/registration/. Online registration is available seven days a week during established registration times. Alternatively, if a student prefers to register in person, he or she may do so at the OGI Graduate Education Department.

TIME LIMITS TO COMPLETE A DEGREE

A master's degree must be completed within seven years from the quarter of matriculation. A Ph.D. degree must be completed within five years from the time the student passes the Ph.D. qualifying exam. Petitions for extensions to the time limit must first be approved by the department and then submitted to the Educational Policy Committee for final approval.

TRANSCRIPTS

A student's official transcript is a formal, written record of all courses, grades and degrees earned while at OGI/OHSU. Requests for transcripts must be in writing with a signature, submitted either by fax, mail or in person to the OHSU Registrar's office. Official transcripts are on special paper and have the official OHSU seal. Official transcripts cost $8 per copy when ordered 48 hours in advance. For quicker service or a faxed official transcript the fee is $10. A request form for an official transcript can be found at www.ohsu.edu/registrar/transcriptreq.pdf.

TRANSFER CREDITS

The OGI School of Science & Engineering accepts transfer credits from accredited institutions that have not, or will not, be applied toward another degree. Up to 12 credits may be transferred to OGI (18 from Portland State University, University of Oregon and Oregon State University). Credits transferred to OGI must typically come from courses completed before matriculation at OGI. The specific credits, if any, which will be accepted as transfer credits into OGI and applied toward degree requirements, are determined solely by the academic department. Only courses with a B (3.0) or better grade may be transferred to a student's OGI academic record. Transfer credit grades are not calculated in the OGI grade point average. Credits graded on a Pass/No Pass basis may not be transferred.

WITHDRAWING FROM A DEGREE PROGRAM

At anytime prior to earning a degree a student may choose to withdraw from his/her academic program. To withdraw from the program a student should notify his/her academic department in writing of his/her intent to withdraw. The student is also required to fill out and submit the OGI Exit form and arrange a financial aid exit interview (if appropriate). Additionally, OGI asks withdrawing students to complete the Learning Outcomes Assessment Survey to provide valuable feedback regarding our programs and educational experiences.

Once withdrawn, if the student wishes to resume his/her work towards a degree, he/she must reapply to the program, submitting a new application and paying a new application fee. Reapplication will be subject to the admissions requirements in place at that time and department review and acceptance in accordance with the department's current admissions practices. If readmitted, the student will be subject to the degree requirements in effect at time of re-matriculation.

THE CAMPUS

GEOGRAPHIC SETTING

The greater-Portland metropolitan area has a population of about 1 million, nearly half the population of Oregon. It provides diverse cultural activities including art, music, entertainment and sports. Portland has an extensive park system, including the largest wilderness park within the limits of any city in the United States. The OGI School of Science & Engineering is located 12 miles west of downtown Portland, in an area known as the "Silicon Forest". OGI's neighbors include Intel's largest research and development facility, Tektronix, IBM, Hewlett-Packard, Mentor Graphics, Nike, Adidas and hundreds of other technology-based companies.

We are the newest school within Oregon Health & Science University (OHSU), joining the Schools of Medicine, Dentistry and Nursing, which are located on the Marquam Hill Campus in downtown Portland. OGI is part of OHSU's 300-acre West Campus, which also includes the Neurological Sciences Institute, the Oregon National Primate Research Center and the Vaccine and Gene Therapy Institute. The OGI campus consists of modern buildings that provide spacious laboratories, faculty and administrative offices and a research library.

Providing a striking setting for collaborative, interdisciplinary research and education, the 80,000 square-foot Bronson Creek Building is the newest addition to OGI's campus landscape. Acquired by OHSU in 2002, the modern three-story brick structure is the new home of the OGI administration, members of the West Campus Services team, and OGI's departments of Biomedical Engineering, Computer Science and Electrical Engineering and Management in Science and Technology.

LIBRARY

The Samuel L. Diack Library's collection includes more than 21,000 monographic titles (including 4,000 electronic books in computer science and business) and over 500 current print and electronic journal subscriptions. These support the teaching and research efforts at the OGI School by providing texts, conference proceedings, reference materials, journals and research monographs in the subject areas of computer science, electrical engineering, environmental science, biochemistry, molecular biology and management as related to science and technology. These resources are supplemented by the OHSU Library's holdings of more than 74,000 monographs and 1,200 print and electronic journal subscriptions.

OGI students can access the OHSU Library's electronic collections from OGI and can use the print collections by visiting the hill campus or requesting materials be sent to OGI. A proxy server allows access to the libraries' electronic collections from off campus. Materials unavailable from the OHSU libraries are obtained on interlibrary loan for faculty, staff and students at no cost. An online catalog, acquisitions and circulation system is in place. The library is a member of two consortia that provide access to other college and university collections. The Orbis Cascade Alliance allows for direct-request borrowing from 26 institutions in Oregon and Washington, including the University of Oregon, Oregon State University, Portland State University and the six baccalaureate institutions in Washington, e.g., University of Washington and Washington State University. The PORTALS consortium includes libraries in the Portland metropolitan area such as Portland State University and Reed College.

The library's public workstations not only provide for searching the catalog and the library's databases but also provide entry to Web resources for faculty, staff and students. The librarians will perform searches on the systems and databases that are not available directly to students. Library orientation is part of the introduction to OGI for new students, and classes on library research methods are offered throughout the year.

COMPUTER FACILITIES

The OGI School of Science & Engineering's computing environment gives members of the community access to a rich array of technologies and information resources. Many of these resources, including networks and telecommunications, are the responsibility of OHSU's central Information Technology Group (ITG). In addition, many OGI departments and laboratories maintain their own computing facilities. Most OGI computers connect to a school-wide local area network and to the Internet, providing convenient access to the World Wide Web. The local area network is connected to the Internet through two high-speed data paths. In addition, it is also connected to the Internet 2 (Internet2.edu) resources. The Internet 2 connection was made possible through an alliance of local academic institutions

HOUSING

The OGI School is situated amid a large residential area and relies on the numerous apartment complexes in the area for housing students. In addition, due to excellent public transportation on bus or light-rail, additional housing opportunities are available throughout the city, including student housing at Portland State University in downtown Portland. The Graduate Education Department maintains a list of local apartment buildings, available at www.ogi.edu/graduate_edu/students/housing/. The OGI Student Council has a Web site for current, new and prospective OGI students who are looking for housing information, roommates, and other related information at cse.ogi.edu/council/forums.html. Additional housing information for the area around OHSU can be found at www.ohsu.edu/academic/acad/housing/.

STUDENT COUNCIL

The OGI Student Council sponsors and coordinates at least one major social event each quarter, open to everyone at the school. These events have included a coffeehouse with live music performed by students, faculty and staff from the school community, an annual International Food and Cultural Fair, the fall orientation picnic and numerous educational forums. Through collaboration with the OHSU Student Council, additional activities, such as periodic skiing and rafting trips, are also available to OGI students. Many student events throughout OHSU are open to all students at the four OHSU schools. More information on OGI's Student Council is available on their Web site, cse.ogi.edu/council/or by e-mail at scouncil@admin.ogi.edu.

OVERVIEW OF OGI ACADEMIC PROGRAMS

OGI prepares its graduates to become leaders in knowledge-driven professions by providing a learning environment strongly focused on collaborative, interdisciplinary research. OGI students learn to reach across traditional academic boundaries to seek the knowledge and resources needed to solve important technological problems. Our curriculum is organized to facilitate this type of educational experience, where students may choose from a number of challenging paths to reach their goal of a degree in a particular discipline. This program-focused curriculum encourages students to work closely with their advisors to select a course of study that matches their specific needs, strengths and career objectives. The following listing summarizes OGI's current academic programs and directs the reader to the corresponding academic department(s) offering that program.

OGI prides itself on its strong student-faculty relationships. Here, EBS graduate Ameer Tavakoli celebrates his Ph.D. hooding with professors Nicole Steckler (MST) and Patricia Toccalino (EBS).

BIOCHEMISTRY AND MOLECULAR BIOLOGY PROGRAM

See **Department of Environmental and Biomolecular Systems**, page 37

Doctor of Philosophy in Biochemistry and Molecular Biology

Master of Science in Biochemistry and Molecular Biology

BIOMEDICAL ENGINEERING PROGRAM

See **Department of Biomedical Engineering**, page 15

Doctor of Philosophy in Biomedical Engineering

Master of Science in Biomedical Engineering

Biomedical Optics Track
Cardiovascular/Tissue Engineering Track
Neuroengineering Track
Speech and Language Engineering Track

COMPUTER SCIENCE AND ENGINEERING PROGRAM

See **Department of Computer Science and Electrical Engineering**, page 25

Doctor of Philosophy in Computer Science and Engineering

Master of Science in Computer Science and Engineering

Adaptive Systems Track
Human-Computer Interfaces Track
Spoken Language Systems Track

ELECTRICAL ENGINEERING PROGRAM

See **Department of Computer Science and Electrical Engineering**, page 25

Doctor of Philosophy in Electrical Engineering

Master of Science in Electrical Engineering

COMPUTER ENGINEERING AND DESIGN CONCENTRATION:

SIGNALS AND SYSTEMS CONCENTRATION:

Machine Learning Track
Signal and Image Processing Track
Speech Processing Track

ENVIRONMENTAL SCIENCE AND ENGINEERING PROGRAM

See **Department of Environmental and Biomolecular Systems**, page 37

Doctor of Philosophy in Environmental Science and Engineering

Environmental Information Technology Track

Master of Science in Environmental Science and Engineering

Environmental Information Technology Track

MANAGEMENT IN SCIENCE AND TECHNOLOGY PROGRAM

See **Department of Management in Science and Technology**, page 55

Master of Science in Management in Science and Technology

Master Graduate Certificates

Health Care Management
Management in Science & Technology

THE DEPARTMENT OF BIOMEDICAL ENGINEERING integrates the disciplines of engineering, basic biomedical science, and clinical science. Our graduate educational program is designed to provide a broad education across these disciplines as well as knowledge and in-depth research training in a specialty field. In our rigorous curriculum, a quantitative engineering approach is applied to the study of medically related systems and topics. Our program prepares students for careers in academia, industry, and government.

The OGI/OHSU Department of Biomedical Engineering offers students both didactic education and nontraditional learning modes. Students can do advanced basic research in leading laboratories and they can do research projects that relate directly to patients, working under medical supervision to develop and apply new technology in the clinics or in laboratories that study patients.

Two degrees are offered:

- Master of Science in Biomedical Engineering
- Doctor of Philosophy in Biomedical Engineering

*Courses in the following specialty tracks are available for both degrees:

> *Biomedical Optics Track*
> *Cardiovascular/Tissue Engineering Track*
> *Neuroengineering Track*
> *Speech and Language Engineering Track*

ADMISSION REQUIREMENTS

Admissions requirements are the same as the general requirements of the OGI School with the following additions.

- Science degree in physics, chemistry, mathematics, engineering or another quantitative science discipline is required.

Highly qualified individuals with degrees in biology may be considered if they have demonstrated adequate quantitative skills.

- GRE test scores are required for both M.S. and Ph.D. applicants unless a waiver is specifically authorized.
- The preferred minimum TOEFL score is 620 paper/250 computer.

Suggested preparatory prerequisites to the Biomedical Engineering program include: courses in anatomy/physiology, one year of college biology, organic chemistry, calculus through differential equations and linear algebra, one year of calculus-based physics, basic programming skills in a higher-level language and some experience with numerical analysis software.

DEGREE REQUIREMENTS

During the first year, both M.S. and Ph.D. students will focus on the core courses (listed below) required for the Biomedical Engineering program. During the student's first year, a Student Program Committee (SPC) composed of three faculty members will be formed for each student. This committee will work with the student to advise a course of study consistent with both the student's interests and the need for broad knowledge in biomedical engineering and knowledge in the student's chosen specialty. For students working on a thesis or dissertation, during the second year the student will transition to a thesis committee composed of five faculty members, including one or more from another department or university.

MASTER OF SCIENCE IN BIOMEDICAL ENGINEERING

The M.S. degree requires a total of 45 credits, comprised of 24 credits of core courses, and 21 credits from elective courses. A research project or masters thesis is not required and may be undertaken only with permission of a supervising faculty member. A student's SPC should approve the selection of elective courses prior to beginning the class.

Department of Biomedical Engineering

Research Engineer Pavel Chytil and Prof. Tamara Hayes make adjustments to a sensor-equipped walker in the BME Department's Point-of-Care Engineering Laboratory.

BME | BIOMEDICAL ENGINEERING

BME CORE COURSES (24 credits)

All M.S. students must complete the following core courses:

BME 505	Readings in Biolomedical Engineering each term	0 credits
BME 507	Biomedical Engineering Seminar	0 credits
BME 508	Ethics Workshop	0 credits

LIFE SCIENCES

BME 517	Systems Physiology	3 credits
CON 561	Structure and Function of Biological Molecules	3 credits
CON 564	Molecular Cell Biology	3 credits

STATISTICS

MATH 530	Probability and Statistical Inference for Scientists and Engineers	3 credits

SIGNALS AND SYSTEMS

BME 582	Nature and Analysis of Biomedical Signals	3 credits
EE 581	Introduction to Signals, Systems and Transforms	3 credits

ENGINEERING

BME 540	Fluid Mechanics and Biotransport	3 credits
BME 541	Mechanical Properties of Tissues	3 credits

SPECIALTY TRACKS

The following specialized tracks are available to students or they may consult with their SPC to define a custom program.

BIOMEDICAL OPTICS TRACKS

- BME CORE COURSES (listed above)
- SUGGESTED ELECTIVES (21 credits)

Note: 5xx courses are for M.S. students; 6xx for Ph.D. students

BME 522/622	Biomedical Optics I: Tissue Optics	3 credits
BME 523/623	Biomedical Optics II: Laser Tissue Interactions	3 credits
BME 524/624	Biomedical Optics III: Engineering Design	3 credits
BME 525/625	Biomedical Photomechanics	3 credits
BME 527/627	Computational Approaches to Light Transport in Biological Tissues	3 credits
BME 528/628	Physical and Geometrical Optics	3 credits
EE 525/625	Introduction to Electromagnetics for Modern Applications	4 credits
EE 526/626	Electromagnetics for Modern Applications II	4 credits
EE 582/628	Introduction to Digital Signal Processing	3 credits
EE 584/684	Introduction to Image Processing	3 credits

Other appropriate Biomedical Optics courses as approved by the SPC

CARDIOVASCULAR/TISSUE ENGINEERING TRACK

- BME CORE COURSES (listed above)
- SUGGESTED ELECTIVES (21 credits)

Note: 5xx courses are for M.S. students; 6xx for Ph.D. students

BCMB 620	Membrane Biochemistry	2 credits
BME 542/642	Mechanicals of Biological Tissues II	3 credits
BME 543/643	Advanced Tissue Engineering Techniques	3 credits
BME 544/644	Advanced Biomaterials	3 credits
BME 545/645	Biocompatibility — Host-Implant Interactions	3 credits
BME 569/669	Analytical Electron Microscopy for Biomedical Engineers	3 credits
CON 654	Signal Transduction	2-3 credits

Other appropriate Cardiovascular/Tissue Engineering courses as approved by the SPC

Students may consider the following course from another university with prior program approval

ME 555	Finite Element Modeling and Analysis (Portland State University)	

NEUROENGINEERING TRACK

- BME CORE COURSES (listed above)
- SUGGESTED ELECTIVES (21 credits)

Note: 5xx courses are for M.S. students; 6xx for Ph.D. students

BME 561/661	Neuronal Control Systems	3 credits
BME 562/662	Motor Control Systems	3 credits
BME 563/663	Mathematical and Computational Modeling of Biological Systems	3 credits
BME 564/664	Methods in Neuromedicine	3 credits
BME 565/665	Introduction to Computational Neurophysiology	3 credits
BME 566/666	Biomedical Signal Processing II	3 credits
BME 567/667	Visual Sensory Systems	3 credits
BME 568/668	Auditory and Visual Processing by Human and Machine	3 credits
EE 582/682	Introduction to Digital Signal Processing	3 credits
EE 584/684	Introduction to Image Processing	3 credits
NEUS 523/623	Introduction to Neuroanatomy	3 credits
NEUS 524/624	Cellular Neurophysiology	4 credits

Other appropriate Neuroengineering courses as approved by the SPC

SPEECH AND LANGUAGE ENGINEERING TRACK

- BME CORE COURSES (listed above)
- SPEECH AND LANGUAGE ENGINEERING CORE (9 credits)

Note: 5xx courses are for M.S. students; 6xx for Ph.D. students

Choose three:

BME 568/668	Auditory and Visual Processing by Human and Machine	3 credits
BME 572/672	Speech Synthesis	3 credits
CS 551/651	Structure of Spoken Language	3 credits
CS 552/652	Hidden Markov Models for Speech Recognition	3 credits

- SUGGESTED ELECTIVES (12 credits)

BME 571/671	Speech Systems	3 credits
CS 540/640	Neural Network Algorithms and Architectures	3 credits
CS 547/647	Statistical Pattern Recognition	3 credits
CS 550/650	Spoken Language Systems	3 credits
CS 561/661	Dialogue	3 credits
CS 562/662	Natural Language Processing	3 credits

EE 580/680	Linear Systems	3 credits
EE 581/681	Intro to Signals, Systems, and Information Processing	3 credits
EE 582/682	Introduction to Digital Signal Processing	3 credits
EE 586/686	Adaptive and Statistical Signal Processing	3 credits
MATH 519/619	Engineering Optimization	3 credits

Other appropriate Speech and Language Engineering courses as approved by your SPC.

Students may consider the following course from another university with prior program approval

SySc 545	Information Theory (Portland State University)	

OTHER ELECTIVES — ALL TRACKS

BME 502/602	Independent Study	variable credit
BME 504/604	Professional Internship	variable credit
BME 506/606	Special Topics Courses	variable credit
BME 581/681	Fourier Analysis	3 credits

DOCTOR OF PHILOSOPHY IN BIOMEDICAL ENGINEERING

In addition to the general OGI requirements for a Ph.D., the BME Ph.D. degree requirements are satisfied in three parts:

BME COURSES: Students are required to complete the BME core courses as listed below. Particularly well-prepared students may petition the BME department to waive one or more courses based on demonstrated graduate-level knowledge of the course content. A student's SPC is likely to require additional elective courses depending on the student's prior education, experience and preparedness for the Ph.D. qualifying exam. Students must also demonstrate satisfactory performance in at least 54 credit hours of dissertation research.

ADVANCEMENT TO PH.D. CANDIDACY: A Ph.D. student is required to pass a Ph.D. qualifying exam. The two-part examination is normally taken 12 to 24 months after initial enrollment. The first part consists of an oral, public presentation of a thesis proposal. The second part is an oral examination by the students' SPC to test knowledge in both the student's chosen specialty and core topics.

DISSERTATION RESEARCH AND DEFENSE: After successful completion of the Qualifying Exam, the SPC will work with the student to develop a research plan and schedule for the dissertation. The student will be required to register for appropriate research credits throughout the research, presentation and submission process. Satisfactory performance in a minimum of 54 credit hours

of dissertation research is required. The dissertation must constitute significant, original research resulting in a written document of publishable quality and must be successfully defended in an oral presentation.

BME CORE COURSES

All Ph.D. students must complete the following core courses or receive a department waiver:

BME 605	Readings in Biomedical	0 credits
	Engineering each term	
BME 607	Biomedical Engineering Seminar	0 credits
BME 608	Ethics Workshop	0 credits

LIFE SCIENCES

BME 617	Systems Physiology	3 credits
CON 661	Structure and Function of	3 credits
	Biological Molecules	
CON 664	Molecular Cell Biology	3 credits

STATISTICS

MATH 630	Probability and Statistical	3 credits
	Inference for Scientists and Engineers	

SIGNALS AND SYSTEMS

BME 682	Nature and Analysis	3 credits
	of Biomedical Signals	
EE 681	Signals, Systems	3 credits
	and Transforms	

ENGINEERING

BME 640	Fluid Mechanics	3 credits
	and Biotransport	
BME 641	Mechanical Properties	3 credits
	of Tissues	

SPECIALTY TRACKS

Elective specialty courses are available in the four tracks (see lists above). The student's advisor and SPC will determine which specialty courses are required in the Ph.D. program. There are no fixed credit hour requirements for electives; however each student will be tested for knowledge of his or her chosen specialty in the qualifying examination.

RESEARCH PROGRAMS

Biomedical Optics

Research in biomedical optics is focused on the development of uses for lasers and light in medicine and biology. Examples of ongoing applications in this well-established research program include the use of lasers in clinical diagnosis, nondestructive evaluation of tissues, optical imaging of disease, and light-activated chemotherapy for cancer. Facilities include those for both clinical application and basic research.
Jacques, Kirkpatrick, Prahl, R. Wang

Cardiovascular Biomedical Engineering

Cardiovascular biomedical engineering (CBE) is a growing area of interest at OHSU. The CBE program encompasses several specialty areas using engineering tools for investigation. The specialty areas include cardiac and vessel mechanics, computational fluid dynamics, electrocardiography and electrical signal processing, 4-D embryo modeling, functional magnetic resonance imaging, ultrasound technology, cellular mechano-transduction and gene expression, blood-material interactions, thrombosis, laser thrombolysis, and hemostasis.
Faber, Goldstein, Gruber, Hanson, Hinds, McCarty, McNames, Sahn, Thong, Thornburg

Imaging Research

Imaging technology is now central to the diagnosis and treatment of nearly all diseases and is critical for drug development, evaluation of treatment effects as basic science on the biology of normal and abnormal tissue function. Core faculty will be hired in biomedical engineering with research foci in medical imaging. In addition, a wide range of faculty across the OHSU campus use imaging in their basic and clinical research. Thus, students will have an opportunity to implement imaging engineering research in a variety of biomedical research settings. Particular areas of concentration at OHSU are Neuroimaging, Cardiac Imaging and Cancer Imaging.
Erdogmus, Janowsky, Neuwelt, Sahn, Song, Spencer, Springer, Szumowski, Wang

Informatics Research

Informatics activities at OHSU are wide ranging; currently they include: managing and analyzing gene expression data; programs in medical informatics and outcomes research; basic research in databases; networks and embedded systems; and techniques for 3-D visualization. BME, in conjunction with the Department of Computer Science and Electrical Engineering and the Department of Medical Informatics, works to develop and apply technologies in such areas as computational bioengineering, medical visualization, integration of genomic and medical information, home health networking and hybrid instrumentation. BME will also contribute to existing curricula in bioinformatics.
Erdogmus, Hersh, Jimison, Maier, Pentacost, Sheard

Neuroengineering Research

Basic neuroscience research, clinical neurology and neurosurgery are strong programs within OHSU. The existence of a department of biomedical engineering in this center of neuroscience research and clinical medicine creates rich opportunities for biomedical engineers. They can work with neuroscientists and clinicians to apply emerging scientific knowledge in the development of processes and devices needed for the diagnosis, assessment and treatment of neurological disorders and diseases. Ongoing research opportunities range from very basic molecular biophysics and modeling to systems analysis to drug delivery systems, neuroprosthetics, and neurosurgical devices.
Baumann, Burchiel, Cohen, Cordo, Hammerstrom, Hayes, Hitzeman, Horak, Larsson, Leen, Neuwelt, Nuttall, Pavel, Peterka, P. Roberts, W. Roberts, Vu, Welsh, Westbrook

Point-of-Care Biomedical Engineering

Research in this area is focused on the development of health care delivery systems suitable for use in homes, assisted-living facilities and other residential settings. Application areas include processes and technologies for the monitoring, evaluation and treatment of people disabled by aging, chronic disease, or disability. Research challenges include the development of unobtrusive sensors, wireless communication of multi-rate signals, processing and fusion of signals from multitudes of noisy sensors, and ubiquitous perceptual interfaces.
Fried-Oken, Hammerstrom, Hayes, Horak, Jimison, Krohn, Maier, Pavel

Rehabilitation and Biomechanics Research

Many diseases and disorders of muscle, bone and the nervous system result in treatment, immobilization, healing and rehabilitation. Basic and applied research in the Department of Biomedical Engineering focuses on the normal and abnormal control of movement and musculoskeletal biology. This research is multidisciplinary and highly collaborative with both clinical and basic science departments at OHSU. Currently active research by our faculty has resulted in the development of novel therapeutic devices and procedures that are tested on patient groups provided by collaborating clinicians.
Cordo, Hart, Herzberg, Horak, Nutt, Orwoll, Peterka

Tissue Engineering and Biomaterials Research

Research in tissue engineering and biomaterials is represented by a multi-disciplinary group of materials scientists, biomedical and tissue engineers, chemists, physiologists, dentists and physicians. Faculty projects include the following research: physical biomechanics of dental and orthopedic implants, computational biomechanics of dental implants, dental restorations, dissolution and volatilization from dental alloys; non-invasive and non-destructive evaluation of engineered tissues; laser welding of tissues; natural, proteinbased biomaterials; polymer mechanics; micromechanics of biocomposites; thermal analysis; tribology; collagen and other biocomposites; skin scaffolds; bone healing; blood vessel substitutes, vascular grafts, and endovascular stents.
Dawson, Ferracane, Gregory, Hanson, Herzberg, Hinds, Kirkpatrick, McCarthy, Mitchell, Sakaguchi

FACILITIES

The Department of Biomedical Engineering occupies approximately 10,000 square feet on the second floor of the Bronson Creek building, a modern building on the OHSU/OGI West Campus, and an additional 20,000 square feet in the Murdock and Vollum buildings and at the adjacent Oregon National Primate Research Center. The department's space accommodates "wet" labs with biosafety hoods as well as other lab space. The department is equipped with a modern computer network system, serviced by OGI's and OHSU's Information Technology Groups. Student workstations are equipped with highspeed network connections. Special facilities, such as a simulated residential health care facility are also located on the OGI campus.. Video teleconferencing facilities are available to allow students and faculty to interact with others at seminars and other events on OHSU's Marquam Hill Campus.

In the late 2006 the BME department will occupy new laboratories and offices on the thirteenth floor of a new OHSU building adjacent to the Marquam Hill Campus – connected to the hill campus by a fast arial tram. Some BME facilities will remain on the West Campus and at the Oregon National Primate Research Center.

Some students' research projects are carried out in laboratories in other OHSU departments or in local industries. Available facilities in which students may do research projects include: Oregon Medical Laser Center, Advanced Imaging Center, Oregon Hearing Research Center, Neurological Sciences Institute, and Heart Research Center, as well as the many labs in the basic science departments and institutes of OHSU.

FACULTY

STEPHEN HANSON

Professor and Department Head
Ph.D., Chemical Engineering
University of Washington, 1977
shanson@bme.ogi.edu

RESEARCH INTERESTS

Thrombosis and vascular healing responses are being evaluated in animal models to identify key hemostatic mechanisms, blood component interactions with natural and synthetic surfaces and the effects of blood-flow phenomena. Our ultimate goals are to develop more effective anti-thrombotic and anti-arteriosclerotic drug therapies, and to improve the performance of prosthetic cardiovascular devices.

REPRESENTATIVE PUBLICATIONS

Tanaka KA, Katori N, Kelly AB, Kotze H, Marzec U, Hanson SR: In vivo platelet redistribution and acute thrombocytopenia after eptifibatide injection in baboons. Thrombosis Research, 115(1-2):79-87, 2005.

Olivero A, Eigenbrot C, Robarge K, Flygare J, Rawson T, Goldsmith R, Cohen F, Kenkare-Mitra S, Kadkhodayan S, Beresini M, DeGuzman L, Artis R, Banner D, Marzec U, Hanson S, Refino C, Bunting S, and Kirchhofer D: A selective, slow binding inhibitor of factor VIIa binds to a non-standard active site conformation and is a potent antithrombotic in-vivo. Journal of Biological Chemistry, 280(10):9160-9169, 2005.

Hanson SR: Blood Coagulation and Blood-Materials Interactions. In: *Biomaterials Science, 2nd Edition* (Ratner BD, Hoffman AS, Schoen FJ, Lemons JE, Eds), Academic Press, New York, NY; 2004, pp. 332-338.

Lin PH, Chen C, Bush RL, Yao Q, Lumsden AB, Hanson SR: Small caliber heparin-coated ePTFE grafts reduce platelet deposition and neointimal hyperplasia in a baboon model. Journal of Vascular Surgery, 39(6):1322-1328, 2004.

Gruber, A.G., Hanson, S.R., "Factor XI-dependence of surface-initiated and tissue factor-initiated thrombus propagation in vivo," *Blood* **102**: 953-955, 2003.

WILLIAM J. ROBERTS

Assistant Professor and
Associate Department Head
Ph.D., Physiology
University of Minnesota, 1970
robertsw@ohsu.edu

RESEARCH INTERESTS

Neuroengineering. Neuronal mechanisms of pain. Influence of sympathetic nervous system on sensory functions. Electrical stimulation for pain relief. Motor systems.

REPRESENTATIVE PUBLICATIONS

Bon, K., Wilson, S.G., Mogil, J.S., Roberts, W.J., "Genetic Evidence for the Correlation of Deep Dorsal Horn fos Protein Immunoreactivity with Tonic Formalin Pain Behavior *Journal of Pain.* **3**,181–189, 2002.

Gillette, R.G., Kramis, R.C., Roberts, W.J., "Suppression of Activity in Spinal Nocireceptive 'Low Back' Neurons by Paravertebral Somatic Stimuli in the Cat," *Neurosci Lett.* 1998 Jan 23;**241**(1), 45–8.

Kramis, R.C., Roberts, W.J., Gillette, R.G., "Non-nociceptive Aspects of Persistent Musculoskeletal Pain," *J Orthop Sports Phys Ther.* 1996 Oct;**24**(4), 255–67.

Kramis, R.C., Roberts, W.J., Gillette, R.G., "Post-sympathectomy Neuralgia: Hypotheses on Peripheral and Central Neuronal Mechanisms," *Pain,* 1996 Jan;**64**(1), 1–9.

Fine, P.G., Roberts, W.J., Gillette, R.G., Child, T.R., "Slowly Developing Placebo Responses Confound Tests of Intravenous Phentolamine to Determine Mechanisms Underlying Idiopathic Chronic Low Back Pain," *Pain,* 1994 Feb;**56**(2), 235–42.

Gillette, R.G., Kramis, R.C., Roberts, W.J., "Sympathetic Activation of Cat Spinal Neurons Responsive to Noxious Stimulation of Deep Tissues in the Low Back," *Pain,* 1994 Jan;**56**(1), 31–42.

ANDRAS GRUBER, M.D.

Associate Professor
M.D.
Semmelweis Medical University,
Budapest, Hungary, 1979
agruber@bme.ogi.edu

RESEARCH INTERESTS

The role of contact activation in acute intraluminal thrombus propagation using synthetic vascular grafts in a primate model of thrombosis and hemostasis. If the functionality of the contact system enzyme complex (FXI/FXII/KK/HMWK) is relevant to the pathogenesis of thrombosis, a FXI inhibitor could become the first safe antithrombotic agent.

Characterization of the effects of endogenous protein C activation on acute arterial thrombogenesis and hemostasis using rationally engineered recombinant enzymes. A pharmacologically viable protein C activator could help utilize the body's own antithrombotic and antiinflammatory system similar to the way streptokinase and tPA became useful fibrinolysis activators.

REPRESENTATIVE PUBLICATIONS

Gruber A, Hanson S.R. "Factor XI-dependence of surface- and tissue factor-initiated thrombus propagation in primates," *Blood* **102**:953-5, 2003.

Gruber A, Hanson S.R. "Potential new targets for antithrombotic therapy," *Curr Pharm Des.* **9**:2367-74, 2003.

Gruber A, Cantwell A.M., Di Cera E., Hanson S.R. "The thrombin mutant W215A/E217A shows safe and potent anticoagulant and antithrombotic effects in vivo," *J Biol Chem.* **277**:27581-4, 2002.

Kim T, Murdande S, Gruber A, Kim S. "Sustained-release morphine for epidural analgesia in rats," *Anesthesiology* **85**:331-8, 1996.

TAMARA HAYES

Assistant Professor
Ph.D., Behavioral Neuroscience
University of Pittsburgh, 1994
tamara.hayes@bme.ogi.edu

RESEARCH INTERESTS

Dr. Hayes' research interest include the use of ubiquitous computing to deliver health care in the home, with the goal of changing the current paradigm of clinic-centered healthcare to a model that is less costly, more effective, and allows an individual to participate more fully in their own health care. This work is done collaboratively with other researchers in the Point of Care Laboratory, with clinicians and scientists at the Layton Center for Alzheimer's and Aging Research, and with industry partners.

Recently, Dr. Hayes' research has been focused on the unobtrusive, continuous, in-home assessment of motor activity using a system based on wireless motion sensor technology. Other projects include the development of a novel device for tracking medication adherence, and collaborations with researchers at HP on the evaluation of an emerging location-aware technology (SPEC's) for monitoring people's activity and interaction in the home and the community.

REPRESENTATIVE PUBLICATIONS

Hayes TL, Pavel M, Kaye JA. An Unobtrusive In-home Monitoring System for Detection of Key Motor Changes Preceding Cognitive Decline. 26th Annual International Conference of the IEEE Engineering In Medicine And Biology Society, 1-5 September, 2004; San Francisco, CA.

Hayes TL, Pavel M., Schallau PK, Adami AM. Unobtrusive Monitoring of Health Status in an Aging Population. 5th International Conference on Ubiquitous Computing, October 12-15, 2003; Seattle, WA.

Adami AM, Hayes TL, Pavel M. Unobtrusive Monitoring of Sleep Patterns. 25th Annual International Conference of the IEEE Engineering In Medicine And Biology Society, 17-21 September, 2003; Cancun, Mexico.

MONICA THACKER HINDS

Assistant Professor
Ph.D., Mechanical Engineering
Johns Hopkins University, 1998
hindsm@bme.ogi.edu

RESEARCH INTERESTS

Relationship between fluid
dynamics and extracellular matrix
production by cells, vascular
tissue engineering, role of
mechanical stimulation in tissue
engineered constructs, elastin
based biomaterials .

REPRESENTATIVE PUBLICATIONS

Hinds, M.T., Courtman D.W., Goodell,
T., Kwong M., Brant-Zawadzki, H.,
Burke A., Fox B., and Gregory K.W.,
"Development of a xenogenic elastin-
based biomaterial: calcification and
inflammatory effects of aluminum
chloride treatment," *Journal of
Biomedical Materials Research*, April
2004, **69**A(1):55-64.

Kirkpatrick, S.J., Hinds, M.T., and
Duncan, D.D., "Acousto-optical
characterization of the viscoelastic
nature of a nuchal elastin tissue
scaffold," *Tiss. Eng.*, 2003 **9**(4):
645-56.

Hinds, M.T., and Kirkpatrick, S.J.,
"Material properties of engineered
tissues evaluated with nondestructive
methods," *Proceedings SPIE*, 2002.
4617:275-283.

Kajitani, M., Wadia, Y., Hinds, M.T.,
Teach, J., Swartz, K.R. and Gregory,
K.W., "Successful repair of esophageal
injury using an elastin-based
biomaterial patch," *Asaio J*, 2001.
47(4), 342–5,

Hinds, M.T., Park, Y.J., Jones, S.A.,
Giddens, D.P., and Alevriadou, B.R.,
"Local hemodynamics affect monocytic
cell adhesion to a three-dimensional
flow model coated with E-selectin,"
Journal of Biomechanical Engineering,
2001, **34**(1): p. 95-103.

Kajitani, M., Wadia, Y., Xie, H., Hinds,
M., Shalaby, S., Schwartz, K., and
Gregory, K.W., "Use of new elastin
patch and glue," *ASAIO J*, 2000. **46**(4),
p. 409-414.

JOHN-PAUL HOSOM

Assistant Professor
Ph.D., Computer Science
and Engineering,
Oregon Graduate Institute of
Science & Technology, 2000
hosom@bme.ogi.edu

RESEARCH INTERESTS

Automatic speech recognition
(ASR). Time alignment of
phonemes. Acoustic-phonetic
analysis of speech.
Assistive technology.

REPRESENTATIVE PUBLICATIONS

J. P. Hosom, L. Shriberg, and J. R.
Green, "Diagnostic Assessment of
Childhood Apraxia of Speech Using
Automatic Speech Recognition (ASR)
Methods," *Journal of Medical Speech-
Language Pathology*, 12 (4), pp.
167-171, 2004.

J. P. Hosom, "Automatic Speech
Recognition," in *Encyclopedia of
Information Systems*, H. Bidgoli (ed.).,
vol. 4, pp. 155-169, Academic Press,
San Francisco, 2003 (invited chapter).

J. P. Hosom, A. B. Kain, T. Mishra,
J. P. H. van Santen, M. Fried-Oken
and J. Staehely, "Intelligibility of
Modifications to Dysarthric Speech,"
*The 2003 International Conference
on Acoustics, Speech, and Signal
Processing* (ICASSP 2003), Hong Kong,
April 2003.

J. P. Hosom, "Automatic Phoneme
Alignment Based on Acoustic-Phonetic
Modeling." *The 2002 International
Conference on Spoken Language
Processing* (ICSLP 2002), Boulder, Co.,
vol. I, pp. 357–360, September 2002.

J.P. Hosom and R.A. Cole, "Burst
Detection Based on Measurements of
Intensity Discrimination." *The 2000
International Conference on Spoken
Language Processing (ICSLP 2000)*,
Beijing, vol. IV, pp. 564-567, Oct. 2000.

J.P. Hosom, R.A. Cole and P. Cosi,
"Improvements in Neural-Network
Training and Search Techniques for
Continuous Digit Recognition,"
*Australian Journal of Intelligent
Information Processing Systems*, **5**(4),
277–284, Summer 1999.

STANLEY J. HUBER

Assistant Professor
M.D., School of Medicine
Oregon Health &
Science University, 1965
hubers@bme.ogi.edu

RESEARCH INTERESTS

Blood chemistry by ophthalmic
spectroscopy; instrumentation;
imaging

REPRESENTATIVE PUBLICATIONS

S.J. Huber, "Photic Pulse Stimulator
for ERG Analysis," Sloan Foundation

S.J. Huber, "Battlefield
Management of Ocular Injuries,"
ICMM, Interlochen, Switzerland

S.J. Huber, "Biological Effects of
Space Radiation Fields," Classified
Report, USAF MOL Project

S.J. Huber, "Triage and
Management of Ocular Injuries,"
CIOMR, Brussels, Belgium

S.J. Huber, "Hazards of Military
Lasers," CIOMR, Brussels, Belgium

S.J. Huber, "Radiation Induced Eye
Injuries," CIOMR, Brussels, Belgium

S.J. Huber, "TacStar, A New Concept
in Military Medical Training," CIOMR,
Wurzburg, Germany

STEVEN L. JACQUES

Professor
Ph.D., Biophysics and
Medical Physics
University of California,
Berkeley, 1984
sjacques@bme.ogi.edu

RESEARCH INTERESTS

Biomedical optics and laser-tissue
interactions. Development of
diagnostic and therapeutic devices
for medicine and biology using
optical technologies.

REPRESENTATIVE PUBLICATIONS

JC Ramella-Roman, K Lee, SA Prahl,
SL Jacques, Design, testing, and
clinical studies of a handheld polarized
light camera. *J. Biomed. Optics*, **9**(5),
in press, 2004.

Daniel S. Gareau, Paulo R. Bargo,
William A Horton, Steven L. Jacques,
"Confocal fluorescence spectroscopy of
subcutaneous cartilage expressing
green fluorescent protein versus
cutaneous collagen autofluorescence,"
J. Biomed. Optics, **9**(2), 254-258,
2004.

Paulo R. Bargo, Scott A. Prahl, and
Steven L. Jacques, "Collection
efficiency of a single optical fiber in
turbid media," *Appl. Optics-OT.*, **42**,
3187-3197, 2003.

Jessica C. Ramella-Roman, Paulo R.
Bargo, Scott A. Prahl, and Steven L.
Jacques, "Evaluation of spherical
particle sizes with an asymmetric
illumination microscope," *IEEE J.
Selected Topics in Quantum
Electronics*, **9**, 301-306, 2003.

S.L. Jacques, J.C. Ramella-Roman and
K. Lee, "Imaging skin pathology with
polarized light," *J. Biomed. Opt.*, **7,**
329-340, 2002.

S.L. Jacques, N. Ramanujam,
G. Vishnoi, R. Choe and B. Chance,
"Modeling Photon Transport in
Transabdominal Fetal Oximetry,"
J. Biomed. Optics, **5**, 277–282, 2000.

SEAN J. KIRKPATRICK

Associate Professor
Ph.D., Biomechanics
Unversity of Miami, 1992
skirkpat@bme.ogi.edu

RESEARCH INTERESTS

Theory and application of light scattering to address issues in the structure and function of healthy and diseased biological tissues. Of particular interest is the micromechanical behavior of biological cells and tissues as a function of disease state. Other interests include the use of optical techniques for the nondestructive evaluation of natural and synthetic biomaterials, including engineered tissues.

REPRESENTATIVE PUBLICATIONS

Kirkpatrick, S.J., Hinds, Monica T., Vigeland, L., and Duncan, D.D., Observations on the forward-scattered speckle patterns form healthy human fibroblasts and melanoma cells, J. Biomedical Optics (submitted), 2005.

Kirkpatrick, SJ, A primer on radiometry, Dental Materials 21(1) 21-26, 2005.

Kirkpatrick, SJ Duncan, DD, Fang, Li, Low frequency surface wave propagation and the viscoelastic behavior of porcine skin, J Biomed Opt., 9(6):1311-1319, 2004.

Kirkpatrick, S.J., Hinds, M.T., and Duncan, D.D., Acousto-optical characterization of the viscoelastic nature of a nuchal elastin tissue scaffold, Tiss. Eng. 9(4):645-656, 2003.

D.D. Duncan and S.J. Kirkpatrick, "Performance analysis of a maximum-likelihood speckle motion estimator," Opt.Express 10, 927-941, 2002,

S.J. Kirkpatrick and D.D. Duncan, "Optical Assessment of Tissue Mechanics," in *Optical Biomedical Diagnostics*, V.V. Tuchin, ed., SPIE Press, Bellingham, WA, 2002.

S.J. Kirkpatrick, D.A. Baker and D.D. Duncan, "Speckle Tracking of Low-frequency Surface Acoustic Waves for Mechanical Characterization of Tissues," *Proceedings SPIE*, p. 461, 2002.

JACK MCCARTHY

Assistant Professor
Ph.D., Materials Science and Engineering
Oregon Graduate Institute of Science & Technology, 1996
jmcarthy@bme.ogi.edu

RESEARCH INTERESTS

Ongoing research includes multibeam electron nanolithography, control of nano-scale hillocks in sputtered Au metallizations for use in GaAs devices and the fabrication and development of sensor array-chip hybrids for the detection of biological agents, pathogens, organic and inorganic gases in the environment. These research areas require fabrication and characterization on the micron, sub-micron and nano-scales. The primary fabrication tool in this research is the focused ion beam workstation (FIB), which permits seeing, machining and microforming on the micron, sub-micron and nano-scales. The characterization is provided by scanning and transmission electron microscopy (SEM, TEM) and atomic force microscopy (AFM). FIB fabrication techniques and SEM, AFM and TEM characterization and in-situ experimentation feedback are used to accelerate research on nanofabrication, biomimetic sensors, biomaterials and microelectronic thin films.

REPRESENTATIVE PUBLICATIONS

Jack M. McCarthy, Fabian Radulescu and Erich Stach, Transmission Electron Microscopy(TEM) In-situ Experiments Coupled with Differential Scanning Calorimetry(DSC) as Characterization Tools for Thin Film Reactions on the Nanoscale, presented NATAS conference 2003, *Thermocim. Acta*, accepted 2004.

S. Gosavi, J.M. McCarthy, J.L. House, B. Scholte van Mast, G. Janaway and C.N. Berglund, "Stability Improvement at High Emission Densities for Gold Thin Film Photocathodes Used in Advanced Electron Beam Lithographies," 45th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication, accepted for publication in *JVSTB*, Nov.-Dec. 2001.

OWEN MCCARTY

Assistant Professor
Ph.D., Chemical and Biomoledular Engineering
Johns Hopkins University, 2002
omccarty@bme.ogi.edu

RESEARCH INTERESTS

Dr. McCarty's research is focused on understanding the interplay between fluid mechanics, convective mass transport, cell biology and molecular biology in the cardiovascular system. There are currently two main areas of special interest:

1) Flow modulation of adhesive interactions between blood-borne cells. In particular, the balance between hydrodynamic shear forces and chemical adhesive interactions presents the most scientifically interesting aspect of this field currently, as well as being an area with great potential to impact public health through its relevance to cancer, cardiovascular disease, and inflammation. Consequently the goal of this research is to rigorously characterize the effects of fluid mechanical stresses on heterotypic vascular cell interactions at the molecular level.

2) Development of models for thrombosis. This research utilizes fluorescent video microscopy and digital image processing to directly visualize the process of mural thrombosis in real time under conditions of controlled surface chemistry and blood flow rate. Numerical simulations incorporating the convective transport model will be employed to delineate the affects of local concentrations of platelet activating substances near growing thrombi.

REPRESENTATIVE PUBLICATIONS

O.J.T. McCarty, Y. Zhao, N. Andrew, L.M. Machesky, D. Staunton, J. Frampton, S.P. Watson, "Evaluation of the role of platelet integrins in fibronectin-dependent spreading and adhesion" Journal of Thrombosis and Haemostasis 2004 Oct; 2:1823-1833.

MISHA PAVEL

Professor
Ph.D., Experimental Psychology
New York University, 1980
pavel@bme.ogi.edu

RESEARCH INTERESTS

Analysis and modeling of complex behaviors of biological systems, including visual and auditory processing, pattern recognition, information fusion and decisionmaking. Development of engineering systems mimicking these abilities to support multimodal communication between humans and machines (speech and video), machine vision, visually guided vehicular control and virtual reality. Applications of these techniques to the development of future biomedical and healthcare systems, in particular point-of care biomedical engineering.

REPRESENTATIVE PUBLICATIONS

Adami, A., Yang, K., Song, X., and Pavel M., "Model-Base Image Processing and Analysis for Fracture Classification," Proceedings of the Second Joint Engineering in Medicine and Biology Conference, October 2002, Houston, TX, pp. 2525–2527.

McGee, D.R., Pavel, M. and Cohen, P.R. (2001) "Context Shifts: Extending the Meanings of Physical Objects with Language," *Human Computer Interaction*, 16, Context-aware computing.

J. Palmer, P. Verghese and M. Pavel, "The Psychophysics of Visual Search," *Vision Research*, **40**, 1227–1268, 2000.

T. Arai, M. Pavel, H. Hermansky and C. Avendano, "Syllable Intelligibility for Temporally Filtered LPC Cepstral Trajectories," *Journal of the Acoustical Society of America*, **105**, 2783–2791, 1999.

R.K. Sharma, T.K. Leen and M.Pavel, "Probabilistic Image Sensor Fusion," in *Advances in Neural Information Processing Systems 11*, M.S. Kearns, S.A. Solla and D.A. Cohn, eds., MIT Press, Cambridge, Mass., 1999.

SANDRA RUGONYI

Assistant Professor
Ph.D., Mechanical Engineering
Massachusetts Institute
of Technology, 2001
rugonyis@bme.ogi.edu

RESEARCH INTERESTS

Dr. Rugonyi's main research interests include the analysis of biological systems, and the development of mathematical and numerical models that describe them. Nowadays, many advances in the medical field require a thorough understanding of complex physico-chemical interactions. Finite element methods and other numerical techniques, when used with appropriate physically-based models, provide a means of calculating and visualizing the response of systems to different conditions, and could therefore become essential to guide the development of treatments for diseases. Dr. Rugonyi's current research is focused on two areas: i) the study of monomolecular layers at the air-water interface that are used to understand the physical basis for the behavior of pulmonary surfactant in the lungs; and ii) the study of cardiovascular systems, which includes the analysis of blood flow through vessels and the heart, as well as the interaction of flow with tissue.

REPRESENTATIVE PUBLICATIONS

S. Rugonyi, E. C. Smith and S. B. Hall, "Transformation diagrams for the collapse of a phospholipid monolayer", Langmuir, vol. 20, pp. 10100-10106 (2004).·

S. Rugonyi and S.B. Hall, "The basis of low surface tensions in the lungs", in: Lung Surfactant (Dys)function, K. Nag, Ed., Marcel Dekker, Inc., in press.·

S. Rugonyi, E. C. Smith and S. B. Hall, "Effect of viscosity and compression rate on the collapse phase transition of pulmonary surfactant at an air-water interface", in Computational Fluid and Solid Mechanics Vol. 2, K.J.Bathe Ed., Elsevier, 2003.·

TRAN THONG

Assistant Professor
Ph.D., Electrical Engineering
Princeton University, 1975
trant@bme.ogi.edu

RESEARCH INTERESTS

Cardiovascular engineering in the area of cardiac tachyarrhythmia prediction and prevention both in atria and ventricles, heart rate variability as an indicator of parasympathetic (vagal) tone during relaxed states such as meditation and sleep and as a long term indicator of health in mindbody exercise programs like yoga and tai-chi, effect of parasympathetic tone on tachyarrhythmia, non-invasive blood pressure and related parameters.

Biomedical signal processing using discrete time modeling and system design.

REPRESENTATIVE PUBLICATIONS

T. Thong and J. McNames, "Transforms for Continuous Time System Modeling," *Proceedings 45th IEEE Midwest Symposium on Circuits and Systems*, August 4–7, 2002, Tulsa, Oklahoma, pp. II-408–II-411.

T. Thong and J. McNames, "Nonlinear Representation of Over-sampled Coarsely Quantized Signals," *Proceedings 45th IEEE Midwest Symposium on Circuits and Systems*, August 4–7, 2002, Tulsa, Oklahoma, pp. II-416–II-417.

T. Thong, B. Goldstein, "Prediction of Tachyarrhythmia Episodes," *Proceedings of the Second Joint EMBS/BMES Conference*, Houston, TX, October 23–26, 2002, pp. 1445–1446.

T. Thong, B. Goldstein, "Prediction of Ventricular Tachyarrhythmia Episodes from Heart Rhythm Data by a Vagal Fatigue Index," Abstract 435, *Circulation*, **106**(19), II-86.

T. Thong, B. Goldstein, "Sustained Ventricular Tachyarrhythmia Prediction from Heart Rhythm Data," Abstract 333, *PACE*, Vol. 26, No. 4, Part II, p. 1012.
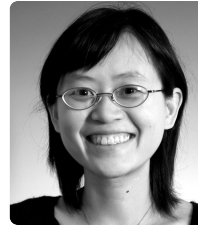
TANIA VU

Assistant Professor
Ph.D., Vision Science
(neuroscience)
UC Berkeley, 1977
twu@bme.ogi.edu

RESEARCH INTERESTS

Functionalized nanoparticle probes for cell-directed delivery, transport, and visualization
Engineered bioplatforms for molecular assay and sensing
Micro/Nanotherapies for the retina and brain

REPRESENTATIVE PUBLICATIONS

Vu TQ, Maddipati R, Blute TA, Nehilla BJ, Nusblat L, and Desai TA. Peptide-Conjugated Quantum Dots Activate Neuronal Receptors and Initiate Downstream Signaling of Neurite Growth, Nano Letters (in press).

Vu TQ, Qian H, Standaert RF, Chowdhurry S, Pepperberg DR. Activation of Neural Receptor Channels Using Neurotransmitter Conjugates Designed for Surface Attachment. Biomaterials, 25(14):1605-2195, 2005.

Nehilla BJ, Popat KC, Vu TQ, Chowdhurry S, Standaert RF, Pepperberg DR, and Desai TA. A Neurotransmitter Analog Tethered to a Silicon Platform for Neuro-bioMEMS Applications, Biotechnology and Bioengineering, 87(5):669-674, 2004.

Saifuddin U*,Vu TQ*, Rezac M, Qian H, Pepperberg DR, Desai TA. Toward Development of Bioactive, Neurotransmitter-immobilized Surfaces for Interaction with Post-synaptic Membrane Receptors. Journal of Biomedical Materials Research, 66A(1):184-191, 2003. (*co-authors)

Vu TQ, Payne JA, Copenhagen DC. Localization and developmental expression patterns of the neuronal K-Cl cotransporter (KCC2) in the rat retina. Journal of Neuroscience 20(4):1414-23, 2000.

Krizaj D, Vu TQ, and Copenhagen, DC. On the shaping, modulation, and synaptic transmission of rod and cone light responses. In The Retinal Basis of Vision, Toyoda, J., Murakami, M., Kaneko, A., and Saito, T., Eds. Amsterdam: Elsevier, 1999.
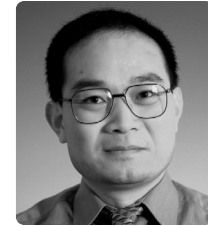
RUIKANG (RICKY) WANG

Professor
Ph.D., Optical Engineering
Glasgow University, 1995
t.k.wang@bme.ogi.edu

RESEARCH INTERESTS

High resolution optical tomographic imaging of biological tissues. Tissue engineering and controlling of optical properties of biological tissues. Imaging of dynamic flow in complex geometry. Ultrasound modulated optical imaging

REPRESENTATIVE PUBLICATIONS

P.H. Tomolins, and R.K. Wang, Theory, Developments and Applications of Optical Coherence Tomography, *Journal of Physics D: Applied Physics* (2005, in press)

Y He, R.K. Wang, Dynamic optical clearing effect of tissue impregnated by hyperosmotic agents: studied with optical coherence tomography. *Journal of Biomedical Optics*, **9**: 200-206 (2004)

X Xu, R.K. Wang, Synergistic effect of hyperosmotic agents on optical clearing of gastric tissue studied with near infrared spectroscopy. Ph*ysics in Medicine and Biology* **49**: 457-468 (2004)

S Whiteman, Y Yang, Y He, D Pittius, M Spiteri, R.K. Wang, Use of OCT in delineating airway microstructures: comparison of OCT images with histopathologies. *Physics in Medicine and Biology* **49**: 1247-56 (2004)

R.K. Wang, High resolution visualisation of fluid dynamics with Doppler Optical Coherence Tomography, *Measurement Science and Technology* **15**: 725-733 (2004)

R.K. Wang, J.C. Hebden, and V.V. Tuchin, Recent developments in Biomedical Optics (editorial), *Physics in Medicine and Biology* **49**: U3-U3 (2004)

Mason C, Markusen JF, Town MA, Dunnill P, Wang RK., The potential of optical coherence tomography in the engineering of living tissue. Phys Med Biol. 2004 Apr 7;49(7):1097-115.

Proskurin SG, Sokolova IA, Wang RK., Imaging of non-parabolic velocity profiles in converging flow with optical coherence tomography. Phys Med Biol. 2003 Sep 7;48(17):2907-18.

JOINT FACULTY

THOMAS BAUMANN, PH.D.

Associated Professor
Department of
Neurological Surgery
Oregon Health & Science University

PHIL COHEN, PH.D.

Professor
Department of Computer Science
& Electrical Engineering
OGI School of Science
& Engineering

PAUL CORDO, PH.D.

Scientist and Director
Neurological Sciences Institute
Oregon Health & Science University

DAVID DAWSON, PH.D.

Professor and Department Head
Department of Physiology
and Pharmacology
Oregon Health & Science University

DENIZ ERDOGMUS, PH.D.

Assistant Professor
Department of Computer Science
& Electrical Engineering,
Department of
Biomedical Engineering
OGI School of Science
& Engineering

JACK FERRACANE, PH.D.

Professor and Chair
Department of Biomaterials
& Biomechanics
Oregon Health & Science University

MELANIE FRIED-OKEN, PH.D.

Associate Professor
Department of Neurology
Oregon Health & Science University

KENTON GREGORY, M.D.

Director
Oregon Medical Laser Center

DAN HAMMERSTROM, PH.D.

Associate Dean for Research
College of Engineering and
Computer Science
Portland State University

FAY HORAK, PH.D.

Senior Scientist
Neurological Sciences Institute
Oregon Health & Science University

HOLLY JIMISON, PH.D.

Assistant Professor
Department of Medical Informatics
& Clinical Epidemiology
Oregon Health & Science University

JEFFREY KAYE, M.D.

Professor and Director
Layton Center for Aging &
Alzheimer's Disease Research
Department of Neurology
Oregon Health & Science University

TODD LEEN, PH.D.

Professor
Department of Computer Science
& Electrical Engineering
OGI School of Science
& Engineering

JOHN MITCHELL, PH.D.

Assistant Professor
Department of Biomaterials
& Biomechanics
Oregon Health & Science University

MELANIE MITCHELL, PH.D.

Associate Professor
Department of Computer Science
Portland State University

ALFRED NUTTALL, PH.D.

Professor
Department of Otolaryngology
Director, Oregon Hearing
Research Center
Oregon Health & Science University

ROBERT PETERKA, PH.D.

Associate Scientist
Neurological Sciences
Institute University

SCOTT PRAHL, PH.D.

Assistant Professor
Oregon Medical Laser Center

PATRICK ROBERTS, PH.D.

Assistant Scientist
Neurological Sciences Institute
Oregon Health & Science University

DAVID SAHN, M.D.

Professor
Department of Pediatrics
Oregon Health & Science University

RON SAKAGUCHI, D.D.S., PH.D.

Professor
Department of Biomaterials
and Biomechanics
OHSU School of Dentistry

XUBO SONG, PH.D.

Assistant Professor
Department of Computer Science
& Electrical Engineering
OGI School of Science
& Engineering

CHARLES SPRINGER, PH.D.

Professor and Director
Advanced Imaging Center
Oregon Health & Science University

KENT THORNBURG, PH.D.

Professor and Director
Heart Research Center
Oregon Health & Science University

JAN VAN SANTEN, PH.D.

Professor
Director, Center for Spoken
Language Understanding
Department Head,
Department of Computer Science
& Electrical Engineering
OGI School of Science
& Engineering

THE DEPARTMENT OF COMPUTER SCIENCE AND ELECTRICAL ENGINEERING has internationally acclaimed programs of research and education. The breadth and depth of the research is apparent in the research projects and research centers listed below and in the educational program. Four degrees are offered through the Department of Computer Science and Electrical Engineering: Master of Science in Computer Science and Engineering, Master of Science in Electrical Engineering, Doctor of Philosophy in Computer Science and Engineering and Doctor of Philosophy in Electrical Engineering.
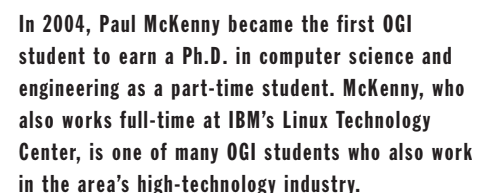
ADMISSION REQUIREMENTS

In addition to the general OGI admission requirements, the CSEE Department requires the general aptitude GRE scores, except in the case of advanced placement admission for M.S. students (see below).

Desirable scores for the Test of English as a Foreign Language (TOEFL) in the CSEE Department is 650 for the paper-base test or 280 for the computer-based test. An applicant whose score is between 580/237 and 650/280 may be admitted if special mitigating factors exist, such as, excellent GRE scores.

Entering students for the CSE programs must have taken undergraduate courses in Discrete Mathematics and Data Structures (typically sophomore level courses) and be proficient in a modern programming language. In addition, each student must have completed senior level courses in Operating Systems and Computer Architecture or take the graduate-level courses at OGI (if offered) or at another school if the courses are not offered at OGI (which will then be counted as electives in the Masters program). Waivers will be considered for students with significant experience in OS implementation or architectural design of hardware.

To be considered for admission to the EE Computer Engineering and Design program, a candidate must hold a bachelor's degree in physics, applied physics, engineering physics, electrical engineering or equivalent. Candidates with undergraduate degrees in applied mathematics as well as other branches of engineering will also be considered.

Students pursuing the EE Signals & Systems program should have a bachelor's degree in EE or other related engineering field and be familiar with undergraduate level material in multivariate calculus, differential equations, linear algebra, complex variables, and probability.

ADVANCED PLACEMENT ADMISSIONS FOR M.S. STUDENTS

Applicants to the CSE and EE master's programs who have completed at least four OGI courses may be eligible to apply for admission under the Advanced Placement option. Under this option, applicants are exempt from the GRE and TOEFL requirements and are required to provide only two letters of recommendation. All other admissions requirements remain the same.

For applicants applying to the M.S. CSE degree program through Advanced Placement, the four courses must include at least two, preferably three, courses from the M.S. CSE Breadth Requirements. (see below). The remaining credits must be CS, EE or MATH courses.

For applicants applying to the M.S. EE program through Advanced Placement, it is recommended the four courses include at least two courses from the Computer Engineering and Design Concentration Core or the Signals and Systems Concentration Core. The remaining credits must be EE, CS or MATH courses.

Students must earn an overall grade point average of 3.0 in their course work at OGI and a "B" or better in each M.S. class to be eligible to apply through Advanced Placement.

For M.S. students and Ph.D. students in CSE and EE, a Student Program Committee (SPC)

Department of Computer Science and Electrical Engineering

www.csee.ogi.edu

DEPARTMENT HEAD
Jan van Santen, Ph.D.
503 748-1138
E-mail: vansanten@csee.ogi.edu

ASSISTANT CHAIR FOR EDUCATION
Lisa Pickert
503 748-1581
E-mail: pickertl@ohsu.edu

DEPARTMENT SECRETARY
Barbara Mosher
503 748-1151
E-mail: bmosher@csee.ogi.edu

CS AND EE GENERAL INQUIRIES
503 748-1151
E-mail: cseedept@csee.ogi.edu

CSEE STUDENT ACADEMIC INQUIRIES
503 748-1581
E-mail: advising@csee.ogi.edu

In 2004, Paul McKenny became the first OGI student to earn a Ph.D. in computer science and engineering as a part-time student. McKenny, who also works full-time at IBM's Linux Technology Center, is one of many OGI students who also work in the area's high-technology industry.

that provides academic advising is assigned for each matriculated student. The SPC approves the application of courses toward the student's degree requirements. The program of study for each M.S. student can be tailored to meet individual needs by the SPC or advisor. Students are encouraged to include "special-topic" (506) courses listed on the OGI Class Schedule Web page relevant to their interests.

DEGREE REQUIREMENTS

MASTER OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

M.S. CSE NON-THESIS OPTION

Students choosing the non-thesis M.S. CSE option must complete a minimum of 15 courses and a minimum of 45 credits. Up to six credits of non-thesis research (CS501) may be included with the approval of the student's Student Program Committee (SPC). The first three credits of non-thesis research may be counted as one class, with an additional three credits counting as a second class toward the 15-class requirement.

M.S. CSE THESIS OPTION

Students choosing the thesis option must find a faculty member willing to serve as a thesis advisor. The department does not assign thesis advisors. The thesis option requires a minimum of 45 credits.

- M.S. CS BREADTH (listed below)
- CS 503 M.S. THESIS RESEARCH (minimum 12 credits)
- ELECTIVES (minimum 15 credits), as identified by the thesis advisor or SPC

M.S. CSE PROFESSIONAL INTERNSHIP OPTION

Participation is limited by available industrial internships. Students declaring this option must complete 45 credits of course work and up to an additional three credits of a professional internship (CS504).

Please note: Students may not receive credit for both CS 519 and OMSE 533.

MS CSE BREADTH REQUIREMENTS

To demonstrate **breadth of knowledge**, each graduate of the MS CSE program at OGI is required to have proficiency in each of the following 6 areas:

Programming
Formal Reasoning
System Design
System Interfaces
Applied Computing
Communication Skills

To gain proficiency, each student must take one course in each area.

Programming
CS 511 Compilers
CS 513 Operating Systems
CS 514 Introduction to Databases
CS 529 Object Oriented Programming
CS 541 Database Implementation

Formal Reasoning
CS 532 Analysis of Algorithms
CS 533 Automata Theory,
CS 560 Artificial Intelligence

System Design
CS 516 Introduction to Software Engineering
CS 519 Object Oriented Analysis & Design
CS 520 Software Architecture

System Interfaces
CS 550 Spoken Language Systems
CS 552 Speech Recognition
CS 564 Human Computer Interfaces
CS 567 User Oriented Systems

Applied Computing
CS 547 Statistical Pattern Recognition
CS 559 Machine Learning
CS 562 Natural Language Processing
EE 582 Digital Signal Processing
EE 584 Image Processing
EE 585 Digital Video Processing
EE 588 Biomedical Imaging,
EE 589 Computer Vision

Communication Skills
CS 517 Software Process Engineering
GEN 515 Scientific Proposal Writing
GEN 569 Scholarship Skills
MST 512 Project Management
MST 520 Becoming an Effective Manager
MST 521 Managing People in Organizations
MST 541 Leadership and Negotiation
MST 590 Effective Business Writing
MST 591 Writing for Non-Native Speakers

Other courses can be substituted for the pre-approved courses listed above with consent of the chair of the student's Student Program Committee (SPC) and a faculty member in the breadth area.

MS CSE DEPTH REQUIREMENTS

Depth of knowledge will be gained by pursuing a M.S. Thesis or a specialty track, which typically consists of 4 or 5 courses in a specified area or an individual program of study approved by the student's advisory committee.

TRACKS

Students pursuing the non-thesis option must choose one of the three tracks defined below or consult their SPC to define a custom program.

ADAPTIVE SYSTEMS TRACK

- M.S. CSE BREADTH (listed above)
- ADAPTIVE SYSTEMS CORE (12 credits)

Required:

CS 547	Statistical Pattern Recognition	3 credits
CS 559	Machine Learning	3 credits

Choose two:

CS 550	Spoken Language Systems	3 credits
CS 558	Evolutionary Computation	3 credits
CS 560	Artificial Intelligence	3 credits
CS 562	Natural Language Processing	3 credits
CS 564	Introduction to Human-Computer Interaction	3 credits
CS 568	Empirical Research Methods	3 credits
EE 586	Adaptive and Statistical Signal Processing	3 credits
EE 587	Data & Signal Compression	3 credits

- SUGGESTED ELECTIVES (minimum 15 credits)

CS 506	Appropriate special topics courses	
EE 580	Linear Systems	3 credits
EE 581	Intro to Signals, Systems & Transforms	3 credits
EE 582	Intro to Digital Signal Processing	3 credits
GEN 569	Scholarship Skills	3 credits
MATH 519	Optimization	3 credits
Any CS class not already taken		

HUMAN-COMPUTER INTERACTION TRACK

- M.S. CSE BREADTH (listed above)
- HUMAN-COMPUTER INTERACTION CORE (15 credits)

Required:

CS 560	Artificial Intelligence	3 credits
CS 564	Introduction to Human-Computer Interactions	3 credits

Choose three:

CS 506	Any special topics course in the human computer interaction area such as:	
	3D Graphics	3 credits
CS 550	Spoken Language Systems	3 credits
CS 559	Machine Learning	3 credits
CS 562	Natural Language Processing	3 credits
CS 565	Advanced Topics in Human-Computer Interaction	3 credits
CS 567	Developing User-Oriented Systems	3 credits
CS 568	Empirical Research Methods	3 credits

- SUGGESTED ELECTIVES (minimum 12 credits)

CS 515	Distributed Computing Systems	3 credits

CS 547	Statistical Pattern Recognition	3 credits
CS 551	Structure of Spoken Language	3 credits
CS 552	Hidden Markov Models for Speech Recognition	3 credits
GEN 569	Scholarship Skills	3 credits

Any CS class not already taken.

SPOKEN LANGUAGE SYSTEMS TRACK

- M.S. CSE BREADTH (listed above)
- SPOKEN LANGUAGE SYSTEMS CORE (15 credits)

Any three:

CS 550	Spoken Language Systems	3 credits
CS 551	Structure of Spoken Language	3 credits
CS 552	Hidden Markov Models for Speech Recognition	3 credits
CS 562	Natural Language Processing	3 credits

Any two:

BME 568	Auditory & Visual Processing by Human & Machine	3 credits
CS 547	Statistical Pattern Recognition	3 credits
CS 553	Speech Synthesis	3 credits
CS 559	Machine Learning	3 credits
CS 560	Artificial Intelligence	3 credits
CS 564	Introduction to Human-Computer Interaction	3 credits
CS 567	Developing User-Oriented Systems	3 credits
EE 581	Introduction to Signals, Systems and Transforms	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits

- SUGGESTED ELECTIVES (minimum 12 credits)

Any CS class not already taken

COOPERATIVE COMPUTER SCIENCE PROGRAMS

The OGI School has established undergraduate/graduate cooperative programs with Lewis & Clark College, Pacific University, Reed College and Willamette University. These programs allow selected undergraduate students to enter the master's program in computer science and engineering at the beginning of their senior year. In two years of residence at OGI, the student can simultaneously fulfill requirements for the bachelor's degree at the undergraduate institution and the Master's degree at OGI.

MASTER OF SCIENCE IN ELECTRIAL ENGINEERING

M.S. EE students may pursue either a Computer Engineering and Design Concentration or Signals and Systems Concentration.

M.S. EE DEGREE REQUIREMENTS

COMPUTER ENGINEERING AND DESIGN

The study of computer engineering produces expertise in a range of technologies from basic logic devices and the transistors that implement them, Register-Transfer Level and microarchitectural design, to computer architecture and software systems. The Computer Engineering program is strongly oriented to silicon design from the circuit to the register-transfer level, and to the implementation of general- and special-purpose (such as signal processing) hardware.

For the M.S. EE degree in Computer Engineering and Design, students must complete a minimum of 48 credits with an average GPA of 3.0 or better.

M.S. EE IN COMPUTER ENGINEERING AND DESIGN CORE

All M.S. EE students pursuing the Computer Engineering and Design Concentration must complete the CE&D Concentration core sequence, consisting of the following courses or their equivalent (24 credits):

EE 570	Advanced Logic Design	4 credits
EE 571	System-on-Chip (SoC) Design with Programmable Logic	4 credits
EE 572	Advanced Digital Design-Timing Analysis and Test	4 credits
EE 573	Computer Organization and Design	4 credits
EE 574	CMOS Digital VLSI Design I	4 credits
EE 575	CMOS Digital VLSI Design II	4 credits

M.S. EE NON-THESIS OPTION (COMPUTER ENGINEERING AND DESIGN)

Students choosing the non-thesis option must complete the CE&D Concentration core listed above, and a minimum of 24 credits from the elective courses listed below. Up to 6 credits of non-thesis research (EE501) or independent study (EE502) may be included with the approval of the student's advisor.

M.S. EE THESIS OPTION (COMPUTER ENGINEERING AND DESIGN)

Students choosing the thesis option must find a faculty member willing to serve as a thesis advisor. The department does not assign thesis advisors. Students must complete the CE&D Concentration core listed above, 12 credits from the elective courses listed below, and 12 credits of M.S. Thesis Research (EE503).

ELECTIVE COURSES IN COMPUTER ENGINEERING AND DESIGN

CS 513	Introduction to Operating Systems	3 credits
CS 521	Introduction to Computer Architecture	3 credits
CS 522	Advanced Computer Architecture	3 credits
EE 506	Any special topics course in Electrical Engineering such as: Transmission Line Theory	4 credits
EE 511	Analytical Scanning Electron Microscopy	3 credits
EE 512	Focused Ion Beam Technology	3 credits
EE 513	Transmission Electron Microscopy	3 credits
EE 546	Design of Digital Communication Circuits	4 credits
EE 549	Introduction to Nanomaterials	4 credits
EE 557	Technology of Photoresists	4 credits
EE 560	Introduction to Electronics and Instrumentation	4 credits
EE 561	Analog Integrated Circuit Design	4 credits
EE 562	Digital Integrated Circuit Design	4 credits
EE 563	Analog CMOS Integrated Circuit Design	4 credits
EE 565	Introduction to Wireless Integrated Circuit Design	4 credits
EE 577	Applied Hardware Verification	4 credits
EE 581	Introduction to Signals, Systems, & Transforms	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits
EE 583	Digital Signal Processing II	3 credits
EE 584	Introduction to Image Processing	3 credits
EE 586	Adaptive and Statistical Signal Processing	3 credits
EE 587	Data and Signal Compression	3 credits
MATH 630	Probability and Statistical Analysis	3 credits

A maximum of two of the Management in Science and Technology courses listed below:

MST 512	Project Management	3 credits
MST 520	Becoming an Effective Manager	4 credits
MST 573	Technology Marketing: Planning for Market	4 credits

Students may petition their SPC for elective credit for other OGI CS, EE, BME or MST courses, or PSU ECE courses relevant to the theory or practice of computer engineering.

SUGGESTED ELECTIVE COURSE COMBINATIONS

By appropriate choice of electives students can create a program of courses that provides depth in specific areas, such as those listed below. Suggested courses to achieve this depth are listed. Other combinations of courses can be selected at the option of the student.

CIRCUIT DESIGN

These elective courses provide depth in the design of circuits in the context of state-of-the-art computer design. The circuits focus area includes courses in CMOS digital and analog circuits, and provides a strong background into circuit design for high-speed logic as well as communication.

EE 560	Introduction to Electronics & Instrumentation	4 credits
EE 561	Analog Integrated Circuit Design	4 credits
EE 562	Digital Integrated Circuit Design	4 credits
EE 563	Analog CMOS Integrated Circuit Design	4 credits

COMPUTER ARCHITECTURE

An important specialization in Computer Engineering design is the development of state-of-the-art processors, which covers a very broad area from circuit/logic design to high-level computer architecture. In this

track the student will learn skills and techniques that will allow them to operate at all levels of processor design.

| CS 521 | Introduction to .... 3 credits Computer Architecture |
| CS 522 | Advanced Computer Architecture . . 3 credits |

SIGNAL PROCESSING

These elective courses provide depth in the design of circuits and algorithms for high-speed signal processing. As computers become more diverse and move into more embedded applications and communication, they increasingly have to deal with real-world data, mostly in the form of single or higher dimensional signals. In this track students will learn techniques for designing specialized processing structures for such applications.

EE 581	Introduction to Signals, Systems, . . 3 credits & Transforms
EE 582	Introduction to Digital .... 3 credits Signal Processing
EE 584	Introduction to Image Processing . . 3 credits

M.S. EE SIGNALS AND SYSTEMS CONCENTRATION

This concentration offers a combination of traditional and modern signal processing core courses, supplemented with focused tracks in image processing, speech processing, and machine learning. The track and elective courses allow students to tailor their programs of study. Elective courses are from diverse areas such as biomedical engineering, speech systems, neural networks, and artificial intelligence. Core, track, and elective courses are taught by faculty with unique interdisciplinary backgrounds.

The MS EE concentration in Signals and Systems requires 45 credits for graduation. Upon approval by the student's program committee, alternative courses offered at OGI and some courses offered at PSU can be substituted towards graduation requirements.

M.S. EE NON-THESIS OPTION (SIGNALS AND SYSTEMS)

Degree requirements for the non-thesis option are:

- S & S Concentration core listed below
- Completion of the chosen track requirements as listed below
- Sufficient elective credits to equal a total credit count of 45 for the degree

Up to 6 credits of non-thesis research (EE 501) or independent study (EE 502) may be included with the approval of the student's advisor.

M.S. EE THESIS OPTION (SIGNALS AND SYSTEMS)

Students choosing the thesis option must find a faculty member willing to serve as a thesis advisor. The department does not assign thesis advisors. Requirements for the theses M.S. degree are:

- S & S Concentration core listed below
- Completion of any of the below tracks
- A minimum of 6 to a maximum of 12 credits of EE 503 M.S. Thesis Research
- Successful oral thesis defense

Up to 6 credits of non-thesis research (EE 501) or independent study (EE 502) may be included with the approval of the student's advisor.

SIGNALS AND SYSTEMS CONCENTRATION CORE

Required core courses for all Tracks:

CS 547	Statistical Pattern Recognition
EE 581	Introduction to Signals, Systems and Transforms
EE 582	Introduction to Digital Signal Processing
EE 586	Adaptive and Statistical Signal Processing
MATH 517	Probability and Statistics

MACHINE LEARNING TRACK

The Machine Learning track provides a modern foundation based on statistical techniques including adaptive signal processing, statistical pattern recognition, time series analysis and prediction. The curriculum provides a strong basis in statistical fundamentals as well as a variety of classical and modern tools such as AR models, neural networks, genetic algorithms, and hidden Markov models.

The following courses are required:

CS 510	Evolutionary Computation**
CS 559	Machine Learning
MATH 519	Engineering Optimization

One of:

| EE 580 | Linear Systems* |
| EE 583 | Information Theoretic Signal Processing* |

  *Linear Systems and Information Theoretic Signal Processing classes are offered at alternating years.

  **Course offered through Portland State University.

SPEECH PROCESSING TRACK

The Speech Processing track encompasses all aspects of the synthesis and analysis of speech, including speech recognition, speech synthesis, speech enhancement, speaker recognition, language identification, spoken human-machine dialogue, and voice transformation. The Speech Processing track focuses on the core theories and applications, including spoken language systems, hidden Markov models, speech synthesis, natural language processing, machine learning, and adaptive and statistical signal processing.

The following courses are required:

CS 550	Spoken Language Systems
CS 551	Structure of Spoken Language
CS 552	Hidden Markov Models for Speech Recognition
CS 553	Speech Synthesis

SIGNALS AND IMAGE PROCESSING TRACK

The Signal and Image Processing track provides a comprehensive and solid background for students interested in learning the basic foundations and algorithmic implementations of signal and image processing techniques, and how they are used in real world applications. The courses cover signal processing, image processing, video processing and computer and human vision.

The following courses are required:

EE 584	Introduction to Image Processing
EE 585	Introduction to Digital Video Processing
EE 587	Data and Signal Compression
EE 589	Foundations of Computer Vision

One of:

| EE 580 | Linear Systems* |
| EE 583 | Information Theoretic Signal Processing* |

  *Linear Systems and Information Processing classes are offered in alternating years.

SIGNALS AND SYSTEMS CONCENTRATION SUGGESTED ELECTIVES

Electives include courses from another signals and systems track or the following suggested courses. Courses in other subjects may be included with the approval of the student's program committee.

BME 513	Biomedical Signal Processing I
BME 568	Auditory and Visual Processing by Human and Machine
BME 571	Speech Systems
CS 532	Analysis and Design of Algorithms
CS 560	Artificial Intelligence
CS 562	Natural Language Processing
EE 588	Introduction to Biomedical Imaging
Math 519	Optimization

The following courses offered through Portland State University may also be considered.

	Control Systems Design
	Digital Communications
	Robotics

PH.D. PROGRAMS IN COMPUTER SCIENCE AND ENGINEERING AND ELECTRICAL ENGINEERING

Upon entry into the program a Student Program Committee (SPC) of three faculty members is formed. The student discusses feasible research areas and eventual research directions with the committee and together they chart an individualized course of study.

In addition to the general OGI requirements for a Ph.D., students are required to pass a research-skills assessment. This is addressed through a research proficiency examination (RPE). The RPE requires a written and oral presentation of a research paper and usually takes place in the spring quarter of the second year of residence and after the student has completed the GEN 669 Scholarhsip Skills course.

Ph.D. students must obtain a grade of "B" or better in each required course. Ph.D. students must also complete a doctoral dissertation that documents a significant, original research contribution of publishable quality in both content and presentation.

The faculty strongly recommends that students prepare a formal thesis proposal that is presented publicly, with the dissertation committee in attendance, between 9 and 18 months before the Ph.D. defense. The proposal provides an opportunity for the student to receive feedback to ensure an acceptable level of intellectual vigor and maturity in the dissertation research.

Starting in the second year, the faculty strongly recommends that students deliver yearly research talks. The RPE, presentation at the student research symposium, the thesis proposal and talks at refereed conferences satisfy this requirement. Practice talks for conference papers should be open for commentary.

The program of study for each Ph.D. student is tailored to meet individual needs and interests. Each student's SPC provides academic advising and is in direct control of the student's program of study. The SPC will work with the student to set and review goals

on a twice-yearly basis. Students must write a progress report for all SPC meetings, except the first one.

The entire faculty reviews each Ph.D. student's academic progress annually.

ADDITIONAL REQUIREMENTS FOR CSE PH.D. STUDENTS:

CSE Ph.D. students entering with Masters degrees in computer science are required to take a minimum of 3 graded courses at the 600 level plus GEN 669 Scholarship Skills. Each student's SPC, in consultation with the student, will determine the courses to be taken. Student Program Committees may require students to take additional courses. Computer Science and Engineering Ph.D. students must complete a minimum of 36 credits of Ph.D. dissertation research (CS 603).

Ph.D. students entering without Masters degrees in computer science are required to complete the Masters program at OGI. GEN699 Scholarship Skills, which must be taken, can be used to satisfy the Masters breadth requirement in Communication Skills. Student Program Committees may require students to take additional courses beyond those taken for the Masters degree.

ADDITIONAL REQUIREMENTS FOR EE PH.D. STUDENTS:

Admission to the Ph.D. program in EE generally requires a prior M.S. in Electrical Engineering, Computer Engineering, or related field, whether from OGI of from another institution. Outstanding students who are admitted to the program with only a B.S. degree are required to complete the coursework for an M.S. EE degree. Completion of these credits can be spread out over multiple years to allow early involvement in research and independent studies.

Students should meet with their SPC committee to design an appropriate course of study. For all students, a minimum of 3 graded courses from OGI's EE program must be completed before taking the RPE exam. Electrical Engineering Ph.D. students must complete a minimum of 36 credits of Ph.D. dissertation research (EE 603).

RESEARCH PROGRAMS

The specific research projects under way at any given time depend upon current interests and obligations of faculty, students and research sponsors. Current programs include the following:

Adaptive Systems

Our work on adaptive systems includes theoretical, algorithmic, scientific and practical aspects. Research on theory and algorithms for machine learning includes supervised, unsupervised and reinforcement learning; neural networks; genetic algorithms; generalization theory (model selection and pruning, invariant learning and theoretical characterization); stochastic optimization; local and mixture models; time series; control; and context-sensitive learning. Research on biological and cognitive modeling includes the effect of noise on learning in neural circuits, cognitive models of visual pattern recognition and analogy-making, and modeling of evolutionary systems. Practical applications of our research in these areas include speech and image processing, medical screening technology, environmental forecasting and observation systems, anomaly detection for aeronautics, aircraft control, sensor fusion and optimization, and automatic programming. *Carreira-Perpiñán, Erdogmus, Hayes, Hammerstrom, Leen, Mitchell, Pavel, Roberts, Song, Wan*

Autonomous Unmanned Aerial Vehicles

This multidisciplinary project is exploring the design and implementation of nonlinear reconfigurable controllers that exploit the coupled dynamics between a model of a flight vehicle and adaptive models of the environment. New model-predictive techniques are developed to perform on-line optimization of vehicle control trajectories under dynamic and situational constraints. This program includes both theoretical and algorithmic development of new control algorithms as well as experimental flight testing with small autonomous helicopters. *Wan*

Estimation and Probabilistic Inference

Probabilistic Inference refers to the problem of optimally estimating the hidden variables (states or parameters) of a system given noisy or incomplete observations. Examples include estimating the states (e.g., position and attitude) of a vehicle from sensors, identifying parameters (e.g., mass, moments of inertia or weights of a neural network, target tracking with motion, robot localization, financial forecasting, etc. Our research focuses on fundamental algorithm development and testing of Recursive Bayesian Estimation techniques that exceed traditional Kalman filters. These algorithms, referred to as

Sigma-Point-Kalman filters, include approximate Gaussian methods and hybrids with Sequential Monte-Carlo Methods (e.g., particle filters). *Wan*

Image, Video Processing and Analysis

Both low-level processing and high-level analysis are studied. Special emphasis is on the interface of machine learning and computer vision, where insights from probability theory, stochastic systems and information theory are used to produce new algorithms that are robust, accurate and efficient. Current projects include information fusion, the incorporation of context for image recognition, model-based image segmentation, enhancement and 3-D reconstruction, and motion analysis for autonomous navigation. *Song, Pavel*

Natural Language Dialogue

The performance of speech recognition systems improves significantly when the spoken language understanding system can predict the next utterance. Accordingly, we are performing perceptual studies of dialogue and building models of human and human-computer dialogue in order to develop computational models of conversation that can be used to track and predict spoken language. This work is based on speech-act theory, multiagent architectures and models of spontaneous speech. *Heeman*

Neurobiological Modeling

The brain handles a continuous temporal flow of sensory information. At the microscopic level of the synapses, the relevant signals are the small variable electrophysiological events called synaptic potentials. When learning occurs, there is a change in the relative weighted value of these synaptic potentials. At the macroscopic level of a functional region of the brain, the relevant variables are systems properties of the response to large numbers of cellular inputs. The system needs to optimize the trade-off between accuracy, which may take some time to establish, and adaptability, which often requires rapid adjustment to changes in the sensory environment. This collaborative project combines statistical adaptive system approaches with tools from computational biology and experimental neurophysiology. The present focus is on modeling adaptation in a sensory-motor system in weakly electric mormyrid fish. The modeling forms a bridge between microscopic dynamics and macroscopic system behavior. This project involves a novel aspect of modeling emphasizing statistical properties of then-synaptic adaptation in the presence of noise, and making testable predictions about how noise can affect the accuracy of the fish's stored signal memories. *Leen, Roberts*

Speech Enhancement

Speech Enhancement is concerned with the processing of corrupted or noisy speech in order to improve the quality or intelligibility of the signal. Applications range from front-ends for speech recognition systems, to enhancement of telecommunications for aviation, military, teleconferencing, and cellular environments. Our goal is to develop state-of-the art systems and conduct fundamental research based on nonlinear signal processing, machine learning, and perceptual techniques. This research is in collaboration with the Center for Spoken Language Understanding (CSLU). *Wan*

Speech Recognition

The goal of Large Vocabulary Continuous Speech Recognition research is to enable normal human speech as an input device in next-generation computers alongside today's keyboard and mouse input. This technology can be used by itself for dictation and command control applications. It can also form part of a powerful information processing system when used together with information retrieval and natural language understanding systems. The research focuses include accurate acoustic modeling, speaker adaptation, confidence measure and rejection, and modeling spontaneous speech.

The goal for language and speaker recognition is to identify which language is being used in a conversation and who is talking by using signal processing, pattern recognition and computer science technology. The technology can be used to increase security and customer services. Our research in this area includes how to analyze, identify and capture these nuances and how to model these specific acoustics landmarks and phonotactic constraints contained in the targeted language and speakers. *van Santen, Heeman*

Spoken Language Engineering

Speech is the most natural and efficient means by which individuals may access a wide variety of information, and the need for speech-based interfaces is growing as computing gradually moves off of the desktop and into mobile devices. Spoken language engineering is an interdisciplinary field that draws elements from digital signal processing, computer science, linguistics, machine learning, and human perception. The Center for Spoken Language Understanding (CSLU) has unique breadth and depth of experience in all components of spoken language engineering, including text-to-speech synthesis, speech recognition, dialogue modeling, and signal processing. Research efforts at CSLU include assistive technology, speech as an information source for medical diagnosis, universal access to computers, small-footprint speech recognition and text-to-speech synthesis, and basic research on all aspects of spoken-language processing. *Heeman, Hosom, van Santen, Wan*

Spoken Language Systems

Spoken language systems make it possible for people to interact with computers using speech, the most natural mode of communication. A spoken language system combines speech recognition, natural language understanding and human interface technology. It functions by recognizing the person's words, interpreting the words in terms of the context and goals of the task, and providing an appropriate response to the user. We are involved in the analysis and development of various components of such systems, ranging from empirical studies of human dialogues through the construction of interactive systems to the development of abstract models of behavior. *Heeman, van Santen*

RESEARCH CENTERS

CENTER FOR HUMAN-COMPUTER COMMUNICATION

The Center for Human-Computer Communication is dedicated to realizing a vision of transparent information and service access. Research projects are broadly interdisciplinary, and include collaborations with numerous universities, federal research laboratories, and the Data-Intensive Systems Center at the OGI School of Science & Engineering. Research activities focus on:

- Multimodal human-computer interaction that allows people to state their needs using speech, writing and gestures, and that provides multimedia output.

- User-centered design of next-generation interface technology, including spoken language and multimodal interfaces, and interfaces for mobile and multimedia technology.

- Intelligent agent technologies-software systems that help users accomplish tasks and can reason about how and where to carry out users' requests in a worldwide distributed information environment.

- Collaboration technologies to support human-human communication, and collaborative decision making among groups of people.

CHCC organizes an annual Distinguished Lecture Series on the Future of Human-Computer Interaction. World-class researchers are invited to share current topics.

Dr. Philip Cohen and Dr. Sharon Oviatt are codirectors of the center. OGI faculty involved in the center include: Dr. Peter Heeman and Dr. Misha Pavel. For more information, visit CHCC's Web pages at http://www.cse.ogi.edu/CHCC/.

CENTER FOR SPOKEN LANGUAGE UNDERSTANDING

The research program of the Center for Spoken Language Understanding encompasses a broad range of speech technologies. Such research is inherently multidisciplinary, and the center brings together a team with expertise in signal processing, speech recognition, speech synthesis, dialog modeling, natural language processing, multimodal systems, linguistics and human-computer interaction.

This program focuses on specific problem areas such as: multimodal, interactive reading tutors for children with reading or hearing problems; robust methods for enhancing speech in noisy environments; large vocabulary recognition of continuous speech, as in broadcast news; unit selection and voice conversion for more realistic speech synthesis; robust parsing and interpretation of spoken and multimodal input; modeling of disfluencies in spontaneous speech; and effective methods for dialog management.

The Center for Spoken Language Understanding participates in the masterís and Ph.D. programs of study in the Departments of Biomedical Engineering and Computer Science and Electrical Engineering. Students who are interested in earning a masterís or Ph.D. degree in biomedical engineering, computer science and engineering, or electrical engineering, with specialization in spoken language understanding, should consult the catalog information for those programs and contact an advisor in the Center for Spoken Language Understanding, the Department of Biomedical Engineering or the Department of Computer Science and Electrical Engineering.

FACULTY

JAN P. H. VAN SANTEN

Professor, Director Center for Spoken Language Understanding

Department Head
Ph.D., Mathematical Psychology
University of Michigan, 1979
vansanten@csee.ogi.edu

RESEARCH INTERESTS

Speech timing, intonation, signal processing, statistical analysis of text and speech corpora, and text-to-speech (TTS) system evaluation.

REPRESENTATIVE PUBLICATIONS

J. van Santen and B. Möbius, "A Model of Fundamental Frequency Contour Alignment," in *Intonation: Analysis, Modelling and Technology*, Cambridge University Press, Cambridge, United Kingdom, 2000.

J. van Santen and C. Shih, "Segmental and Suprasegmental Timing in American English and Manadarin Chinese," *Journal of the Acoustical Society of America*, 1012–1026, 2000.

J. van Santen and R. Sproat, "Highaccuracy Automatic Segmentation," *Proceedings of EUROSPEECH 99,* Budapest, Hungary, 1999.

J. van Santen, "Combinatorial Issues in Text-to-speech Synthesis," *Proceedings of EUROSPEECH 97,* Rhodes, Greece, 1997.

J. van Santen and A.L. Buchsbaum, "Methods for Optimal Text Selection," in *Proceedings Eurospeech 1997,* Rhodes, Greece, 1997.

J. van Santen, "Prosodic Modelling in Text-to-speech Synthesis," in *Proceedings Eurospeech, 1997,* Rhodes, Greece, 1997.

J. van Santen, "Segmental Duration and Speech Timing," in Y. Sagisaka, W.N. Campbell and N., Higuchi, eds., *Computing Prosody*, New York, Springer, 1996.

J. van Santen, R.W. Sproat, J. Olive and J. Hirschberg, eds., *Progress in Speech Synthesis*, New York, Springer-Verlag, 1996

MIGUEL Á CARREIRA-PERPIÑÁN

Assistant professor
Ph.D., Computer Science
University of Sheffield, UK, 2001
miguel@csee.ogi.edu

RESEARCH INTERESTS

Machine learning and pattern recognition, with applications to speech processing and computer vision. Computational neuroscience, in particular cortical map models.

REPRESENTATIVE PUBLICATIONS

M. Á. Carreira-Perpiñán and R. S. Zemel (2005): "Proximity graphs for clustering and manifold learning". Advances in Neural Information Processing Systems 17 (NIPS'2004).

M. Á. Carreira-Perpiñán and G. J. Goodhill (2004): "The influence of lateral connections on the structure of cortical maps". J. Neurophysiology 92(5): 2947-2959.

X. He, R. S. Zemel, and M. Á. Carreira-Perpiñán (2004): "Multiscale conditional random fields for image labelling". IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2004), pp. 695-702, Washington, DC, 27 June - 2 July 2004.

M. Á. Carreira-Perpiñán and G. J. Goodhill (2002): "Are visual cortex maps optimized for coverage?". Neural Computation 14(7): 1545-1560.

M. Á. Carreira-Perpiñán (2000): "Mode-finding for mixtures of Gaussian distributions". IEEE Trans. on Pattern Analysis and Machine Intelligence 22(11): 1318-1323.

M. Á. Carreira-Perpiñán (2000): "Reconstruction of sequential data with probabilistic models and continuity constraints". Advances in Neural Information Processing Systems 12 (NIPS'99), pp. 414-420.

M. Á. Carreira-Perpiñán and S. Renals (1999): "Practical identifiability of finite mixtures of multivariate Bernoulli distributions". Neural Computation 12(1): 141-152.

M. Á. Carreira-Perpiñán and S. Renals (1998): "Dimensionality reduction of electropalatographic data using latent variable models". Speech Communication 26(4): 259-282.

DENIZ ERDOGMUS

Assistant Professor
Ph.D., Electrical and Computer Engineering
University of Florida, 2002
deniz@csee.ogi.edu

RESEARCH INTERESTS

Adaptive, nonlinear, and statistical signal/image processing; information theory and its applications to signal processing, learning, and adaptation theories; applications of these principles to biomedical engineering, communications, and control systems.

REPRESENTATIVE PUBLICATIONS

D. Erdogmus, K.E. Hild II, Y.N. Rao, J.C. Principe, "Minimax Mutual Information Approach for Independent Components Analysis," Neural Computation, vol. 16, no. 6, pp. 1235-1252, 2004.

D. Erdogmus, K.E. Hild II, M. Lazaro, I. Santamaria, J.C. Principe, "Adaptive Blind Deconvolution of Linear Channels Using Renyi's Entropy with Parzen Estimation," IEEE Transactions on Signal Processing, vol. 52, no. 6, pp. 1489-1498, 2004.

D. Erdogmus, J.C. Principe, "Lower and Upper Bounds for Misclassification Probability Based on Renyi's Information," Journal of VLSI Signal Processing Systems, vol. 37, no. 2/3, pp. 305-317, 2004.

D. Erdogmus, J.C. Principe, K.E, Hild II, "On-Line Entropy Manipulation: Stochastic Information Gradient," IEEE Signal Processing Letters, vol. 10, no. 8, pp. 242-245, Aug 2003.

Y.N. Rao, D. Erdogmus, G.Y. Rao, J.C. Principe, "Stochastic Error Whitening Algorithm for Linear Filter Estimation with Noisy Data," Neural Networks, vol. 16, no. 5-6, pp. 873-880, Jun 2003.

D. Erdogmus, K.E. Hild II, J.C. Principe, "Blind Source Separation Using Renyi's a-Marginal Entropies," Neurocomputing, vol. 49, no. 1, pp. 25-38, Dec 2002.

D. Erdogmus, J.C. Principe, "An Error-Entropy Minimization Algorithm for Supervised Training of Nonlinear Adaptive Systems,: IEEE Transactions on Signal Processing, vol. 50, no. 7, pp. 1780-1786, Jul 2002.

JULIANA FREIRE

Assistant Professor
Ph.D., Computer Science
State University of New York at Stony Brook, 1997
http://www.cse.ogi.edu/~juliana/
juliana.freire@csee.ogi.edu

RESEARCH INTERESTS

Databases and knowledge-base systems; information integration; management of semi-stuctured data; Web information systems and Internet applications.

REPRESENTATIVE PUBLICATIONS

Vassilis Christophides, Juliana Freire, Eds. Proceedings of the International Workshop on Web and Databases, 2003.

M. Benedikt, C-Y. Chan, W. Fan, J. Freire, and R. Rastogi. "Capturing both Types and Constraints in Data Integration," ACM SIGMOD International Conference on Management of Data, 2003.

P. Bohannon, J. Freire, J.R. Haritsa, M. Ramanath, P. Roy and J. Siméon, "Bridging the XML-Relational Divide with LegoDB: A Demonstration," IEEE International Conference on Data Engineering (ICDE), 2003.

J. Freire, J.R. Haritsa, M. Ramanath, P. Roy and J. Siméon, "StatiX: Making XML Count," ACM SIGMOD International Conference on Management of Data, pp. 181-192, 2002.

J. Freire and J. Simeon, "Adaptive XML Shredding: Architecture, Implementation, and Challenges," Efficiency and Effectiveness of XML Tools, and Techniques (EEXTT), pp. 104-116, 2002.

P. Bohannon, J. Freire, J.R. Haritsa, M. Ramanath, P. Roy and J. Siméon, "LegoDB: Customizing Relational Storage for XML Documents," Very Large Databases Conference (VLDB), pp. 1091-1094, 2002.

M. Benedikt, J. Freire and P. Godefroid, "VeriWeb: Automatically Testing Dynamic Web Sites," International World Wide Web Conference (WWW), 2002.

P. Bohannon, J. Freire, P. Roy and J. Siméon, "From XML Schema to Relations: A Cost-based Approach to XML Storage," IEEE International Conference on Data Engineering (ICDE), pp. 64-75, 2002.

PETER A. HEEMAN

Assistant Professor
Ph.D., Computer Science
University of Rochester, 1997
heeman@csee.ogi.edu

RESEARCH INTERESTS

Spontaneous speech recognition;
modeling disfluencies and
intonation; dialogue
management; collaboration;
spoken dialogue systems;
natural language processing.

REPRESENTATIVE PUBLICATIONS

P. Heeman, S. Yaruss and
A. McMillin, "Towards a Detailed
Annotation Scheme for Clustered
Disfluencies", in the Workshop on
The Characteristics and Assessment
of Stuttered Speech, London England,
June 2005.

P. Heeman, F. Yang, A. Kun and
A. Shyrokov, "Conventions in Human-
Human Multi-threaded Dialogues:
A Preliminary Study", in International
Conference on Intelligent User
Interfaces, San Diego CA, Jan, 2005.

F. Yang and P. Heeman, "Using
Computer Simulation to Compare
Two Models of Mixed-Initiative", in
Proceedings of the 8th International
Conference on Spoken Language
Processing, Oct, 2004 .

P. Heeman and F.Yang and S. Strayer,
"Control in Task-Oriented Dialogues",
in Proceedings of the 8th European
Conference on Speech Communication
and Technology (Eurospeech), pp. 209-
212, Geneva Switzerland, Sep, 2003.

P. Heeman, F. Yang and S. Strayer,
DialogueView: An annotation tool for
dialogue,Third SIGdial Workshop on
Discourse and Dialogue, 2002.

P. Heeman and J. Allen, Speech
Repairs, Intonational Phrases and
Discourse Markers: Modeling
Speakers' Utterances in Spoken
Dialog, Computational Linguistics,
Vol. 25-4, 1999.

RICHARD B. KIEBURTZ

Professor Emeritus
Ph.D., Electrical Engineering
University of Washington, 1961
dick@csee.ogi.edu

RESEARCH INTERESTS

Functional programming; program
transformation; domain-specific
languages; program verification;
high-confidence software.

REPRESENTATIVE PUBLICATIONS

R.B. Kieburtz, "Real-time Reactive
Programming for Embedded
Controllers," QAPL 2001,
September 2001.

R.B. Kieburtz, "A Logic for Rewriting
Strategies," Strategies '01, June 2001.

R.B. Kieburtz, "Defining and
Implementing Closed Domain-Specific
Languages," SAIG '00, September 2000.

R.B. Kieburtz, "Taming Effects
with Monadic Typing," in Proc. 3rd
International Conf. on Functional
Programming, ACM Press, April 1998.

R.B. Kieburtz, "Reactive Functional
Programming," in PROCOMET'98,
pp. 263-284, Chapman and Hall,
June 1998.

R.B. Kieburtz, L. McKinney, J. Bell,
J. Hook, A. Kotov, J. Lewis, D. Oliva,
T. Sheard, I. Smith and L.Walton, "A
Software Engineering Experiment in
Software Component Generation," in
Proceedings of the 18th International
Conference on Software Engineering,
Berlin, March 1996.

R.B. Kieburtz, F. Bellegarde, J. Bell,
J. Hook, J. Lewis, D. Oliva, T. Sheard,
L. Walton and T. Zhou, "Calculating
Software Generators from Solution
Specifications," TAPSOFT '95, Springer-
Verlag, series LNCS, 915, 546, 1995.

R.B. Kieburtz, "Programming with
Algebras," in *Advanced Functional
Programming*, E. Meijer and J.Jeuring,
eds., Springer-Verlag, Series LNCS,
Vol. 925, 1995.

R.B. Kieburtz, "Results of the SDRR
Validation Experiment," Pacific
Software Research Center Software
Design for Reliability and Reuse:
Phase I Final Scientific and Technical
Report, Vol. VI, CDRL No. 0002.11,
February 1995

JOHN LAUNCHBURY

Professor
Ph.D., Computing Science
University of Glasgow, 1990
jl@csee.ogi.edu

RESEARCH INTERESTS

Functional programming
languages; semantics-based
program analysis; program
transformation and partial
evaluation.

REPRESENTATIVE PUBLICATIONS

J. Lewis, M. Shields, E. Maijer and
J. Launchbury, "Implicit Parameters,"
Implicit Parameters, ACM Principles of
Programming Languages, 2000.

J. Matthews and J. Launchbury,
"Elementary Microarchitecture
Algebra," *Computer Aided
Verification,* 1999.

J. Launchbury, J. Lewis and B. Cook.
"On Embedding a Microarchitecture
Design Language within Haskell,"
International Conference on Functional
Programming, ACM, 1999.

J. Launchbury and A. Sabry,
"Axiomatization and Type Safety
of Monadic State," Proc. ACM
International Conference on Functional
Programming, 1997.

J. Launchbury and R. Paterson,
"Parametricity and Unboxing with
Unpointed Types," Proc. European
Symposium on Programming,
Linkoping, 1996.

J. Launchbury and S.P. Jones, "State
in Haskell," *J. of Lisp and Symbolic
Computation*, December 1995.

J. Launchbury and S.P. Jones, "Lazy
Functional State Threads," in Proc.
SIGPLAN Programming Languages
Design and Implementation, Orlando,
Fla., 1994.

A. Gill, J. Launchbury and S.P. Jones,
"A Short Cut to Deforestation," in
Proc. SIGPLAN/SIGARCH Functional
Programming and Computer
Architecture, Copenhagen, 1993.

J. Launchbury, "A Natural Semantics
for Lazy Evaluation," in Proc. SIGPLAN
Principles of Programming Languages,
Charleston, S.C., 1993.

J. Hughes and J. Launchbury,
"Projections for Polymorphic
First- Order Strictness Analysis," in
*Mathematical Structures in Computer
Science*, 2, 301, C.U.P., 1992.

TODD K. LEEN

Professor
Ph.D., Physics
University of Wisconsin, 1982
tleen@csee.ogi.edu

RESEARCH INTERESTS

Machine Learning: Local and
mixture models, stochastic
learning, and Bayesian methods
with applications to environmental
sensor network monitoring, data
and model/data fusion, and fault
detection. Computational
neuroscience.

REPRESENTATIVE PUBLICATIONS

Semi-supervised Learning with
Penalized Probabilistic Clustering,
Zhengdong Lu and Todd K. Leen.
Advances in Neural Information
Processing Systems 17, 2005.

Random walks for spike-timing-
dependent plasticity, Alan Williams,
Todd Leen, and Pat Roberts, Physical
Review E, 70, 021916, 2004.

Parameterized Novelty Detection for
Environmental Sensor Monitoring,
Cynthia Archer, Todd Leen, Antonio
Baptista. Advances in Neural Information
Processing Systems 16 (2004).

Stability of Negative-Image Equilibria
in Spike-Timing-Dependent Plasticity,
Alan Williams, Pat Roberts, and Todd K.
Leen, Physical Review E, 68, 2003.

A Generalized Lloyd-type Algorithm
for Adaptive Transform Coder Design,
Cythia Archer and Todd Leen, IEEE
Transactions on Signal Processing, 52,
1, 255-264, 2004.

Fault Detection for Salinity Sensors in
the Columbia River Estuary, Cynthia
Archer, Antonio Baptista, and Todd
Leen, Water Resources Research, 39, 3,
19 March, 2003.

Bayesian Sensor Image Fusion Using
Local Linear Generative Models, Ravi
K. Sharma, Todd K. Leen, and Misha
Pavel, Optical Engineering, 40, 1364-
1376, July, 2001.

The Coding Optimal Transform, C.
Archer and T. Leen, in Data
Compression Conference 2001, IEEE
Computer Society Press, 2001.

From Mixtures of Mixtures to
Adaptive Transform Coding, C. Archer
and T. Leen, in T. Leen, T. Dietterich, V.
Tresp (eds.), Advances in Neural
Information Processing Systems 13,
The MIT Press, 2001.

JOHN MATTHEWS

Assistant Professor
Ph.D., Computer Science
Oregon Graduate Institute, 2000
johnm@csee.ogi.edu

RESEARCH INTERESTS

Formal verification; theorem proving; model checking; specification languages; functional and constraint logic programming languages.

REPRESENTATIVE PUBLICATIONS

L. Lamport, J. Matthews, M. Tuttle and Y. Yu, "Specifying and Verifying Systems With TLA+," Tenth ACM SIGOPS European Workshop: Can we really depend on an OS?, Saint-Emilion, France, September 2002 (to appear).

S. Krstic and J. Matthews, "Verifying BDD Algorithms through Monadic Interpretation," Proceedings of the Third International Workshop on Verification, Model Checking and Abstract Interpretation, Venice, Italy, January 2002.

J. Matthews, "Recursive Function Definition over Coinductive Types," Proceedings of the 12th International Conference on Theorem Proving in Higher Order Logics, Nice, France, LNCS Vol. 1690, September 1999.

J. Matthews and J. Launchbury, "Elementary Microarchitecture Algebra," Proceedings of the 11th International Conference on Computer Aided Verification, Trento, Italy, LNCS Vol. 1633, July, 1999.

B. Cook, J. Launchbury and J. Matthews, "Specifying Superscalar Microprocessors in Hawk," Workshop on Formal Techniques for Hardware and Hardware-like Systems, Marstrand, Sweden, June 1998.

J. Matthews, J. Launchbury and B. Cook, "Microprocessor Specification in Hawk," Proceedings of the IEEE International Conference on Computer Languages 1998, Chicago, May 1998.

BRIAN E. ROARK

Assistant Professor
Ph.D., Linguistics
Brown University, 2001
roark@cslu.ori.edu

RESEARCH INTERESTS

Parsing of text and speech; language modeling for automatic speech recognition; supervised and unsupervised learning of language and parsing models; weighted finite-state approaches to language processing,

REPRESENTATIVE PUBLICATIONS

M. Bacchiani, M. Riley, B. Roark and R. Sproat. "MAP Adaptation of Stochastic Grammars," To appear in Computer Speech and Language.

B. Roark, M. Saraclar, M. Collins, and M. Johnson. "Discriminative language modeling with conditional random fields and the perceptron algorithm," In Proceedings of the 42nd Annual Meeting of the ACL, Barcelona, 2004.

B. Roark. "Robust garden path parsing," Natural Language Engineering, 10(1), 1-24, 2004.

S.R. Maskey, M. Bacchiani, B. Roark, and R. Sproat. "Improved name recognition with meta-data dependent name networks," In Proceedings of ICASSP, Montreal, 2004.

C. Allauzen, M. Mohri, and B. Roark. "Generalized algorithms for constructing language models," In Proceedings of the 41st Annual Meeting of the ACL, Sapporo, Japan, 2003.

B. Roark and M. Bacchiani. "Supervised and unsupervised PCFG adaptation to novel domains," In Proceedings of HLT-NAACL, Edmonton, Canada, 2003

M. Bacchiani and B. Roark. "Unsupervised language model adaptation," In Proceedings of ICASSP, Hong Kong, 2003.

B. Roark. "Markov parsing: lattice rescoring with a statistical parser," In Proceedings of the 40th Annual Meeting of the ACL, Philadelphia, 2002.

B. Roark. "Probabilistic top-down parsing and language modeling," Computational Linguistics, 27(2), 249-276, 2001.

CLÁUDIO T. SILVA

Associate Professor
Ph.D., Computer Science
State University of New York
at Stony Brook, 1996
csilva@csee.ogi.edu

RESEARCH INTERESTS

Computer graphics; scientific visualization; applied computational geometry; high performance computing.

REPRESENTATIVE PUBLICATIONS

R. Cook, N. Max, C. Silva, and P. Williams, "Image-Space Visibility Ordering for Cell Projection Volume Rendering of Unstructured Data", *IEEE Transactions on Visualization and Computer Graphics* (to appear).

S. Fleishman, M. Alexa, D. Cohen-Or and C. Silva, "Progressive Point Set Surfaces," *ACM Transactions on Graphics* (to appear).

W. Corrêa, J. Klosowski and C. Silva, "Out-Of-Core Sort-First Parallel Rendering for Cluster-Based Tiled Displays," *Parallel Computing*, **29**, 325-338, 2003.

M. Alexa, J. Behr, D. Cohen-Or, S. Fleishman, C. Silva and D. Levin, "Computing and Rendering Point Set Surfaces," *IEEE Transactions on Visualization and Computer Graphics*, **9**(1), 3-15, 2003.

R. Farias and C. Silva, "Out-Of-Core Rendering of Large Unstructured Grids," *IEEE Computer Graphics and Applications*, **21**(4), 42-50, 2001.

P. Lindstrom and C. Silva, "A Memory Insensitive Technique for Large Model Simplification," IEEE Visualization 2001, pp. 121-126.

J. El-Sana, N. Sokolovsky and C. Silva, "Integrating Occlusion Culling with View-Dependent Rendering," IEEE Visualization 2001, pp. 371-378.

J. Klosowski and C. Silva, "The Prioritized-Layered Projection Algorithm for Visible Set Estimation," *IEEE Transactions on Visualization and Computer Graphics*, **6**(2), 108-123, 2000.

B. Wei, C. Silva, E. Koutsofios, S. Krishnan and S. North. "Visualization Research with Large Displays," *IEEE Computer Graphics and Applications*, **20**(4), 50-54, 2000.

XUBO SONG

Assistant Professor
Ph.D. Electrical Engineering
California Institute of Technology, 1999
xubosong@csee.ogi.edu

RESEARCH INTERESTS

Digital image and video processing; statistical pattern recognition; machine learning; sensor fusion; computer vision; information theory; biomedical engineering.

REPRESENTATIVE PUBLICATIONS

Song X.B., Yang K., Pavel M., "Robust Density Estimation via Boosting", International Conference on Neural Information Processing, 2004.

Song X.B., Pavel P., "Performance Analysis of Classifier Combination Using Majority Vote", International Conference on Neural Information Processing, 2004.

G. Wang, M. Pavel, X. Song, "Robust Recognition Based on Combination of Weak Classifiers," International Joint Conference of Neural Networks, July 2003.

X. Song, Y.S. Abu-Mostafa, J. Sill, H.L. Kasdan and M. Pavel, "Image Recognition by Fusion of Contextual Information," *Information Fusion Journal* **3**, 277-287, 2002.

A. Adami, K. Yang, X. Song, M. Pavel and D. Dirschl, "Model-based Image Processing and Analysis for Fracture Classification," The Second Joint Meeting of the IEEE Engineering in Medicine and Biology Society (EMBS) and the Biomedical Engineering Society (BMES), 2002.

X. Song, Y. Abu-Mostafa, J. Sill and H. Kasdan, "Image Recognition in Context: Application to Microscopic Urinalysis," in Advances in Neural Information Processing Systems, S.A. Solla, T.K. Leen, and K.R. Muller (eds.), MIT Press, pp. 963-969, 2000.

X. Song, Y. Abu-Mostafa, J. Sill and H. Kasdan, "Incorporating Contextual Information into White Blood Cell Image Recognition," in Advances in Neural Information Processing Systems, M.I. Jordan, M.J. Kearns, and S.A. Solla (eds.), MIT Press, pp. 950-956, 1998.

ERIC A. WAN

Associate Professor
Ph.D., Electrical Engineering
Stanford University, 1994
ericwan@csee.ogi.edu

RESEARCH INTERESTS

Learning algorithms and architectures for neural networks and adaptive signal processing; applications to time-series prediction, speech enhancement, adaptive control and telecommunications.

REPRESENTATIVE PUBLICATIONS

E.A. Wan, A.A. Bogdanov, R. Kieburtz, A. Baptista, M. Carlsson, Y. Zhang and M. Zulauf, "Model Predictive Neural Control for Aggressive Helicopter Maneuvers," IEEE volume on Software-Enabled Control, T. Samad and G. Balas (eds.), 2003.

E.A. Wan and R. van der Merwe, "The Unscented Kalman Filter," in *Kalman Filtering and Neural Networks*, S. Haykin (ed.), John Wiley & Sons, 2001.

E. Wan, and A. Nelson, "Networks for Speech Enhancement," in *Handbook of Neural Networks for Speech Processing*, S. Katagiri (ed.), Artech House, Boston, 1999.

E. Wan and F. Beaufays, "Diagrammatic Methods for Deriving and Relating Temporal Neural Networks Algorithms," in Adaptive Processing of Sequences and Data Structures," Lecture Notes in Artificial Intelligence, M. Gori, and C.L. Giles (eds.), Springer Verlag, 1998.

E. Wan, and A. Nelson, "Neural Dual Extended Kalman Filtering: Applications in Speech Enhancement and Monaural Blind Signal Separation," IEEE Workshop on Neural Networks and Signal Processing, 1997.

E. Wan, "Adjoint LMS: An Alternative to Filtered-X LMS and Multiple Error LMS," ICASSP96, 3, 1842-1845, 1996.

E. Wan, "Time Series Prediction Using a Neural Network with Embedded Tapped Delay-Lines," in *Predicting the Future and Understanding the Past*, A. Weigend, and N. Gershenfeld (eds.), SFI Studies in the Science of Complexity, Proc., 17, Addison-Wesley, 1993.

E. Wan, "Discrete Time Neural Networks," *Journal of Applied Intelligence*, 3(1), 91-105, 1993.

INSTRUCTORS

JOHN D. LYNCH, B.S.

Electrical Engineering
University of Utah, 1979
jdlynch@csee.ogi.edu

REPRESENTATIVE PUBLICATIONS

J. Lynch, D. Hammerstrom and R. Kravitz, "A Cohesive FPGA-based System-on-Chip Design Curriculum", Proceedings of the International Conference on Microelectronic Systems Education, Anaheim, June 2005

J. Lynch and H. Schiefer, "Concurrent Engineering Delivers at the Chip and System Level," Integrated System Design, December 1997

JOHN M. HUNT, M.S.

Electrical Engineering
Johns Hopkins, 1979
johnhunt@csee.ogi.edu

JOINT FACULTY

ANTÓNIO BAPTISTA, PH.D.

Environmental & Biomolecular Systems
OGI School of Science & Engineering

ANDREW BLACK, PH.D.

Department of Computer Science
Portland State University

LOIS DELCAMBRE, PH.D.

Department of Computer Science
Portland State University

WU-CHANG FENG, PH.D.

Department of Computer Science
Portland State University

WU-CHI FENG, PH.D.

Department of Computer Science
Portland State University

DAN HAMMERSTROM, PH.D.

College of Engineering & Computer Science
Department of Electrical and Computer Engineering
Portland State University

TAMARA HAYES, PH.D.

Biomedical Engineering
OGI School of Science & Engineering

JAMES HOOK, PH.D.

Department of Computer Science
Portland State University

JOHN-PAUL HOSOM, PH.D.

Biomedical Engineering
OGI School of Science & Engineering

DAVID MAIER, PH.D.

Department of Computer Science
Portland State University

SHANNON K. MCWEENEY, PH.D.

Public Health and Preventive Medicine
Oregon Health & Science University

MELANIE MITCHELL, PH.D.

Department of Computer Science
Portland State University

MISHA PAVEL, PH.D.

Biomedical Engineering
OGI School of Science & Engineering

ANDREW TOLMACH, PH.D.

Department of Computer Science
Portland State University

ADJUNCT FACULTY

MARK ANDERS
Intel Corporation

AHMAD ARABI
Consultant

ROBERT BAUER
Rational Software Corp.

C. MIC BOWMAN, PH.D.
Intel Corporation

SHEKHAR BORKAR
Intel Corporation

BRENT CAPPS Zenobia
Oregon Master of Software Engineering

CRISPIN COWAN
Immunix

CHRISTOPHER DUBAY, PH.D.
Oregon Health & Science University

DAVID EVANS
Sharp Labs

ANREW GILL, PH.D.
Galois

ROY HALL
Crisis in Perspective

DAVID HANSEN
George Fox University

HOWARD HECK
Intel Corporation

MARWAN JABRI
Industry Consultant

ROY KRAVITZ
RadiSys Corporation

SAVA KRSTIC, PH.D.
Intel Corporation

JAMES LARSON, PH.D.
Intel Corporation
Larson Technical Services

SUDARSHAN MURTHY
Portland State University

WAYNE MUSIC, PH.D.
Lattice Semiconductor
Harish Muthali

SANJEEV QAZI
Intel Corporation

KARTIK RAOL
Intel Corporation

BART RYLANDER
University of Portland

STEWART TAYLOR
Maxim

PAUL THADIKARAN, PH.D.
Intel Corporation

THOMAS THOMAS
Intel Corporation

JAMES TSCHANZ
Intel Corporation

REBECCA WIRFS-BROCK
Wirfs-Brock Associates

MAZIN YOUSIF, PH.D.
Intel Corporation

MICHAEL ZASLAVSKY
Intel Corporation

The mission of the DEPARTMENT OF ENVIRONMENTAL AND BIOMOLECULAR SYSTEMS is to study physical, chemical and biological processes that occur naturally or result from the interaction of humans with the environment, emphasizing approaches that are possible through novel advances in biomolecular, genetic, computational and information sciences and technology.

Three over-arching goals characterize our research and education programs:

- Fundamental understanding of processes at molecular, cellular and particle levels
- Integrative, process-based understanding of ecosystems and other complex environmental and biological systems
- Effective integration of science in society's approaches to ecosystem health, human health, and economic development

Prospective students are asked to carefully examine faculty research interests and departmental research programs to determine whether their specific professional goals can be fulfilled at OGI in the Department of Environmental and Biomolecular Systems. Communication with individual faculty members is encouraged before applying or enrolling.

DEGREES OFFERED

The EBS department offers four degrees:

Master of Science in Environmental Science and Engineering
    Optional Environmental Information Technology Track

Doctor of Philosophy in Environmental Science and Engineering
    Optional Environmental Information Technology Track

Master of Science in Biochemistry and Molecular Biology

Doctor of Philosophy in Biochemistry and Molecular Biology

M.S. degrees are available in the thesis or non-thesis options. The thesis option generally requires up to eight academic quarters, and the non-thesis option can generally be completed in four academic quarters.

ENVIRONMENTAL SCIENCE AND ENGINEERING (ESE)

The ESE degree balances practical applications with fundamental investigations of the physical, chemical and biological processes underlying environmental phenomena. Degrees in Environmental Science and Engineering prepare students for careers in environmental management, practice, or research. The curriculum is highly interdisciplinary and is built on a solid foundation of fundamental science and engineering.

- #### ENVIRONMENTAL INFORMATION TECHNOLOGY (EIT) TRACK

    The EIT track combines the expertise and coursework found in the Department of Environmental and Biomolecular Systems and in the Department of Computer Science and Electrical Engineering (CSEE). The goal of the EIT track is to combine a deep understanding of environmental processes with mastery of sensing, modeling and information technology. The EIT curriculum includes fundamental courses, science courses, technology courses, electives and capstone integrative courses.

BIOCHEMISTRY AND MOLECULAR BIOLOGY (BMB)

The BMB degree offers students immediate participation in research upon entering. This early exposure to research allows each student to become familiar with the variety of activities represented in the EBS Department and aids the student in thesis research selection. Degrees in Biochemistry and Molecular Biology prepare students for careers in the biotechnology industry; academic, medical, and corporate research; and can meet the advanced technical degree requirement for patent attorneys.

Department of Environmental and Biomolecular Systems
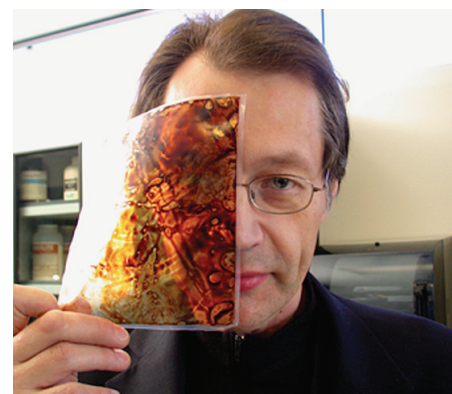
Prof. James Pankow's news-making nicotine research is an example of how the EBS Department focuses on the connections between human health and the environment. His "smoke in a bag" demonstration shows how the smoke residue from one pack of cigarettes can affect the lungs.

ADMISSION REQUIREMENTS

In addition to the general OGI admission requirements, the Department requires the following:

ENVIRONMENTAL SCIENCE AND ENGINEERING (M.S. AND PH.D.)

GRE general scores are required. GRE subject scores are not required. TOEFL minimum score is 600 for the paper-based test or 250 for the computer-based test.

BIOCHEMISTRY AND MOLECULAR BIOLOGY (M.S.)

GRE scores are not required. TOEFL minimum score is 550 for the paper-based test or 213 for the computer-based test.

BIOCHEMISTRY AND MOLECULAR BIOLOGY (PH.D.)

GRE general scores and GRE subject scores for one of the following tests are required: (a) Biology; (b) Chemistry; or (c) Biochemistry, Cell and Molecular Biology. TOEFL minimum score is 550 for the paper-based test or 213 for the computer-based test.

APPLICATION DEADLINES

Applications for fall quarter received by March 1 receive priority review for admission and financial support. Applicants are encouraged to complete the application process by July 31 for fall quarter admission. Applications are accepted year-round. However, M.S. applications for the Biochemistry and Molecular Biology track are advised to seek fall quarter admission due to the sequence of required courses; admission in other quarters will be decided on a case-by-case basis. Ph.D. applications for admission in quarters other than fall are considered on the basis of available space and financial assistance.

CREDITS FROM OTHER OHSU DEPARTMENTS

Up to eight credits from courses taken in other OHSU departments may be applied to the BMB or ESE programs. The Student Program Committee (SPC) must first approve the credits from other OHSU departments.

DEPOSIT

Upon acceptance to the EBS Department, students in the M.S. programs are required to pay a nonrefundable deposit of $100, which will be applied to the tuition payment for the first academic quarter.

DEGREE REQUIREMENTS

ENVIRONMENTAL SCIENCE AND ENGINEERING

Students may pursue the Ph.D. program or M.S. program (non-thesis or thesis) in Environmental Science and Engineering (ESE). Within the ESE degree, a student may focus on the specialty track of Environmental Information Technology (EIT). Students who complete the EIT track receive their degree in Environmental Science and Engineering and complete different course distribution requirements.

Full-time in-residence M.S. and Ph.D. students are required to enroll in the EBS Department Seminar (EBS 507A/607A) each academic quarter, except summer. This non-credit course does not count toward degree credit requirements and there is no additional tuition charged for this course.

M.S. IN ENVIRONMENTAL SCIENCE AND ENGINEERING

M.S. NON-THESIS OPTION

Students pursuing the M.S. non-thesis option must complete at least 45 credit hours of coursework. These credits include the distribution requirements (listed below) and additional courses selected with the approval of the Student Program Committee (SPC). A maximum of eight credit hours may be granted for approved participation in non-thesis research and/or a professional internship. Comprehensive examinations are not required.

M.S. THESIS OPTION

Students pursuing the M.S. thesis option must complete at least 45 credits of coursework. These credits include the distribution requirements (listed below), additional courses selected with the approval of the SPC, and research credits. M.S. thesis research (EBS 503) is usually no more than nine credits. A written M.S. dissertation with an oral defense is required. Comprehensive examinations are not required.

PH.D. IN ENVIRONMENTAL SCIENCE AND ENGINEERING

Ph.D. students must complete at least 52 credit hours of coursework. These credits include the distribution requirements (listed below) and additional courses selected with the approval of the SPC. Ph.D. candidates must pass a two-part comprehensive examination. The first part is a written examination covering four subject areas selected by the department. The second part is the preparation and oral defense of a proposal that defines the student's Ph.D. dissertation research. A written Ph.D. dissertation with an oral defense is required.

ESE DISTRIBUTION REQUIREMENTS

To achieve the necessary breadth in training, M.S. and Ph.D. ESE students take courses that cover a range of scientific disciplines and environmental media. Five courses must be taken to satisfy the following distribution requirements. No course can satisfy more than one requirement. The following courses are representative of the courses available in each discipline. Alternative courses may be accepted towards distribution requirements with prior approval from the student's SPC.

At least 1 course must be taken from 3 of the following 4 discipline groups:

APPLIED MATHEMATICS

EBS 547/547	Uncertainty Analysis
EBS 550/650	Environmental Systems Analysis
EBS 555/655	Computational Fluid Dynamics
EBS 561/661	Introduction to Spatial Sciences
MATH 511/611	Introduction to Discrete Numerical Methods

CHEMISTRY

EBS 510/610	Aquatic Chemistry
EBS 511/611	Advanced Aquatic Chemistry
EBS 535/635	Distribution and Fate of Organic Pollutants
EBS 537/637	Chemical Degradation and remediation

FLUID DYNAMICS

EBS 560/660	Introduction to Environmental Observation and Forecasting Systems
EBS 574/674	Introduction to Environmental Forecasting Systems
EBS 575/675	Transport Processes
EBS 578/678	Methods in Estuarine Oceanography: Field Observation

BIOLOGY

EBS 590/690	Environmental Microbiology
EBS 593/693	Biodegradation and Bioremediation

At least 1 course must be taken from 2 of the following 3 environmental media groups:

SURFACE WATERS

EBS 560/660	Introduction to Environmental Observation and Forecasting Systems
EBS 575/675	Transport Processes
EBS 578/678	Methods in Estuarine Oceanography: Field Observation
EBS 581/681	Ecosystem Management and Restoration

GROUNDWATER

EBS 570/670	Groundwater and Watershed Hydrology
EBS 571/671	Groundwater Modeling
EBS 572/672	Contaminant Hydrology
EBS 573/673	Modeling in Contaminant Hydrogeology

AIR

EBS538/638	Air Pollution: Origins, Chemistry and Control

Students in the EIT track have customized distribution requirements defined by their SPC.

BIOCHEMISTRY AND MOLECULAR BIOLOGY

Students may pursue the Ph.D. program or M.S. program (non-thesis or thesis options) in BMB.

Full-time in-residence M.S. and Ph.D. students are required to enroll in the EBS Department Seminar (EBS 507A/607A) each academic quarter, except summer. This non-credit course does not count toward degree credit requirements and there is no additional tuition charged for this course.

M.S. IN BIOCHEMISTRY AND MOLECULAR BIOLOGY

M.S. NON-THESIS OPTION

Students pursuing the M.S. non-thesis option must satisfactorily complete at least 44 credits; 28 in graded courses and 16 derived from an experimental research project (EBS 501), and complete a written report on the research.

The 28 credits in graded courses must include (12 credits):

EBS 512	Biochemistry I: Proteins and Enzymes
EBS 513	Biochemistry II: Introduction to Molecular Biology
EBS 514	Biochemistry III: Metabolism and Bioenergetics

Plus 16 or more credits in
Advanced courses (EBS 525 - 598)
Student Seminars (EBS 507B or 507C)
Reading Groups (EBS 505A, B, C, D)
Special Topics (EBS 506)

Research for the M.S. non-thesis option is typically a specific contribution to a larger project, providing the student with extensive hands-on experience in biochemical and molecular biological techniques.

M.S. THESIS OPTION

The M.S. thesis option is a research degree that requires satisfactory completion of at least 44 credits; 20 of which are in graded courses, and a written thesis based on independent research (EBS 503).

The 20 credits in graded courses must include (12 credits):

EBS 512	Biochemistry I: Proteins and Enzymes
EBS 513	Biochemistry II: Introduction to Molecular Biology
EBS 514	Biochemistry III: Metabolism and Bioenergetics

Plus 8 or more credits in
Advanced courses (EBS 525 - 598)
Student Seminars (EBS 507B or 507C)
Reading Groups (EBS 505A, B, C, D)
Special Topics (EBS 506)

PH.D. IN BIOCHEMISTRY AND MOLECULAR BIOLOGY

Ph.D. students are required to take:

EBS 612	Biochemistry I: Proteins and Enzymes
EBS 613	Biochemistry II: Introduction to Molecular Biology
EBS 614	Biochemistry III: Metabolism and Bioenergetics

Plus three of the following core courses:

EBS 625	Bioenergetics and Membrane Transport
EBS 628	Enzyme Structure, Function and Mechanisms
EBS 640	Instrumental Methods in Biophysics I
EBS 685	Advanced Molecular Biology
EBS 687	Molecular Cell Biology

Courses in other departments and schools within OHSU may be substituted for the core course requirements with permission of the SPC. The SPC may also require additional courses based upon the particular research interests and needs of the student.

Ph.D. Students must register for 12 credits per academic quarter. These credits typically include available courses, Student Seminars (EBS 607B or 607C), and Research (EBS 601 or 603).

The qualifying examination for the Ph.D. is a comprehensive examination in Biochemistry. It must be completed within 2 years of entering the school.

A written Ph.D. dissertation with an oral defense is required.

RESEARCH PROGRAMS

(alphabetically by faculty name)

CORIE: A Multipurpose Coastal Observatory

Operating since 1996, CORIE is a multipurpose coastal observatory for the Columbia River (http://www.ccalmr.ogi.edu/ CORIE). The motivation of this research program is twofold. First, the Columbia River and its near-shore plume are a dominant oceanographic feature of the northeastern Pacific Ocean and the focus of controversial ecosystem management issues. CORIE represents a novel, promising and much-needed infrastructure for physical and ecological research in this system. Second, we envision that multipurpose observation and forecasting systems will become central to the management of coasts and estuaries worldwide. The Columbia River estuary is a challenging natural laboratory to test concepts and tools, and CORIE is a pilot system developed to anchor our environmental information technology and our coastal observation and prediction research.
Baptista, Zhang, Zulauf

Ocean Survival of Salmonids Relative to Migrational Timing, Fish Health and Oceanographic Conditions.

Interannual variation in ocean recruitment of salmon is high and thought to be associated with variation in nearshore ocean conditions. The nearshore ocean environment, particularly that associated with the Columbia River plume, is a critical habitat to outmigrating juvenile salmon. Several investigators have suggested that survival during the first year of ocean life is a key to establishing year-class strength. In the case of salmonids originating in the Columbia River Basin, survival success hinges on the complex interaction of smolt quality and the abiotic and biotic ocean conditions at the time of entry and during their first year of ocean existence. This research hypothesizes that variation in the physical and biological conditions of the nearshore environment, particularly that associated with the Columbia River plume, affects overall survival of Columbia River stocks. Further, the research hypothesizes that primary factors driving the variation in the nearshore environment include (a) food availability and habits, (b) time of entry, smolt quality and growth and bioenergetic status at the time of entry and during the first growing season in the ocean and (c) predation (a companion study on predation on juvenile salmon is ongoing). This project will characterize, over a 10-year period, the physical and biological features of the nearshore ocean environment with real-time and modeling projections of the Columbia River plume as it interacts with the

coastal circulation regime, and will relate these features, both spatially and temporally, to variation in salmon health, condition and survival.
Baptista, Jay, and multi-institutional collaborators (PI: E. Casillas, NOAA Fisheries)

Estuarine Habitat and Juvenile Salmon — Current and Historic Linkages in the Lower Columbia River and Estuary

Estuaries are considered important to rearing of juvenile salmon and represent an integral component of the continuum of habitats that salmon occupy for significant periods of time. There is, however, a general lack of science-based information concerning attributes of these tidal freshwater and oligohaline transition zones needed to support juvenile salmon, particularly in the Columbia River estuary. Further, recent evidence supports the concern that flow in the Columbia River significantly affects the availability of estuarine habitats, that flow is much reduced compared to historic levels, and that seasonal flow patterns are much different now than a century ago. The long history of wetland loss in the Columbia River estuary coupled with change in flow patterns suggests that restoration of the habitats may benefit recovery of depressed salmon stocks. The need to develop effective restoration strategies led us to propose empirically identifying the benefit of these habitats to juvenile salmon by evaluating habitat-salmon linkages in the lower Columbia River and estuary. We are conducting a monitoring approach to identify associations between salmon and habitat in the lower Columbia River and estuary.
Baptista, Jay, and multi-institutional collaborators (PI: D. Bottom, NOAA Fisheries)

Cascadia Subduction Zone Tsunamis

Large tsunamis are believed to be locally generated in the Cascadia Subduction Zone (CSZ) every 200 to 600 years, based on geological records. The last large tsunami dates back about 300 years, raising concerns about the protection of coastal communities in Oregon, Washington, California and British Columbia. The coastal impact of potential CSZ tsunamis is being investigated through numerical modeling. The need to use geological evidence on paleotsunamis as the sole, loose reference for model validation makes this an unusually interesting and challenging problem. The Oregon Department of Geology and Mineral Industry (DOGAMI) has incorporated our joint research results into the development of tsunami inundation maps for the Oregon coast.
Baptista, external collaborators

Chemistry of Copper-Containing Enzymes

Increasing numbers of important enzymes are known to contain copper at their active sites. Of particular interest are enzymes involved in neurotransmitter biosynthesis and metabolism

(including important neuroactive amines such as nor-adrenaline and amphetamine); enzymes protecting against oxidative cellular damage caused by reactive oxygen metabolites; and enzymes catalyzing the biosynthesis of neuropeptide hormones. A major goal is to understand the catalytic role of copper and the molecular mechanism of oxygen binding and utilization by these oxidase and oxygenase enzymes. In our laboratory we overexpress wild-type and mutant proteins in mammalian cell culture using large-scale hollow fiber bioreactors, purified them to homogeneity and study them using a variety of physical and kinetic methods which include high pressure liquid chromatography (HPLC), mass spectrometry (MS), electron paramagnetic resonance (EPR), Fourier transform-infrared (FT-IR) and X-ray absorption spectroscopy (XAS). The XAS technique is performed at the Stanford Synchrotron Radiation Laboratory http://www-ssrl.slac.stanford.edu/, which is a national user facility.
Blackburn

Cellular Transport and Regulation of Metal Ions

Metal ions such as iron and copper play an essential role in many cellular processes including energy production, biosynthesis and antioxidation. The key to their usefulness as enzyme cofactors lies in their ability to catalyze redox reactions, but this very chemistry introduces the need to tightly regulate the speciation, concentration and transport of cellular metal ions, since the free ions are themselves cytotoxic. Our lab is involved in deducing the molecular mechanism of metal ion transport. Copper enters the cell through the transporter CTR1 and is then partitioned between a number of small molecule metallochaperone molecules (CCS, COX17, SCO1, HAH1) which selectively metallate target copper enzymes (e.g., SOD1, cytochrome c oxidase), or P-type ATPases (MNK, WND) which provide further transport machinery for metallation of secreted proteins. Through application of advanced spectroscopic techniques such as X-ray absorption and mass spectrometry we are studying the mode of copper binding and transport within a number of these chaperone-target systems. Part of this research involves developing semisynthetic methods for incorporation of Se as selenocysteine into the metallochaperones which will provide us with a unique probe of metal coordination via Se- and Cu-K absorption edge spectroscopy. These studies will lead to a better understanding of the molecular mechanisms of metal-ion homeostasis and will aid in combating diseases (Menkes, Wilson, ALS) believed to be associated with aberrant metal ion regulation.
Blackburn

Symbionts of Marine Invertebrates: Biosynthetic Sources of Bioactive Natural Products

Marine invertebrates are rich sources of bioactive metabolites, which they often use for chemical defense. Many of these compounds have great

promise as drugs, but are difficult to develop because of problems in obtaining sufficient quantities from wild-collected animals. Based on our research, it is now apparent that, in many cases, bioactive metabolites of invertebrates are biosynthesized by microbial symbionts that are maintained by the invertebrate host and frequently are passed directly from one generation to the next. In this project we study the basic biology of these systems: their structure and function, how they evolved, and how they function in nature, as well as how to exploit them to provide robust supplies of compounds for drug development. Specific subprojects include the study of bryostatin biosynthesis by *Endobugula* species in bryozoans of the genus *Bugula*, ecteinascidin biosynthesis by symbionts of ascidians of the genus, *Ecteinascidia*, and cyclic peptide biosynthesis by *Prochloron didemni* in ascidians of the genus *Lissoclinum*, as well as a variety of complex multi-microbe symbioses in sponges.
Haygood

Iron Acquisition by Marine Bacteria

Iron is much less abundant in the ocean than in most terrestrial and freshwater environments. Iron availability is believed to have an important influence on the productivity of the oceans, as well as on the types of microorganisms that can live in various marine environments. The chemistry of iron in the ocean is still poorly understood, but there is an emerging consensus that iron is largely complexed by organic compounds in seawater, thus affecting the chemical behavior of iron, as well as its availability to organisms. Many microorganisms secrete strong iron binding compounds, called siderophores, when stressed by low iron. Such siderophores could contribute to iron complexation in seawater. We are studying siderophore production by marine bacteria in order to determine whether siderophores participate in iron complexation in seawater, and what environmental conditions control their production. Specific subprojects include investigation of the microbial community associated with the colonial nitrogen-fixing cyanobacterium *Trichodesmium*, a major source of fixed nitrogen in oligotrophic tropical oceans, and the role of the community in iron supply to the colony; genomic analysis of siderophore production and iron regulation in the marine cytophaga *Microscilla marina*, a common species in marine particles; and identification of novel siderophores from marine bacteria.
Haygood

Collaborative Research: Productivity, Biogeochemical Transformations and Cross-Margin Transport in an Eastern Boundary Buoyant Plume Region (A.K.A. RISERiver Influences on Shelf Ecosystems)

River plumes significantly alter nutrient supply, plankton growth rates and standing stocks as well as enhance material export from productive coastal areas across the continental margin. Because the typical (upwelling-favorable) wind stress and ambient currents act to move plumes

away from the coast during high production periods, cross margin export is extremely effective on eastern boundaries. In this proposal we focus on a highly productive Eastern Boundary river plume, the Columbia - a plume sufficiently large to be of regional importance, yet small enough to allow determination of dominant processes affecting river plumes, and to facilitate rate comparisons with regions outside the plume. Available data suggest that the Columbia affects regional productivity from phytoplankton up the food chain to juvenile fish (e.g., salmon). Prior measurements provide a framework for a new collaborative study that uses the Columbia to examine plume effects on a productive eastern margin. This study will integrate results from a nearby wind-driven CoOP study as well as salmon-related regional studies to provide definitive new information on alteration of rates of biogeochemical processes by the unique stratification, turbidity, mixing environment and nutrients of a river plume. Because the Columbia River provides no significant terrigenous nitrate to the plume in the growing season, our study allows plume-endemic processes to be isolated and hence process results can be directly applied to other plumes. Results can also be contrasted with contrasted with more eutrophic, buoyancy influenced coasts.

Our study is designed to address the following three hypotheses:

• During upwelling the growth rate of phytoplankton within the plume exceeds that in nearby areas outside the plume being fueled by the same upwelling macronutrients.

• The plume enhances cross-margin transport of plankton and nutrients.

• Plume-specific nutrients (iron and silicate) alter and enhance productivity on nearby shelves.
Jay, Baptista, and multi-institutional collaborators (PI: B. Hickey, University of Washington)

Remediation of Explosives in Groundwater Using Passive In Situ Permeable Reactive Barriers

Groundwater contamination associated with the use of explosives (e.g., TNT) is widespread at many Department of Defense sites. Research in our laboratories has shown that explosives can be rapidly destroyed in situ using zero-valent iron (ZVI). When ZVI is placed in the subsurface as part of a permeable reactive barrier, it can prevent the migration of explosives in groundwater for decades in a manner that is completely passive.
Johnson and Tratnyek

Simulation of Subsurface Processes Using Very Large Scale Experimental Aquifers

Many important chemical, physical and biological processes are difficult to study in the laboratory because of problems of scaling. Many of these processes are also difficult to characterize in the field, because of the complex and uncontrolled nature of environmental systems. For these reasons, OGI has established the Large Experimental Aquifer Program (OGI/LEAP). At present, the facility consists of five large aquifers used to examine the movements of organic solvents and petroleum compounds in the unsaturated and saturated porous media. Future LEAP aquifers will examine inorganic geochemistry and the interactions between chemical, biological and physical processes in contaminated aquifers.
Johnson and other faculty

Gas-Phase Transport in Unsaturated Porous Media

Gas-phase transport is important in controlling many subsurface processes, including respiration, pesticide behavior and contaminant volatilization and movement. Laboratory experiments have been conducted to determine diffusion rates of a variety of organic compounds in porous media and the kinetics of adsorption and desorption for a variety of soil types and a range of water contents.
Johnson

Multiphase Monitoring of Gasoline Movement Using a Very Large Physical Model (OGI/LEAP)

Leaks from underground storage tanks (UST) represent a major ongoing source of groundwater contamination. The rapid detection of leaks is, therefore, a major goal of UST legislation. The OGI/LEAP facility is used to study the movement of gasoline components in the vapor, aqueous and pure-product phases. This work will help establish which of a variety of leak-detection technologies is best suited to detect leaks under a range of environmental conditions.
Johnson

Statistical Pattern Recognition in Environmental Observation and Forecasting Systems

Environmental observation and forecasting systems (EOFS) are emerging new technologies with unparalleled potential to impact sustainable development. EOFS are expected to foster and support new paradigms for generation, transfer and social application of knowledge in domains that range from the global earth to its regional and local subsystems. At the core of EOFS is the timely and customized acquisition, generation, processing and delivery of reliable, relevant information to many and very diverse audiences. Multiple challenges need to be met to implement this concept. A critical challenge is the development of automated procedures to verify the quality of the huge amounts of observational and simulation data that are generated by EOFS both in real time and off-line. Processing based strategies for quality control of scientific data, while effective for moderate-sized archival data, are too labor-intensive to map well into EOFS-scale data sets. Strategies based on pattern recognition and machine learning hold significant promise as an alternative or complement. Under the proposed project, we are developing approaches based on statistical pattern recognition and signal processing, on-line adaptive systems, data mining and advanced search to address critical quality control issues including: 1) Detecting sensor corruption in non-stationary, spatial-temporal systems, 2) Estimating true signals from corrupted sensor data, and 3) Detecting and characterizing regimes where model anomalies are likely. These quality control techniques will be developed and exercised on CORIE, a pilot coastal observatory for the Columbia River estuary and adjacent coastal waters (www.ccalmr.ogi.edu/CORIE/).
Leen and Baptista

Vibrational Spectroscopy of Metalloprotein Reaction Intermediates

The experimental characterization of reaction intermediates is essential to decipher biological catalytic processes. It is also critical to validate theoretical models that can eventually map the entire coordinates of these biochemical reactions. The vast majority of catalytic reactions involve metalloenzymes. X-ray crystal studies are required to elucidate complete structures of these proteins, but spectroscopic techniques are used to better define the structural details of the protein active sites. In particular, resonance Raman (RR) and Fourier-transform infrared (FTIR) vibrational spectroscopic methods can define submolecular interactions in enzyme-substrate complexes. Using a rapid freeze-quenching set-up, reaction intermediates with lifetimes in the millisecond range can be investigated. For example, we defined the first reaction intermediate formed during the ferroxidase reaction catalyzed by ferritin. This ubiquitous protein is composed of 24 structurally equivalent subunits that form a "soccer ball" like complex with a large inner cavity. Toxic iron(II) is converted as an iron(III)-oxide core mineral and safely stored within the inner cavity. The bridging diiron(III)-peroxo complex we observed eventually produce hydrogen peroxide and an initial iron-oxide. Recent advances in RFQ instrumentation which allow trapping of transient species within 100 sec have begun to reveal reaction intermediates previous inaccessible and something unsuspected.
Moënne-Loccoz

Iron Proteins and O2 Activation

Iron containing enzymes react with molecular oxygen to form powerful oxidizing agents and carry out very difficult chemical reactions. We work with three enzymes that contain a non-heme diiron cluster at their active site: Ribonucleotide reductase protein R2, which oxidizes tyrosine 122 to its catalytically important neutral radical form; methane monooxygenase, whose hydroxylase component oxidizes hydrocarbons to alcohols ; and a plant acyl desaturase, which oxidize fatty acids to olefins. In the reduced form of these enzymes, the diferrous cluster reacts with oxygen to form an initial peroxo intermediate before further conversion to higher valent intermediates capable

of carrying out the oxidative chemistry. We are interested in characterizing the pathway of these oxygen activation processes. Our approach is to elucidate the structure of trapped reaction intermediates using various molecular spectroscopic techniques and to compare these results with observations in synthetic and computational models.
Moënne-Loccoz

Nitric oxide reaction with diiron proteins

Many bacteria and archaea respire anaerobically via denitrification, using nitrate (NO3-) rather than O2 as an electron sink. This process consists in 4 successive reductions (NO3- NO2- NO N2O N2), each catalyzed by a dedicated metalloenzyme. The reduction of two NO molecules into nitrous oxide (N2O) is catalyzed by a membrane-spanning protein that contains a dinuclear active site composed of a heme iron and a non-heme iron. NO reductase belongs to the superfamily of terminal oxidases and shares some basic structural features with the cytochrome c oxidase family of enzymes. Using different spectroscopic techniques and substrate analogues, we investigate the role of the metal centers within the active site. Synthetic models that mimic the putative active site metal clusters are also used. In addition, we also study structurally unrelated NO reductases found in non-denitrifying bacteria which play an important role in protection against toxic levels of NO. Again in these enzymes, iron is essential to catalysis.
Moënne-Loccoz

Structure-function Studies of Hemoproteins

Heme cofactors are porphyrin macrocycles which bind iron very tightly at their core. Two additional coordination sites perpendicular to the porphyrin plane allow binding of two axial ligands. In many cytochromes both axial ligation sites are occupied by endogenous amino acid side chains from the protein matrix and the heme's role is limited to electron transfer, with the iron cycling between its iron(II) and iron(III) oxidation state. In contrast, in hemoproteins such as cytochrome P450, peroxidase, and heme oxygenase, one axial ligation site is available to coordinate oxygen species and carry out redox chemistry. We investigate how the reactivity of the coordinated oxygen species can be fine-tuned by the combined influences of the heme iron proximal (axial endogenous) ligand, the microenvironment in the substrate binding pocket, and the interaction between the protein and the heme moiety which can affect its planarity and electronic configuration.
Moënne-Loccoz

Anaerobiosis of Bacillus subtilis

A gram-positive soil bacterium, B. subtilis, is highly amenable to genetic analysis and has been used as a model system to study fundamental microbiological research. In addition, B. subtilis is medically and industrially important since it produces a variety of antibiotics and extracellular enzymes. Although the organism has been widely used, it has been mistakenly referred to as a strict aerobe until recently. Our studies, together with others, have shown that B. subtilis is able to grow under anaerobic conditions by utilizing nitrate or nitrite as an alternative electron acceptor. In the absence of terminal electron acceptors, it undergoes fermentative growth. Our research aims include elucidation of the regulatory mechanisms through which the cells adapt to oxygen limitation. Molecular genetic and biochemical approaches are applied.
Nakano

ResD-ResE Two-Component Signal Transduction System

Bacteria often encounter sudden environmental changes. Cells cope with such changes by an elaborate network of adaptive responses. The two-component signal transduction system senses and then processes information derived from environmental changes so that the cell can choose the appropriate adaptive response. This simple signal transduction system is widespread in bacteria and also found in plants and lower eukaryotes. ResE is a histidine kinase and ResD is a response regulator of this large protein family. We have shown that ResD and ResE are indispensable for anaerobic respiration in B. subtilis. A specific signal derived by oxygen limitation is recognized by the N-terminal input domain of the ResE kinase leading to autophosphorylation of a conserved histidine residue in the C-terminal transmitter domain. This phosphoryl group is then transferred to aspartate in the conserved N-terminal domain of ResD, altering the activity of its C-terminal domain as a transcriptional activator. The ResD-ResE signal transduction system is activated by oxygen limitation or by addition of nitric oxide generators. The objectives of our studies are to determine how ResE senses oxygen limitation or nitric oxide and how anaerobically induced genes are activated by ResD.
Nakano

Long-Term Anaerobic Survival and Flavohemoglobin (Hmp)

B. subtilis can survive for many years by forming dormant spores. However, B. subtilis is unable to develop spores under anaerobic conditions, suggesting that a different mechanism is adapted for anaerobic long-term survival. We have found that flavohemoglobin (Hmp) has a pivotal role for the anaerobic survival. The N-terminal part of Hmp has similarity to hemoglobin and the C-terminus is homologous to reductase with a flavin-binding domain. Recent studies showed that Hmp from enteric bacteria catalyzes oxidation of nitric oxide to nitrate. B. subtilis hmp was identified among genes, expression of which is induced by oxygen limitation and nitric oxide. The detailed mechanism of how B. subtilis survives under anaerobic conditions and the role of Hmp are currently investigated using genome-wide approach such as DNA microarray and proteomic analysis.
Nakano

Distribution of Organic Compounds Between the Gas and Urban Aerosol Particulate Phases

The behavior of organic compounds in the atmosphere depends in large part on the extent to which they partition from the gas phase to aerosol particulate matter. Processes that are affected by this partitioning process include precipitation scavenging of gases and particles as well as dry deposition of gases and particles. Fundamental gas/solid sorption theory is being used to investigate important aspects of atmospheric gas/particle partitioning. The study involves the investigation of basic partitioning behavior of a wide range of representative atmospheric compounds (including alkanes and polycyclic aromatic hydrocarbons) on a variety of representative model particulate substrates, including elemental carbon, organic carbon, silica and clay.
Pankow

Prioritization of Nationally Important Compounds for Future Monitoring

The chemical industry produces thousands of organic compounds that are in widespread use across the Nation. It is critically important that organic compounds not presently monitored in the U.S. Geological Survey's National Water-Quality Assessment Program be systematically evaluated so that future monitoring programs can consider the compounds that are of greatest concern because of the magnitude of their use/releases, environmental behaviors, and potential toxicities. The primary objective of this work is to develop a science-based strategy to anticipate those organic compounds that are likely to emerge as major, national water-quality issues.
Pankow, Toccalino

Fate and Effects of Fuel Oxygenates

The recent realization that oxygenated fuel additives such as MTBE are becoming widely distributed groundwater contaminants has created a sudden and pressing demand for data on the processes that control their environmental fate. Ongoing work in this area includes modeling of MTBE infiltration to the groundwater, laboratory studies of MTBE biodegradation, and field studies of several contaminated sites for MTBE and its possible breakdown products. For more information on this work, see www.cgr.ese.ogi.edu/mtbe/.
Pankow, Tratnyek, Johnson

Mechanisms of Mammalian Chemical Communication and Vomeronasal Olfaction

Chemical communication plays a significant role in life strategies for many mammals. Our research focuses on chemical identification of pheromones functioning during reproductive events in the Asian elephant, Elephas maximus. A female-to-male preovulatory urinary sex pheromone, (Z)-7-dodecen-1-yl acetate, has been identified and demonstrated to be robust in its synthetic form.

This compound is also bioactive in many Lepidoptera, making it a good example of convergent evolution of structure and function. Biochemical studies have established the presence of the pheromone in the serum, and future studies will investigate its biosynthetic pathways. Considerable progress has been made on establishing the proteins functioning as pheromone transporters prior to signal transduction in the neuroreceptive cells of the vomeronasal organ. Radiolabeled analogs, competition experiments and molecular biological studies have established unusual roles for elephant albumin and olfactory binding protein. A second pheromonal system is actively being investigated. The facial temporal gland, breath and urine exude unusual chemical compounds during musth in Asian male elephants. These signals have a role in mate choice by female elephants, spatial distribution by male elephants and other reactions by conspecifics. Utilizing several state-of-the-art gas chromatographic/mass spectrometric techniques, we are identifying specific compounds that have a chemical communication function, i.e., elicit behavioral responses, and correlating the release of such compounds with serum androgen levels.
L. Rasmussen

Global Distributions and Mass Balances of Halocarbons, Nitrous Oxide and Other Trace Gases

Gases such as CCl_3F (F-11), CCl_2F_2 (F-12) $CHClF_2$ (F-22), CF_4 (F-14), $C_2Cl_3F_3$ (F-113), CH_3CCl_3, CH_3Cl and N_2O are being added to the atmosphere by various industrial processes and the public's use of high-technology products. Such chlorine-containing compounds are believed to threaten the Earth's natural ozone layer high in the atmosphere (stratosphere). This research will systematically obtain a long-time series of concentration measurements by a flask sampling system. The results are then interpreted with global mass balance models and sophisticated statistical techniques to quantify the sources and lifetimes of these gases in the environment. Such data are now obtained from sites all over the world extending from the Arctic Circle to the South Pole.
R. Rasmussen

Studies of Past Atmospheres

Atmospheric gases such as N_2O, CO_2, CO, CH_3Cl, carbonyl sulfide (OCS) and CH_4 are primarily produced by natural processes, but over the past century human activities have been adding growing amounts to their natural abundance. This process can upset the cycles of these gases and lead to possibly adverse environmental effects such as the warming of the Earth's surface (N_2O, CO_2, CH_4). When both natural and anthropogenic processes contribute to the current atmospheric abundance of a trace gas, it is of interest to determine the amount which existed before human activities had any effect. Perhaps the only realistic method to determine the composition of the ancient atmosphere is to analyze the air in bubbles buried deep in polar ice. The depth of the ice indicates the age of the air in the bubbles. By going far enough back in time, the relationship between past atmospheric composition and climate might be found. The novel and simple method of studying the old atmosphere of the earth is beset by many problems that complicate the relationship between the gases in the bubbles and the composition of the old atmosphere. Theoretical and experimental research for resolving these problems as well as the measurement of trace gases are the major goals of this project.
R. Rasmussen

Ocean-Air Exchange of Gases

Some atmospheric gases are greatly influenced by the Earth's oceans. For instance, a large amount of the atmospheric methyl chloride (CH_3Cl) and methyl iodide (CH_3I) are produced in the oceans, possibly by biogenic processes. It has also been shown recently that carbonyl sulfide (OCS) is produced in the oceans and subsequently emitted to the atmosphere. On the other hand, manmade gases such as CCl_3F (F-11) can dissolve in the oceans and thus be removed from the atmosphere. This research project is devoted to determining the solubility of such gases in water and to modeling the flux of gases into or out of the oceans. The results obtained are essential ingredients in determining the sources and fates of atmospheric trace gases and in estimating the effects of human activities on the future warming of the Earth or depletion of the ozone layer.
R. Rasmussen

Studies of Atmospheric Methane

Considerable evidence has been accumulated showing that methane (CH_4) is increasing in the atmosphere, most likely as an indirect result of growing human population. In the future, such an increase of CH_4 can lead to a global warming by enhancing the Earth's natural greenhouse effect and create more ozone and carbon monoxide in the atmosphere. However, it might also prevent some of the destruction of the stratospheric ozone layer by the manmade fluorocarbons 11 and 12. In this project, experimental and theoretical research is focused on statistical trend analyses for the global increase of CH_4, its seasonal variation, sources and sinks, models of its effect on the CO, O_3, and OH cycles and its role in the future of the environment.
R. Rasmussen

Development of Experimental Methods for Trace Gas Measurements

At present, some 50 atmospheric gases can be measured at the Trace Gas Laboratory. Still, new methods are needed to improve the accuracy and precision of measurements and to satisfy the stringent demands of ultra-clean background air sampling. New methods are also being developed for automated real-time analysis of many trace gases. Research programs include development of gas chromatographic and mass spectrometric methods for the analysis of trace gases. At present,

GC/MS systems in the laboratory are being used to routinely measure C2-C12 nonmethane hydrocarbons at tens of parts-per-trillion levels. Techniques for collecting and storing air and water samples also are being developed.
R. Rasmussen

Biogenic Sources of Atmospheric Gases

Living organisms produce and consume a variety of gases and may therefore form an integral part of the global cycle of a trace gas. Selected plants and animals, living in the sea or on land, are being studied to determine their role in the cycles of CH_4, N_2O, CH_3Cl, CH_3I, isoprene and other hydrocarbons.
R. Rasmussen

The Global Cycle of Carbon Monoxide (CO)

Based on 15 years of global sampling and the application of modern trend analysis techniques, our data have shown that CO increased in the atmosphere until around 1987 and has since declined. These changes in CO have major implications for atmospheric chemistry and the role of biomass burning in causing global increases of trace gases. Present research includes modeling of the global budgets, seasonal cycles and potential environmental effects.
R. Rasmussen

Methane Emissions from Rice Fields

Methane concentrations have nearly tripled compared to the natural atmosphere of 300 years ago (based on ice core analyses). The increase of rice agriculture to sustain an increasing population may be a major contributor to the increase of methane during the last century. This research program is designed to determine the role of rice agriculture in the global methane cycle. Field experiments are being conducted in China, Indonesia and the United States. Laboratory experiments and theoretical research are being done at the Global Change Research Center (Portland State University) in a comprehensive research program. This work includes modeling the production, oxidation and transport of methane in the rice paddy ecosystem and measuring the controlling parameters.
R. Rasmussen

Translational Control in Fungal Amino Acid Biosynthesis

A greater understanding of many human health issues relies on increased knowledge of how cells express genetic information. Gene expression can be controlled by regulating the synthesis and stability of functional RNA and protein. The goal of our research is to obtain a greater understanding of how these mechanisms work using the Neurospora crassa arg-2 and Saccharomyces cerevisiae CPA1 genes as models. These homologous genes encode the first enzyme in arginine biosynthesis and they are negatively regulated at both transcriptional and translational

levels in response to the availability of arginine. An evolutionarily conserved upstream open reading frame (uORF) present in the 5' leader regions of these transcripts is responsible for translational control. Synthesis of the uORF-encoded peptide causes ribosomes to stall when the level of arginine is high, blocking access of ribosomes to the translation initiation site for the polypeptide encoding the arginine biosynthetic enzyme. Our current work is focused on developing a molecular understanding of how synthesis of this uORF encoded peptide causes ribosomes to stall, since this will provide important insights into the fundamental cellular process of protein synthesis.
Sachs

Genome Organization in Fungi

The N. crassa genome and the genomes of other filamentous fungi are being sequenced, enabling comparisons of how these fungi differ from each other and from the yeasts. We are focusing on the characterization of the sub-telomeric regions of N. crassa, since genes in sub-telomeric regions are implicated in environmental sensing and in interactions with host species.
Sachs

Bacterial Manganese(II) Oxidation

Manganese(II)-oxidizing bacteria accelerate the rate of Mn biomineralization several orders of magnitude faster than abiotic processes. This biogeochemical process has gained much attention in recent years as Mn(III,IV) oxide minerals are abundant in terrestrial and marine environments. These Mn oxide minerals impact a variety of biological processes, including photosynthesis, carbon fixation, and scavenging of reactive oxygen species (ROS). Next to oxygen, Mn oxides are some of the strongest naturally occurring oxidizing agents in the environment. They participate in numerous redox and sorption reactions, thereby controlling the distributions of many other trace and contaminant elements as well as serving as a terminal electron acceptor for bacterial respiration. Dr. Tebo's research spans the disciplines of microbiology, molecular biology, genomics, bioinorganic chemistry, mineralogy, and environmental aqueous geochemistry to investigate the molecular mechanisms of manganese oxidation by bacteria and the mechanisms by which the resulting oxide solids impact the chemistry of heavy metals and organic contaminants in soils and natural waters. We have demonstrated that Mn(II) oxidation in diverse bacteria is mediated by a novel multicopper oxidase-like protein. Recent studies using synchrotron-based X-ray absorption spectroscopy have shown that biogenic Mn oxides are nanoparticulate, cryptocrystalline materials and are representative of the most highly reactive and important Mn oxide phases in the environment. Research projects in the lab address questions such as why bacteria oxidize Mn(II), can Mn(II)-oxidizing bacteria be used for heavy metal removal and bioremediation, what are the properties of the biogenic Mn oxide minerals, how

do bacteria influence the biogeochemical cycling of Mn in the environment and how are they influenced by environmental factors? Specific environments studied include the oxic/anoxic transition zones that occur in anoxic water bodies (e.g., the Black Sea), at hydrothermal vents, and on rock and mineral surfaces.
Tebo

Biotransformations of Chromium and Uranium

Hexavalent chromium (Cr(VI)) and hexavalent uranium (U(VI)) are the toxic and highly soluble forms of these elements and are of great concern as pollutants in the environment. When reduced to Cr(III) or U(IV) these elements are much less soluble and hence less toxic. Thus, hexavalent Cr and U reduction, particularly by bacteria, is being explored as a (bio)remediation strategy for these elements. However, for this to be effective Cr and U must be stable in their reduced forms. The Tebo lab is interested in the mechanisms of Cr and U reduction by bacteria, the properties and stability of the reduced forms of these elements, and the mechanisms by which they may be reoxidized. We have isolated a number of novel bacteria capable of growing with Cr(VI) and U(VI) as electron acceptors and are investigating their response to Cr(VI) and U(VI) exposure. The full genome sequence of one our organisms, Desulfotomaculum reducens MI-1, will be used to characterize the metabolic capabilities of this bacterium. Both Cr(III) and U(IV) (hydr)oxides may be oxidized by Mn oxides, suggesting that Mn(II)-oxidizing bacteria play an important role in the stability of these phases. We have shown that Mn(II)-oxidizing bacteria accelerate the oxidation of Cr(III) over that observed by synthetic or biogenic Mn oxides alone and we seek to understand the mechanism of catalysis and the possible role of Mn(II)-oxidizing bacteria in U(IV) oxidation.
Tebo

Microbial Weathering of Ocean Basalts

To date, it has been challenging to determine the extent to which microbes are involved in low temperature (<100°C) basalt weathering reactions, although textural, chemical and biological evidence suggests that bacterial activity may be widespread. Research in the Tebo lab focuses on the role of iron- and manganese-oxidizing bacteria, siderophore-producing bacteria, and other bacteria in basalt weathering. Our research is designed to identify which microorganisms are involved in the initial stages of basalt weathering, their identity and modes of metabolic activity, and how transient these microbial communities may be. The project is a blend of field and laboratory work combining field exposure experiments with bacterial cultivation and molecular microbiological methods. The field work is being conducted on Loihi seamount and Puna Ridge, the submarine extension of the Kilauea Volcano (Hawaii), and on Vailulu'u, a seamount hotspot located near American Samoa. We sample basalts, vent fluids and ambient seawater, as well as deploy and retrieve basalt and mono-

mineralogic charges, using research submersibles. Molecular methods are used to identify the major colonizers of the basalts. Physiological experiments in the lab focus on measuring the rates and mechanisms of basalt alteration.
Tebo

Remediation of Halocarbon-Contaminated Groundwater

There is enormous demand for improved ways to clean up aquifers that have been contaminated with halogenated hydrocarbon solvents like carbon tetrachloride and TCE. Recent field-scale tests have shown that technologies based on dechlorination with granular iron may have substantial value. The goal of our research in this area is to provide a sound scientific basis for designing and operating such technologies by determining the mechanisms of dechlorination by iron and the geochemical and microbiological processes that affect the performance of this technique in the field. For more information on this work, see www.cgr.ese.ogi.edu/iron.
Tratnyek

Remediation of Explosives-Contaminated Groundwater

There are numerous facilities where military operations have resulted in contamination of groundwater with explosives such as TNT and RDX. Both TNT and RDX react rapidly with zerovalent iron, suggesting that permeable reactive barriers of zero-valent iron might be useful in remediation of these sites. However, the products of these reactions with zero-valent iron may not present a satisfactory remediation endpoint. Therefore, we are investigating the kinetics and mechanisms of this reaction in the experiments performed in the laboratory and in the field. See www.cgr.ese.ogi.edu/iron/.
Tratnyek and Johnson

Reduction Reactions of Organic Pollutants in Anaerobic Environments

Some organic pollutants undergo rapid reduction in anaerobic sediments, soils and groundwaters. Despite the potential importance of this process, little is known about the natural reducing agents that are responsible for these reactions. In this project, assays are being developed to identify and quantify environmental reducing agents in situ. These assays will be used in kinetic studies of important pollutant reduction reactions.
Tratnyek

Oxidation Reactions of Organic Pollutants

Some organic pollutants undergo rapid oxidation in natural waters, when catalyzed by sunlight, and in technological systems, when chemical oxidants are added to effect remediation. These reactions are usually mediated by "activated oxygen species" such as hydroxyl radical. We are studying the kinetics, mechanisms and products of these reactions with a wide variety of contaminants. The aim of this work is to help assess the suitability of various advanced oxidation technologies (AOTs) for

remediation of groundwater, as well as to better understand the fate of contaminants in natural waters that are exposed to sunlight.
Tratnyek

Correlation Analysis of Contaminant Reactivity

Quantitative Structure-Activity Relationships (QSARs) are of enormous importance in environmental chemistry and toxicology because of their predictive power, but they also reveal a great deal about reaction mechanisms and the nature of substituent effects. We are involved in the development of QSARs for a wide range of redox reactions involving organic contaminants. This work involves the use of computational chemistry methods as well as advanced statistical techniques in exploratory data analysis.
Tratnyek

Systems Biology Modeling

Living systems integrate processes at multiple scales of organization and interact with the abiotic environment. In analyzing such systems, models (e.g., biological, physical and mathematical/computational) are developed to understand observed phenomena and to predict responses that are unobservable (e.g., a forecast/prediction of a future point in time, or a response to a new set of conditions). Dr. Watanabe's research focuses on the development of mathematical/computational models to understand the biological fate of chemical xenobiotics, and the risks of exposure to such chemicals for humans and ecosystems. Ongoing research includes:

Systems Biology Modeling of Fathead Minnow Response to Endocrine Disruptors. To reduce our dependence on animal testing in quantitative risk assessment, the U.S. Environmental Protection Agency has undertaken research in the area of Computational Toxicology. The goal of this project is to determine molecular and protein biomarkers that are diagnostic for endocrine disruption in fathead minnows (FHM, Pimephales promelas). Our hypotheses are (i) molecular biomarkers are diagnostic of the reproductive effects of environmental estrogens, and (ii) these biomarkers provide a broader understanding of the FHM reproductive system. We are developing a physiologically based computational model to simulate the FHM hypothalamic-gonadal-pituitary axis and its responses to endocrine disrupting chemicals. The model will be used to predict reproductive effects in fathead minnows exposed to environmental estrogens based upon molecular and protein biomarkers.
Watanabe and multi-institutional collaborators (PI: N. Denslow, University of Florida, co-PIs: K. Watanabe, OHSU, E. Orlando, Florida Atlantic University, and M. Sepùlveda, Purdue University)

Radical Copper Oxidases

Radical copper oxidases are a new class of redox metalloenzymes (including the fungal enzymes galactose oxidase and glyoxal oxidase) containing a protein free radical directly coordinated to a copper center. This free radical-coupled Cu complex catalyzes the two-electron oxidation of simple alcohols and aldehydes and the reduction of O2 to hydrogen peroxide, fueling extracellular peroxidases involved in lignin degradation. In these proteins, the free radical is localized on a tyrosine residue covalently crosslinked to a cysteinyl side chain (a Tyr-Cys dimer). The catalytically active enzyme is an intense green color, the result of unusual optical spectra arising from electronic transitions within the copper radical complex. Low energy transitions in the near IR result from interligand redox in this metal complex, ligand-to-ligand charge transfer (LLCT) processes that are closely related to the electron transfer coordinate for substrate oxidation. The active site metal complex is surprisingly flexible, twisting through a pseudo-rotation distortion when exogenous ligands bind, thereby modulating the basicity of a second tyrosine ligand that serves as a general base in catalysis. Many of these aspects of electronic structure and dynamics of the radical copper oxidases are the focus of active research.
Whittaker

Manganese Metalloenzymes

Manganese is an essential element for life, forming the active site for a large number of metalloenzymes catalyzing hydrolytic or redox reactions, including the photosynthetic oxygen evolving complex. We are interested in the Mn redox sites in Mn superoxide dismutase (MnSD, mononuclear Mn) and Mn catalase (MnC, dinuclear Mn), enzymes that provide protection from toxic oxygen metabolites. The key question is: How do interactions between the protein, metal ion and exogenous ligands tune the redox potential and chemistry of these complexes? We are combining the powerful tools of molecular biology with advanced spectroscopic and computational approaches to explore the structure and dynamics of Mn active sites. For MnSD, we find an unexpected temperature dependence for the structures of anion complexes, which change coordination as the temperature is raised. This thermal transition implies that the stability of the active site structure is determined by dynamical features of the complex and that dynamical excitation may play an important role in controlling the energetics of ligand binding and redox. A wide range of projects relating to the chemistry and biology of Mn are in progress.
Whittaker

Electronic Spectroscopy of Biological Metal Complexes

Electronic spectroscopy extends structural studies of biomolecules beyond the atomic resolution of X-ray crystallography to a level of structural detail that directly relates to chemistry. The techniques used in these studies span five decades of the electromagnetic spectrum, from microwaves to the ultraviolet and beyond. At the lowest energy, electron paramagnetic resonance (EPR) spectroscopy gives information on the electronic ground state, defining the molecular orbital that contains the unpaired electron in a paramagnetic complex. At higher energy, UV-visible absorption spectroscopy excites orbital transitions between electronic states, giving information on characteristic metal-ligand interaction energies that can be understood in terms of a ligand field or molecular orbital analysis. Polarization spectroscopy (linear dichroism, circular dichroism and magnetic circular dichroism) can give more detailed information on ground and excited state electronic wave functions using geometric features of light to probe the active site. These experimental approaches can be complemented by spectroscopic modeling and computational biology methods to provide a detailed description of a metalloprotein complex and its interactions.
Whittaker

Regulation of Long Chain Fatty Acid Transport and Oxidation in Mammalian Heart and Liver

The rate-limiting step in ß-oxidation is the conversion of long-chain acyl-CoA to acylcarnitine, a reaction catalyzed by the outer mitochondrial membrane enzyme carnitine palmitoyltransferase I (CPTI) and inhibited by malonyl-CoA. The acylcarnitine is then translocated across the inner mitochondrial membrane by the carnitine/acylcarnitine translocase and converted back to acyl-CoA by CPTII. This reaction in intact mitochondria is inhibited by malonyl-CoA, the first intermediate in fatty acid synthesis, suggesting coordinated regulation of fatty acid oxidation and synthesis.

Structure-Function Studies with the Mitochondrial CPT System. We have separately expressed the genes for human heart muscle M-CPTI and rat liver LCPTI and CPTII in Pichia pastoris, a yeast with no endogenous CPT activity. We have constructed a series of deletion and substitution mutations to the N-terminus of L-CPTI, and demonstrated that Glu-3 and His-5 are necessary for malonyl-CoA inhibition and binding of L-CPTI, but not catalytic activity. Similar mutagenesis studies with the human heart M-CPTI revealed that Glu-3, Val-19, Leu-23, and Ser-24 are necessary for malonyl CoA inhibition and binding, in accordance with the differences in malonyl-CoA sensitivity observed with the two isoforms of the enzyme. We have also expressed pig L-CPTI in yeast and shown that Pig L-CPTI is much more sensitive to malonyl CoA inhibition than rat L-CPTI, a kinetic characteristic similar to that of human or rat M-CPTI enzymes. Hence, pig LCPTI behaves like a natural chimera of the L- and M-CPTI isotypes, which makes it a useful model to study the structure-function relationships of CPTI.

Our site-directed mutagenesis studies of conserved basic and aromatic residues in the C-terminal region of L-CPTI suggest that conserved arginine and tryptophan residues contribute to the stabilization of the enzyme substrate complex by charge neutralization and hydrophobic interactions. The predicted secondary structure of the 100-

amino acid region of L-CPTI, spanning arginines 388 and tryptophans 452, consists of four ±-helices similar to that of the acyl CoA binding protein with a known 3D structure, and may constitute the putative palmitoyl CoA-binding site in L-CPTI. Furthermore, our mutagenesis studies of the conserved acidic and basic residues in the C-terminal region of L-CPTI showed that residues E590, E603, R601 and R606 are important for both substrate and inhibitor binding. We predict that the region of L-CPTI spanning the conserved residues R601 and R606 may be the putative low affinity acyl-CoA/malonyl-CoA binding site. With M-CPTI, deletion of L764 or substitution with arginine was found to inactivate the enzyme, suggesting that L764 may be important for native folding and optimal activity of M-CPTI. For CPTII, our site-directed mutagenesis studies demonstrated that Glu487 is essential for catalysis. We will purify milligram quantities of the His-tagged yeast-expressed M-CPTI, L-CPTI, CPTII and engineered fragments for structural studies.
Woldegiorgis

Transgenic and Knockout Mice Models for CPTI

We will determine the molecular basis for tissue-specific and hormonal/dietary regulation of human heart M-CPTI gene expression in a transgenic mouse model in vivo carrying a 1.1 kb of the 5Ñ flanking region of the human heart M-CPTI gene promoter fused to a CAT reporter gene. We will employ homologous recombination in embryonic stem cells to produce mice lacking the M-CPTI gene (knockout mice) using our cloned mouse genomic M-CPTI DNA. We will also generate a transgenic mouse model overexpressing human heart M-CPTI in vivo carrying the murine ±-myosin heavy-chain gene promoter fused to human heart muscle M-CPTI cDNA (reporter gene). Transgenic and knockout mice models would provide valuable information about the role of M-CPTI in fatty acid metabolism in the normal and diseased heart. Because the enzyme is essential for heart function, loss of M-CPTI may be incompatible with life.
Woldegiorgis

Prokaryotic Signal Transduction/Gene Regulation

Bacteria can respond in variety of ways to a growth-restricting environment. Prolonged exposure to a nutritionally poor environment results in the induction of antibiotic biosynthesis, functions required for cell motility and processes of cellular differentiation that give rise to highly resistant cell types. How cells respond to nutritional stress is profoundly influenced by cell density. Extracellular signal molecules accumulate in the local environment of densely populated cell cultures and trigger antibiotic production and developmental processes such as sporulation and genetic competence. The objective of our research is to understand, in molecular terms, the regulatory networks that cells utilize to choose the most appropriate response to harsh conditions. In the spore-forming bacterium, Bacillus subtilis,

establishment of genetic competence is coregulated with peptide antibiotic biosynthesis by a complex network of signal transduction pathways that utilize protein components common to all prokaryotic and most eukaryotic organisms.
Zuber

Role of Chaperones/Proteases in the Control of Gene Expression

There is growing evidence that protein complexes that function in protein folding, remodeling and degradation interact directly with the molecular machinery that initiates gene expression. In mammalian, fungal and bacterial cells, components of ATP-dependent protease complexes have been implicated in the control of RNA polymerase activity through direct protein-protein interaction. In the spore-forming bacterium, Bacillus subtilis, developmentally regulated transcription during the early stages of sporulation, genetic competence development and antibiotic biosynthesis is profoundly affected by members of the heat shock protein family that normally function as chaperones and multicomponent proteases. Evidence from our studies indicates that these proteins operate closely with RNA polymerase during the process of regulated transcription initiation. Our work is aimed at determining the nature of these interactions and their effects on the systems controlling bacterial developmental processes.
Zuber

RESEARCH CENTERS

CENTER FOR COASTAL AND LAND-MARGIN RESEARCH (CCALMR)
www.ccalmr.ogi.edu

The Center for Coastal and Land-Margin Research (CCALMR) is an interdisciplinary research center affiliated with the Department of Environmental and Biomolecular Systems. CCALMR conducts research, graduate education and advanced technology development that directly address the need for better scientific understanding of coasts, land margins and estuaries. Improved knowledge of these complex systems is necessary to preserve and enhance their environmental integrity, maintain the economic viability of communities dependent on them and protect human populations from natural and manmade hazards. Real-world natural resource management issues motivate CCALMR research and education activities. Insights drawn from the experience of science and engineering professionals in the public and private sectors influence the identification of emerging research challenges, the design of research projects, the development of supporting tools and applications and the transfer of knowledge and technology. Additional information about CCALMR may be obtained from:

ANTÓNIO M. BAPTISTA, PH.D.
Phone: 503 748-1147
E-mail: baptista@ebs.ogi.edu

CENTER FACULTY AND RESEARCH SCIENTISTS

António M. Baptista, Professor and Director

Todd Leen, Professor
(Computer Science and Electrical Engineering)

David Maier, Professor
(Computer Science, Portland State University)

Yinglong (Joseph) Zhang, Associate Research Scientist

Mike Zulauf, Assistant Research Scientist

CCALMR RESEARCH FACILITIES

CCALMR is well equipped to conduct state-of-the-art scientific research. The following is a list of facilities and instruments available in addition to those available through EBS.

REAL-TIME DATA ACQUISITION NETWORK

The coastal observatory CORIE includes a realtime data acquisition network with close to 20 multisensor oceanographic stations in the Columbia River estuary and plume. Field operations are conducted from the Marine Environmental Research and Training Station (MERTS). MERTS is a facility developed in partnership with and operated by the Clatsop Community College (CCC). CCC operates a training and research vessel, the 50-foot M/V Forerunner. CCALMR operates a 21-foot research vessel, the R/V CORIE.

OCEANOGRAPHIC EQUIPMENT

- 500 and 1500 kHz Acoustic Doppler profilers (Sontek)
- Conductivity and temperature pairs (Seabird)
- Conductivity, temperature and pressure sensors (Coastal Leasing and Ocean Sensors)
- Optical backscatter sensors (Downing Associates)
- Wind gauges (Coastal Leasing)
- High-density thermistor chains (CCALMR)
- Differential GPS (Trimble)
- Spread spectrum radio data modems (FreeWave)

COMPUTATIONAL ENGINES AND ON-LINE STORAGE

- 16 parallel Intel dual CPU compute nodes (2.4 GHz, 4 Gb)
- 6 single CPU Alpha compute nodes
- 10 TB primary storage

CENTER FOR GROUNDWATER RESEARCH
www.cgr.ese.ogi.edu.

The The principal mission of the Center for Groundwater Research (CGR) is to conduct state-of-the-art research in areas relating to the transport and fate of contaminants in the subsurface. This is accomplished through a combination of research grants and contracts and collaboration with other universities, industries and government agencies.

The Center coordinates a range of projects relating to the transport and fate of contaminants in soils and groundwater. The scope of the Center includes, among other things, the development of: 1) new sampling and site characterization techniques; 2) new analytical techniques; 3) improved groundwater remediation methods and 4) physical and numerical models of groundwater- and watershed-scale processes.

The Center operates the Large Experimental Aquifer Program (LEAP), which contains the experimental facilities outlined below. The LEAP facility provides staff with the capability to conduct both bench-scale experiments and essentially full-scale pilot demonstrations. Students involved in LEAP receive a rare combination of experiences, including full-scale remediation engineering and process-level understanding of contaminant hydrology and chemistry.

For additional information about CGR, contact:

RICHARD JOHNSON, PH.D.
Phone: 503 748-1193
E-mail: rjohnson@ese.ogi.edu

CENTER FACULTY

Richard Johnson, Professor and Director
James F. Pankow, Professor
Patricia L. Toccalino, Assistant Professor
Paul Tratnyek, Professor

LEAP EQUIPMENT

- Five tanks: one 10 m x 10 m x 3 m; two 10 m x 10 m x 5 m; one 10 m x 2.5 m x 0.5 m; and one 8 m x 2.5 m x 0.5 m
- In-situ instrumentation, including automated temperature, pressure and water-level monitoring; multilevel samplers; down-hole video camera; and automated vapor and product-sensing equipment
- Remediation equipment, including soil vapor extraction and air sparging capabilities
- Automated on-site analytical equipment, including capillary GC-MS

RESEARCH FACILITIES

The Department of Environmental and Biomolecular Systems is well equipped to carry on a vigorous research program. Instruments and equipment available in the department include :

- Gas chromatograph/mass spectrometer with computer data system
- High-resolution mass spectrometer
- UV/Visible spectrometer
- Capillary column gas chromatographs with flame ionization detectors
- Fourier transfor-infrared spectrometers
- Fourier transfor-Raman spectrometer with CW Nd:YAG laser
- X-band electron paramagnetic resonance spectrometer
- Ultraviolet/visible/near-infrared spectrophotometers
- Scanning fluorescence spectrophotometers
- Magnetic circular dichroism (MCD) spectrometer
- Diode array UV/Visible spectrophotometer
- Laser Raman spectrophotometer
- Raman spectrograph with CCD detector
- Ar, Kr, HeCd, HeNe and dye lasers
- High-vacuum lines
- Phosphor imager
- Controlled atmosphere reaction chamber
- Super speed centrifuges
- Ultracentrifuges
- HPLCs
- FPLCs
- Fraction collectors
- Liquid scintillation systems
- Gel electrophoresis systems
- Laminar flow hoods for sterile culture
- Growth chambers
- Constant temperature rooms
- Light and electron microscopes
- Ultrafiltration systems
- Autoclaves
- Photographic facilities
- Probe-type sonicators and extruder
- Laser-Scanning Confocal Microscope
- Anaerobic Chambers

See additional research equipment listings in the Research Centers section.

FACULTY

ANTÓNIO M. BAPTISTA

Professor and Department Head
Director, Center for Coastal
and Land-Margin Research
Ph.D., Civil Engineering
Massachusetts Institute
of Technology, 1987
baptista@ebs.ogi.edu

RESEARCH INTERESTS

Integrated understanding and
prediction of hydrodynamic and
environmental processes in
estuaries and coasts. Development
of associated concepts and
technologies: coastal
observatories, environmental
information technology, numerical
methods and modeling systems,
error and uncertainty analysis,
and physically based ecological
indicators.

REPRESENTATIVE PUBLICATIONS

A.M. Baptista, Y.L. Zhang, A. Chawla,
M.A. Zulauf, C. Seaton, E.P. Myers,
J. Kindle, M. Wilkin, M. Burla, and P.J.
Turner, "A Cross-scale Model for 3D
Baroclinic Circulation in Estuary-
plume-shelf Systems: II. Application to
the Columbia River," Continental Shelf
Research, 25, 935-972, 2005.

Y.L. Zhang, A.M. Baptista and E.P.
Myers, "A Cross-scale Model for 3D
Baroclinic Circulation in Estuary-
plume-shelf systems: I. Formulation
and Skill Assessment," Continental
Shelf Research, 24, 2187-2214, 2004.

B. Howe, D. Maier and A.M. Baptista,
"A Language for Spatial Data
Manipulation," Journal of
Environmental Informatics 2(2),
23-37, 2003.

C. Archer, A.M. Baptista and T.K.
Leen, "Fault Detection for Salinity
Sensors in the Columbia Estuary,"
Water Resources Research, 39 (3),
1060, 2003.

A.M. Baptista, "Environmental
Observation and Forecasting Systems,"
in Encyclopedia of Physical Science and
Technology, 3rd Edition, Vol. 5,
Academic Press, 2002.

E.P. Myers and A.M. Baptista,
"Inversion for Tides in the Eastern
North Pacific Ocean," Advances in
Water Resources, 24 (5), 505-519,
2001.

NINIAN J. BLACKBURN

Professor
Ph.D., Inorganic Chemistry
University of Dundee,
Scotland, U.K., 1975
ninian@ebs.ogi.edu

RESEARCH INTERESTS

Structure and function of oxidase
and oxygenase metalloenzymes;
spectroscopy of metal sites in
proteins with emphasis on EPR,
EXAFS, absorption edge and FT-IR
spectroscopies; coordination
chemistry and biochemistry of
copper. Biochemistry of metal
trafficking in cells.

REPRESENTATIVE PUBLICATIONS

J.P. Stasser, J.F. Eisses, A.N. Barry,
J.H. Kaplan and N.J. Blackburn,
"Cysteine-to-serine Mutants of the
Human Copper Chaperone for
Superoxide Dismutase Reveal a Copper
Cluster at a Domain III Dimer
Interface," Biochemistry, 44, 3143-
3152, 2005.

M. Ralle, S.M. Berry, M.J.Nilges,
M.D.Gieselman, W.A.van der Donk, Y.
Lu and N.J.Blackburn, "The
Selenocysteine-substituted Blue Copper
Center: Spectroscopic Investigations of
Cys112SeCys Pseudomonas aeruginosa
Azurin," J. Am. Chem. Soc.,126, 7244-
7256, 2004.

J.M.Walker, D. Huster, M. Ralle, C.T.
Morgan, N.J. Blackburn and S.
Lutsenko, "The N-terminal Metal-
binding Site 2 of the Wilson's Disease
Protein Plays a Key Role in the Transfer
of Copper from Atox1," J. Biol. Chem.,
279,15376-15384, 2004. Epub 2004
Jan 30.

S.M. Berry, M. Ralle, D.W.Low,
N.J.Blackburn and Y. Lu, "Probing the
Role of Axial Methionine in the Blue
Copper Center of Azurin with Unnatural
Amino Acids," J. Am. Chem. Soc., 25,
8760-8768, 2003.

M. Ralle, S. Lutsenko and N.J.
Blackburn, "X-ray Absorption
Spectroscopy of the Copper Chaperone
HAH1 Reveals a Linear Two-coordinate
Cu(I) Center Capable of Adduct
Formation with Exogenous Thiols and
Phosphines," J. Biol. Chem., 278,
23163-23170, 2003. Epub 2003 Apr 9

WILLIAM H. GLAZE

Professor and Associate Dean
for Research
Ph.D., Physical Chemistry
University of Wisconsin,
Madison, 1961
glazeb@ebs.ogi.edu

RESEARCH INTERESTS

Integration of ecological sciences
with human health sciences
including the integration of
functional genomics. Sustainable
technologies applied to urban
design and to the energy and
transportation sectors.

REPRESENTATIVE PUBLICATIONS

W.H. Glaze, D.S. Maddox and P. Bose,
"Degradation of RDX by Various
Advanced Oxidation Processes:
I. Reaction Rates," Water Research,
997-1004, 1998.

P. Bose, W.H. Glaze and D.S. Maddox,
"Degredation of RDX by Various
Advanced Oxidation Processes: II.
Organic By-Products," Water Research,
1005-1018, 1998.

David R. Pesiri, David K. Morita,
William Tumas and William Glaze,
"Selective Epoxidation in Dense-
Phase Carbon Dioxide," Chem.
Commun. (Cambridge), Issue 9,
1015-1016, 1998.

John L. Ferry and William H. Glaze,
"Photocatalytic Reduction of Nitro
Organics over Illuminated Titanium
Dioxide: Electron Transfer Between
Excited-State TiO2 and
Nitroaromatics," J. Phys. Chem. B
102(12), 2239-2244, 1998.

John L. Ferry and William H. Glaze,
"Photocatalytic Reduction of Nitro
Organics over Illuminated Titanium
Dioxide: Role of the TiO2 Surface,"
Langmuir, 14(13), 3551-3555, 1998.

H.S. Weinberg and W.H. Glaze,
"A Unified Approach to the Analysis of
Polar Organic By-Products of Oxidation
in Aqueous Matrices," Water Research,
1555-1572, 1997.

MARGO G. HAYGOOD

Professor
Ph.D., Marine Biology
Scripps Institution of Oceanography
University of California,
San Diego, 1984
haygoodm@ebs.ogi.edu

RESEARCH INTERESTS

Environmental microbiology;
bacterial physiology; bacterial
evolution, marine biotechnology.
Role of microbial symbionts in the
production of bioactive
compounds. Iron acquisition and
regulation in marine bacteria.

REPRESENTATIVE PUBLICATIONS

C.P. Ridley, P.R. Bergquist, M.K.
Harper, D.J. Faulkner, J.N. Hooper and
M.G. Haygood, "Speciation and
Biosynthetic Variation in Four
Dictyoceratid Sponges and Their
Cyanobacterial Symbiont, Oscillatoria
spongeliae," Chem Biol., 12, 397-406,
2005.

E.W. Schmidt, J.T. Nelson D.A. Rasko,
S. Sudek, J. Eisen, M.G. Haygood, and
J. Ravel, "Patellamide A and C
biosynthesis by a microcin-like pathway
in Prochloron didemni, the
cyanobacterial symbiont of Lissoclinum
patella," Proc. Nat. Acad. Sci. USA,
102, 7315-7320, 2005.

M.L. Hildebrand, M., L. Waggoner, H.
Liu, S. Sudek, S. Allen, C. Anderson, D.
Sherman, and M. Haygood. "bryA: An
unusual modular polyketide synthase
gene from the uncultivated bacterial
symbiont of the marine bryozoan
Bugula neritina," Chemistry and
Biology, 11, 1543-1552, 2004.

G.E. Lim and M.G. Haygood,
"Candidatus Endobugula glebosa, a
specific symbiont of the marine
bryozoan Bugula simplex," Appl.
Env.Microbiol., 70, 4921-4929, 2004.

J.S. Martinez, J.N. Carter, E.L. Mann,
J.D. Martin, M.G. Haygood and A.
Butler, "Structure and Dynamics of a
New Suite of Amphiphic Siderophores
Produced by a Marine Bacterium,"
Proc. Natl. Acad. Sci., 100, 3754-3759,
2003.

M.G. Haygood, E.W. Schmidt, S.K.
Davidson, and D.J. Faulkner, "Microbial
Symbionts of Marine Invertebrates:
Opportunities for Microbial
Biotechnology," J. Mol. Microbiol.
Biotechnol. 1, 33-43, 1999.

RICHARD L. JOHNSON

Professor
Director, Center for
Groundwater Research
Ph.D., Environmental Science
Oregon Graduate Center, 1985
rjohnson@ebs.ogi.edu

RESEARCH INTERESTS

Physical and chemical behavior of
organic contaminants in the air,
soil and water; environmental
analytical organic chemistry;
transport and fate of contaminants
at the watershed scale; modeling
of contaminant transport.

REPRESENTATIVE PUBLICATIONS

J.Z. Bandstra, R. Miehr, R.L. Johnson
and P.G. Tratnyek, "Reduction of 3,4,6-
Trinitrotoluene by Iron Metal: Kinetic
Controls on Product Distributions in
Batch and Column Experiments,"
Environ. Sci. Technol., 39(1), 230-238,
2005. 10.1021/es049129p S0013-
936X(04)09129-1 Web Release Date:
December 2, 2004

I.L. Amerson and R.L. Johnson, "A
Natural Gradient Tracer Test to
Evaluate Natural Attenuation of MTBE
Under Anaerobic Conditions,"
Groundwater Monitoring and
Remediation, 23(1), 54-61, 2003.

R.L. Johnson, P.C. Johnson, T.L.
Johnson and A. Leeson, "Helium Tracer
Tests for Assessing Contaminant Vapor
Recovery and Air Distribution During
In-Situ Air Sparging," Bioremediation
Journal, 5(4), 321-336, 2001.

R.L. Johnson, P.C. Johnson, T.L.
Johnson, N.R. Thomson and A. Leeson,
"Diagnosis of In-Situ Air Sparging
Performance Using Transient
Groundwater Pressure Changes During
Startup and Shutdown," Bioremediation
Journal, 5(4), 299-320, 2001.

R.L. Johnson, P.C. Johnson, I.L.
Amerson, T.L. Johnson, C.L. Bruce, A.
Leeson and C.M. Vogel, "Diagnostic
Tools for Integrated In-Situ Air Sparging
Pilot Tests," Bioremediation Journal,
5(4), 283-298, 2001.

PIERRE MOËNNE-LOCCOZ

Assistant Professor
Ph.D., Biophysics
University of Pierre & Marie Curie,
1989
ploccoz@ebs.ogi.edu

RESEARCH INTERESTS

Structure-function relationships
within proteins. Metallo- and
heme-proteins. Spectroscopic
studies of enzyme-active sites and
their cofactors. Reaction
intermediates within catalysis.

REPRESENTATIVE PUBLICATIONS

S. Lu, M.H. Sazinsky, J.W. Whittaker,
S.J. Lippard and P. Moënne-Loccoz,
"Fourier Transform Infrared
Characterization of the Azido Complex
of Methane Monooxygenase
Hydroxylase from Methylococcus
capsulatus (Bath),"J. Am. Chem. Soc.,
127, in press, 2005. ASAP article.

S. Lu, F.G.M. Wiertz, S. de Vries and
P. Moënne-Loccoz, "Resonance Raman
Characterization of a High-spin Six-
coordinate Iron(III) Intermediate in the
Metmyoglobin-azido Complex Formation
Trapped by Microsecond Freeze-
Hyperquenching (MHQ)," J. Raman
Spectrosc., 36, in press, 2005. ASAP
article.

S. Lu, Suharti, S. de Vries, and P.
Moënne-Loccoz, "Two CO Molecules can
Bind Concomitantly at the Diiron Site of
NO Reductase from Bacillus
azotoformans," J. Am. Chem. Soc.,
126, 15332-15333. 2004.

S. Lu, E. Libby, L. Saleh, G. Xing, J.
M. Bollinger, Jr. and P. Moënne-Loccoz,
"Characterization of NO Adducts of the
Diiron Center in Protein R2 of
Escherichia coli Ribonucleotide
Reductase and Site-directed Variants.
Implications for the O2 Activation
Mechanism,"J. Biol. Inorg. Chem. 9,
818-827, 2004.

E. Kim, M.E. Helton, I.M. Wasser, K.D.
Karlin, S. Lu, H.-W. Huang, P. Moënne-
Loccoz, C.D. Incarvito, A.L. Rheingold,
S. Kaderli, M. Honecker and A.D.
Zuberbühler, "Superoxo, _-Peroxo and
_-Oxo Complexes Derived from
Heme/O2 and Heme-copper/O2
Reactivity Studies: Copper-ligand
Influences in Synthetic Model Reactivity
Studies of the Cytochrome c Oxidase
Binuclear Active Site," Proc. Natl.
Acad. Sci. U.S.A. 100, 3623-3628,
2003.

MICHIKO M. NAKANO

Research Associate Professor
Ph.D., Cell Biology
University of Tokyo, 1976
mnakano@ebs.ogi.edu

RESEARCH INTERESTS

Anaerobiosis of *Bacillus subtilis*;
oxygen-controlled gene regulation;
two-component signal transduction
system; transcriptional activation;
nitrate/nitrite reductases;
flavohemoglobin; anaerobic
electron transport; nitric oxide
signaling.

REPRESENTATIVE PUBLICATIONS

E. Härtig, H. Geng, H. A. Hartmann,
A. Hubacek, R. Münch, D. Jahn, R. W.
Ye, and M. M. Nakano, "*Bacillus
subtilis* ResD Induces Expression of
Potential Regulatory Genes yclJK upon
Oxygen Limitation." J. Bacteriol. 186,
6477-6484, 2004.

C. M. Moore, M. M. Nakano, T. Wang,
R. W.Ye, and J. D. Helmann, "Response
of Bacillus subtilis to Nitric Oxide and
the Nitrosating Agent Sodium
Nitroprusside." J. Bacteriol. 186, 4655-
4604, 2004.

H. Geng, S. Nakano, and M. M.
Nakano, "Transcriptional Activation by
Bacillus subtilis ResD: Tandem Binding
to Target Elements and
Phosphorylation-dependent and -
independent Transcriptional
Activation." J. Bacteriol., 186, 2028-
2037, 2004.

A. Baruah, B. Lindsey, Y. Zhu, and M.
M. Nakano, "Mutational Analysis of the
Signal-sensing Domain of ResE
Histidine Kinase from Bacillus subtilis."
J. Bacteriol., 186, 1694-1704, 2004.

S. Nakano, M. M. Nakano, Y. Zhang,
M. Leelakriangsak and P. Zuber, "A
Regulatory Protein that Interferes with
Activator-Stimulated Transcription in
Bacteria," Proc. Natl. Acad. Sci. USA,
100, 4233-4238, 2003.

JAMES F. PANKOW

Professor
Ph.D., Environmental
Engineering Science
California Institute of Technology,
1978
pankow@ebs.ogi.edu

RESEARCH INTERESTS

Physical and analytical chemistry
of organic and inorganic species in
natural waters, the atmosphere,
and smoke aerosols; the formation
and chemistry of atmospheric
aerosols; the chemistry of the
delivery of nicotine and
carcinogens by tobacco smoke .

REPRESENTATIVE PUBLICATIONS

J.F. Pankow, W. Luo, A.D. Tavakoli, C.
Chen and L.M. Isabelle, "Delivery
Levels and Behavior of 1,3-Butadiene,
Acrylonitrile, Benzene, and Other Toxic
Volatile Organic Compounds in
Mainstream Tobacco Smoke from Two
Brands of Commercial Cigarettes,"
Chem. Res. Toxicol., 17, 805-813,
2004.

J.F. Pankow, K.C. Barsanti and D.H.
Peyton, "Fraction of Free-Base Nicotine
in Fresh Smoke Particulate Matter
from the Eclipse 'Cigarette' by 1H-NMR
Spectroscopy," Chem. Res. Toxicol., 16,
23-27, 2003.

J.F. Pankow, A.D. Tavakoli, W. Luo
and L.M. Isabelle, "Percent Free-Base
Nicotine in the Tobacco Smoke
Particulate Matter of Selected
Commercial and Reference Cigarettes,"
Chem. Res. Toxicol., 16, 1014-1018,
2003.

J.F. Pankow, J.H. Seinfeld, W.E. Asher
and G.B. Erdakos, "Modeling the
Formation of Secondary Organic
Aerosols. 1. Theory and Measurements
for the (-Pinene-, (-Pinene-, Sabinene-,
(3-Carene, and Cyclohexene-Ozone
Systems," Environ. Sci. Technol., 35,
1164-1172, 2001. See also Errata,
Environ. Sci. Technol., 35, 3272, 2001.

J.H. Seinfeld, W.E. Asher, G.B.
Erdakos and J. F. Pankow, "Modeling
the Formation of Secondary Organic
Aerosols. 2. The Predicted Effects of
Relative Humidity on Aerosol Formation
in the (-Pinene-, (-Pinene-, Sabinene-,
(3-Carene, and Cyclohexene- Ozone
Systems," Environ. Sci. Technol., 35,
1806-1817, 2001.

L. E. L. (BETS) RASMUSSEN

Research Professor
Ph.D., Neurochemistry
Washington University
(St. Louis), 1964
betsr@ebs.ogi.edu

RESEARCH INTERESTS

Mammalian chemocommunication: the transport, olfactory and vomeronasal organ reception of (Z)-7-dodecenyl acetate, the sex pheromone of the Asian elephant; the origin and synthesis of (Z)-7-dodecenyl acetate; identification and function of pheromones and chemical signals of the elephantunique temporal gland.

REPRESENTATIVE PUBLICATIONS

Rasmussen, L.E.L., Krishnamurthy, V., & Sukumar, R. (2005) Behavioral and chemical confirmation of the preovulatory pheromone, Z7-dodecenyl acetate, in wild Asian elephants: Its relationship to musth. Behaviour (in press).

Lazar, J., Rasmussen, L.E.L., Greenwood, D.R., In-Soek Bang, & Prestwich, G. D. (2004) Elephant albumin: A multi-purpose pheromone shuttle. Chemistry & Biology 11: 1093-1100 and Cover.

Rasmussen, L.E.L. & Greenwood, D.R. (2003) Frontalin: A chemical message of musth in Asian elephants. Chem. Senses 28: 433-446.

Rasmussen, L.E.L., Lazar, J., & Greenwood, D. R. (2003) The olfactory adventures of elephantine pheromones. Trans. J. Biochem. 31: 137-141.

Rasmussen, L.E.L., Riddle, H.S., and Krishnamurthy, V. (2002) Mellifluous matures to Malodorous in musth. Nature 415: 975-76.

L.E.L. Rasmussen, H.S. Riddle and V. Krishnamurthy, "Mellifluous Matures to Malodorous in Musth," Nature, 415, 975-976, 2002.

L.E.L. Rasmussen, "Source and Cyclic Release Pattern of (Z)-7-Dodecenyl Acetate, the Preovulatory Pheromone of the Female Asian Elephant," Chem. Senses, 26, 611-623, 2001.

L.E.L. Rasmussen and T.E. Perrin. "Physiological Correlates of Musth: Lipid Metabolites and Chemosignal Composition," Physiol. Behav., 67, 539-549, 1999.

REINHOLD A. RASMUSSEN

Professor
Ph.D., Botany/Plant Physiology
Washington University,
(St. Louis), 1964
rei@ebs.ogi.edu

RESEARCH INTERESTS

Atmospheric chemistry of trace gases; biogenic and anthropogenic emissions of trace gases and their roles in stratospheric ozone destruction and tropospheric ozone formation; measurements of trace gases at parts per trillion to parts per quadrillion levels; sources and sinks of isoprene and other hydrocarbons.

REPRESENTATIVE PUBLICATIONS

C. Geron, R.A. Rasmussen, R.R. Arnts and A. Guenther, "A Review and Synthesis of Monoterpene Speciation from Forests in the United States," Atmos. Environ, 34 (11), 1761- 1781, 2000.

J. Zhang, K.R. Smith, R. Uma, Y. Ma, V.V.N. Kishore, K. Lata, M.A.K. Khalil, R.A. Rasmussen and S.T. Thorneloe, "Carbon Monoxide from Cookstoves in Developing Countries: 2. Exposure Potentials," Chemosphere: Global Change Sci., 1 (1-3), 367-375, 1999.

J. Zhang, K.R. Smith, R. Uma, Y. Ma, V.V.N. Kishore, K. Lata, M.A.K. Khalil, R.A. Rasmussen and S.T. Thorneloe, "Carbon Monoxide from Cookstoves in Developing Countries: 1. Emission factors," Chemosphere: Chemosphere: Global Change Sci., 1 (1-3), 353-366, 1999.

E. Grosjean, R.A. Rasmussen and D. Grosjean, "Toxic Air Contaminants in Porto Alegre, Brazil," Environ. Sci. Technol., 33 (12), 1970-1978, 1999.

R.A. Rasmussen, M.A.K. Khalil and F. Moraes, "Permafrost Methane Content: 1. Experimental Data from Sites in Northern Alaska," Chemosphere, 26, 591, 1993.

M.A.K. Khalil, R.A. Rasmussen, J.R. French and J. Holt, "The Influence of Termites on Atmospheric Trace Gases:CH_4, CO_2, $CHCl_3$, N_2O, CO, H_2 and Light Hydrocarbons," J. Geophys. Res., 95, 3619, 1990.

D.A. Hegg, L.F. Radke, P.V. Hobbs, R.A. Rasmussen and P.J. Riggan, "Emissions of Some Trace Gases from Biomass Fires," J. Geophys. Res., 95, 5669, 1990.

MATTHEW S. SACHS

Associate Professor
Ph.D., Biology
Massachusetts Institute of Technology, 1986
msachs@ebs.ogi.edu

RESEARCH INTERESTS

Mechanisms of translational and transcriptional control that regulate the expression of the *Neurospora crassa arg-2* and *Saccharomyces cerevisiae CPA1* genes; fungal genomes.

REPRESENTATIVE PUBLICATIONS

P. Fang, C.C. Spevak, C. Wu and M.S. Sachs, "A Nascent Polypeptide Domain that can Regulate Translation Elongation," Proc. Natl. Acad. Sci. USA 101, 4059-4064, 2004.

C. Catalanotto, M. Pallotta, P. ReFalo, M.S. Sachs, L.Vayssie, G. Macino and C. Cogoni, "Redundancy of the Two Dicer Genes in Transgene-induced Posttranscriptional Gene Silencing in Neurospora crassa," Mol. Cell. Biol. 24, 2536-2545, 2004.

K.A. Borkovich, L.A. Alex, O.Yarden, M. Freitag, G.E. Turner, N.D. Read, S. Seiler, D. Bell-Pedersen, J. Paietta, N. Plesofsky, M. Plamann, M. Goodrich-Tanrikulu, U. Schulte, G. Mannhaupt, F.E. Nargang, A. Radford, C. Selitrennikoff, J.E. Galagan, J.C. Dunlap, J.J. Loros, D. Catcheside, H. Inoue, R. Aramayo, M. Polymenis, E.U. Selker, M.S. Sachs, G.A. Marzluf, I. Paulsen, R. Davis, D.J. Ebbole, A. Zelter, E.R. Kalkman, R. O'Rourke, F. Bowring, J. Yeadon, C. Ishii, K. Suzuki, W. Sakai and R. Pratt, "Lessons from the Genome Sequence of Neurospora crassa: Tracing the Path from Genomic Blueprint to Multicellular Organism," Microbiol. Mol. Biol. Rev., 68, 1-108, 2004.

M.S. Sachs and A.P. Geballe, "Biochemistry. Sense and Sensitivity - Controlling the Ribosome," Science 297, 1820-1821, 2002.

M.S. Sachs, Z.Wang, A. Gaba, P. Fang, J. Belk, R. Ganesan, N. Amrani and A. Jacobson, "Toeprint Analysis of the Positioning of Translational Apparatus Components at Initiation and Termination Codons of Fungal mRNAs," Methods 26, 105-114, 2002.

HOLLY SIMON

Assistant Professor
Ph.D., Bacteriology
University of Wisconsin-Madison, 1996
simonh@ebs.ogi.edu

RESEARCH INTERESTS

Microbial interactions, ecology and genomics; ecophysiology of mesophilic crenarchaeota.

REPRESENTATIVE PUBLICATIONS

H.M. Simon, C.E. Jahn, L.T. Bergerud, M.K. Sliwinski, P.J. Weimer, D.K. Willis and R.M. Goodman, "Cultivation of Mesophilic Soil Crenarchaeotes in Enrichments from Plant Roots," Appl. Environ. Microbiol., in press, 2005.

H.M. Simon and R. M. Goodman. "Archaea in Soil Habitats," in The Encyclopedia of Environmental Microbiology (G. Bitton, ed.), John Wiley & Sons, New York. pp. 293-305, 2002.

H.M. Simon, K.P. Smith, J.A. Dodsworth, B. Guenthner, J. Handelsman and R. M. Goodman, "Influence of Tomato Genotype on Growth of Inoculated and Indigenous Bacteria in the Spermosphere," Appl. Environ. Microbiol., 67, 514-520, 2001.

H.M. Simon, J.A. Dodsworth and R.M. Goodman, "Crenarchaeota Colonize Terrestrial Plant Roots," Environ. Microbiol., 2, 495-505, 2000.

H.M. Simon, M.M. Gosink and G. P. Roberts, "Importance of cis Determinants and Nitrogenase Activity in Regulated Stability of the Klebsiella pneumoniae Nitrogenase Structural Gene mRNA," J. Bacteriol., 181, 3751-3760, 1999.

R.M. Goodman, S.B. Bintrim, J. Handelsman, J.C. Rosas, B.F. Quirino, H.M. Simon and K. P. Smith, "A Dirty Look: Soil Microflora and Rhizosphere Microbiology," in Radical Biology; Advances and Perspectives on the Function of Plant Roots (H.E. Flores, J.P. Lynch, and J. Shannon, Eds.), American Society of Plant Physiologists, Rockville, MD, pp. 219-234, 1998.

H.M. Simon, M.J. Homer and G. P. Roberts, "Perturbation of nifT Expression in Klebsiella pneumoniae has Limited Effect on Nitrogen Fixation," J. Bacteriol., 178: 2975-2977, 1996.
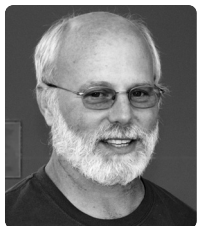
BRADLEY M. TEBO

Professor
Ph.D., Marine Biology, 1983
Scripps Institution of Oceanography
University of California, San Diego
tebob@ebs.ogi.edu

RESEARCH INTERESTS

Geomicrobiology-physiology, biochemistry, and molecular biology of bacteria that catalyze metal transformations; molecular mechanisms of microbial metal binding, electron transfer (redox reactions), and mineral formation; the biogeochemical cycling of metals in the environment; marine biotechnology; bioremediation .

REPRESENTATIVE PUBLICATIONS

B.M. Tebo, H.A. Johnson, J.K. McCarthy, and A.S. Templeton, "Geomicrobiology of manganese(II) oxidation," Trends in Microbiology 13, 421-428, 2005.

S.M. Webb, G.J. Dick, J.R. Bargar, and B.M. Tebo, "Evidence for the presence of Mn(III) intermediates in the bacterial oxidation of Mn(II)," Proceedings, National Academy of Sciences 102, 5558-5563, 2005.

A.S. Templeton, H. Staudigel, and B.M. Tebo, "Diverse Mn(II)-oxidizing bacteria isolated from submarine basalts at Loihi Seamount," Geomicrobiology Journal 22, 127-139, 2005.

B.M. Tebo, J.R. Bargar, B. Clement, G. Dick, K.J. Murray, D. Parker, R. Verity, and S. Webb, "Biogenic manganese oxides: Properties and mechanisms of formation," Annual Reviews of Earth and Planetary Sciences 32, 287-328, 2004.

D.L. Parker, D.L., G. Sposito, and B.M. Tebo, "Manganese(III) binding to a pyoverdine siderophore produced by a manganese(II)-oxidizing bacterium," Geochimica et Cosmochimica Acta 68, 4809-4820, 2004.

Y.M. Arias, A. Obraztsova, C. Green-Ruiz, and B.M. Tebo, "Natural attenuation of Cr(VI) contamination in laboratory mesocosms," Geomicrobiology Journal 20, 389-401, 2003.

C.A. Francis and B.M. Tebo, "Enzymatic manganese(II) oxidationby metabolically dormant spores of diverse Bacillus species," Applied and Environmental Microbiology 68, 874-880, 2002.

PAUL G. TRATNYEK

Professor
Ph.D., Chemistry
Colorado School of Mines, 1987
tratnyek@ebs.ogi.edu

RESEARCH INTERESTS

Mechanistic and kinetic aspects of the fate of organic pollutants in the environment; degradation reactions involving pesticides, phenols, munitions, dyestuffs and chlorinated hydrocarbon solvents; chemical and microbiological processes in sediments, soils and groundwaters as well as photochemical processes in surface waters; natural and engineered remediation systems .

REPRESENTATIVE PUBLICATIONS

J.T. Nurmi, P.G. Tratnyek, V. Sarathy, D.R. Baer, J.E. Amonette, K. Pecher, C. Wang, J.C. Linehan, D.W. Matson, R.L. Penn and M. D. Driessen, "Characterization and Properties of Metallic Iron Nanoparticles: Spectroscopy, Electrochemistry, and Kinetics," Environ. Sci. Technol., 39(5), 1221-1230. 2005.

J.Z. Bandstra, R. Miehr, R.L. Johnson and P.G. Tratnyek, "Reduction of 2,4,6-trinitrotoluene (TNT) by Iron Metal: Kinetic Controls on Product Distributions in Batch and Column Experiments," Environ. Sci. Technol., 39(1), 230-238, 2005.

J.T. Nurmi, J.Z. Bandstra and P.G. Tratnyek, "Packed Powder Electrodes for Characterizing the Reactivity of Granular Iron in Borate Solutions," J. Electrochem. Soc., 151(6), B347-B353, 2004.

J.Z. Bandstra and P.G. Tratnyek, "Applicability of Single-site Rate Equations for Reactions on Inhomogenous Surfaces," Ind. Eng. Chem. Res., 43(7), 1615-1622, 2004.

R. Miehr, P.G. Tratnyek, J.Z. Bandstra, M.M. Scherer, M. Alowitz and E.J. Bylaska, "The Diversity of Contaminant Reduction Reactions by Zero-valent Iron: Role of the Reductate," Environ. Sci. Technol., 38(1), 139-147, 2004.

KAREN WATANABE

Research Assistant Professor
Ph.D., Mechanical Engineering
University of California,
Berkeley 1993
watanabe@ebs.ogi.edu

RESEARCH INTERESTS

Computational methods in biology to study the biological fate of chemical xenobiotics and to assess the risks of exposure to such chemicals for humans and ecosystems.

REPRESENTATIVE PUBLICATIONS

K.H. Watanabe, "Modeling Exposure and Target Organ Concentrations," in: Quantitative Methods in Cancer and Human Health Risk Assessment. L. Edler and C. Kitsos, Eds., Chichester, West Sussex, United Kingdom, John Wiley & Sons., in press, pp.115-124, 2005.

K.H. Watanabe, H. Lin, H.L. Bart, Jr., P. Martinat, J.C. Means, M.L. Kunas and D.A. Grimm, "Bayesian Estimation of Kinetic Rate Constants in a Food Web Model of Polycyclic Aromatic Hydrocarbon Bioaccumulation," Ecol. Modelling, 181(2-3), 229-246, 2005.

H. Lin, D.W.Berzins, L. Myers, W.J. George, A.Abdelghani and K.H. Watanabe, K. H., "A Bayesian Approach to Parameter Estimation for a Crayfish (Procambarus Spp.) Bioaccumulation Model," Environ. Toxicol. Chem., 23(9), 2259-2266, 2004.

K.H. Watanabe, F.W. Desimone, A. Thiyagarajah, W.R. Hartley and A.E. Hindrichs, "Fish Tissue Quality in the Lower Mississippi River and Health Risks from Fish Consumption," The Science of the Total Environment 302(1-3), 109-126, 2003

K.H. Watanabe, "Fundamentals of Physiologically-based Toxicokinetic Models," in Endocrine Disrupters and Carcinogenic Risk Assessment. L. Chyczewski, J. Niklinski and E. Pluygers, Eds., Amsterdam, Netherlands, IOS Press, 271-280, 2002.

E.G. Luebeck, K.Watanabe and C. Travis, "Biologically Based Models of Carcinogenesis," in Perspectives on Biologically Based Cancer Risk Assessment. V. J. Cogliano, E. G. Luebeck and G. A. Zapponi, Eds., New York, Kluwer Academic/Plenum Publishers, 205-241, 1999.

JAMES W. WHITTAKER

Associate Professor
Ph.D., Biochemistry
University of Minnesota, 1983
jim@ebs.ogi.edu

RESEARCH INTERESTS

Electronic structures and dynamics of metalloenzyme active sites; spectroscopic and computational approaches to biomolecular structure; metalloenzyme mechanisms; enzyme engineering; biology of metal ions.

REPRESENTATIVE PUBLICATIONS

M.M.Whittaker and J.W.Whittaker, "Cu(I)-dependent Biogenesis of the Galactose Oxidase Cofactor," J. Biol. Chem., 278, 22090-22101, 2993.

M.M.Whittaker, V.V. Barynin, T. Igarashi and J.W. Whittaker, "Outer Sphere Mutagenesis of Lactobacillus plantarum Manganese Catalase Disrupts the Cluster Core," Eur. J. Biochem., 270, 1102-1116, 2003.

S.G. Minasian, M.M.Whittaker and J.W. Whittaker, "Stereoselective Hydrogen Abstraction by Galactose Oxidase," Biochemistry, 43, 13683-13693, 2004.

K. Mizuno, M.M. Whittaker, H.P. Bächinger and J.W. Whittaker, "Calorimetric Studies on the Tight Binding Metal Interactions of Escherichia coli Manganese Superoxide Dismutase," J. Biol. Chem., 279, 27339-27344, 2004.

J.W. Whittaker, "The Radical Chemistry of Galactose Oxidase," Arch. Biochem. Biophys. (Special Issue - Enzyme Mechanisms), 433, 227-239, 2005.

M.M. Whittaker and J.W. Whittaker, "Characterization of Recombinant Barley Oxalate Oxidase Expressed by Pichia pastoris," J. Biol. Inorg. Chem., 7, 136-145, 2002.

V.V. Barynin, M.M. Whittaker, S.V. Antonyuk, V.S. Lamzin, P.M. Harrison, P.J. Artymiuk and J.W. Whittaker, "Crystal Structure of Manganese Catalase from Lactobacillus plantarum," Structure, 9, 725-738, 2001.

M.M. Whittaker and J.W. Whittaker, "Catalytic Reaction Profile for Alcohol Oxidation by Galactose Oxidase," Biochemistry, 40, 7140-7148, 2001.

GEBRETATEOS WOLDEGIORGIS

Associate Professor
Ph.D., Nutritional Biochemistry
University of Wisconsin,
Madison, 1976
gwoldeg@ebs.ogi.edu

RESEARCH INTERESTS

Structure-function studies with the mitochondrial carnitine palmitoyltransferases I and II (CPTI and CPTII); regulation of CPTI gene expression, fatty acid transport, and oxidation in mammalian cells; investigations into the role of CPTI in diabetes, obesity, heart disease, and the molecular basis of human CPT deficiency diseases using animal models; regulation of cell metabolism and signaling by llong-chain acyl-CoA esters; mitochondrial ion transport and bioenergetics.

REPRESENTATIVE PUBLICATIONS

Liu, H., Zheng, G., Dai, J., and Woldegiorgis, G. (2005) Cysteine-scanning mutagenesis of muscle carnitine palmitoyltransferase I reveals a single cysteine residue (Cys-305) is important for catalysis. J. Biol. Chem., 280, 4524-31.

J. Relat, C. Nicot, M. Gacias, G.Woldegiorgis, P.F. Marrero and D. Haro, "Pig Muscle Carnitine Palmitoyltransferase I (CPTI beta), with Low Km for Carnitine and Low sensitivity to Malonyl-CoA Inhibition, has Kinetic Characteristics Similar to Those of the Rat Liver (CPTI alpha) Enzyme," Biochemistry, 43,12686-12691, 2004.

H. Huang, O. Starodub, A. McIntosh, B.P. Atshaves, B. Woldegiorgis, A.B. Kier and F. Schroeder, "Liver Fatty Acid-Binding Protein Colocalizes with Peroxisome Proliferator Activated Receptor alpha and Enhances Ligand Distribution to Nuclei of Living Cells," Biochemistry, 43, 2484-2500, 2004.

L. Napal, J. Dai, M. Treber, D. Haro, P.F. Marrero and G .Woldegiorgis, "A Single Amino Acid Change(Substitution of the Conserved Glu-590 with Alanine) in the C-terminal Domain of Rat Liver Carnitine Palmitoyltransferase I Increases its Malonyl-CoA Sensitivity Close to that Observed with the Muscle Isoform of the Enzyme," J. Biol. Chem., 278, 34084-34089, 2003.

PETER ZUBER

Professor
Ph.D., Microbiology
University of Virginia
pzuber@ebs.ogi.edu

RESEARCH INTERESTS

Regulation of bacterial gene expression in response to oxidative stress. Control of gene expression at the level of transcription initiation. Bacterial sporulation and applied spore biology/chemistry. Peptide antibiotic biosynthesis.

REPRESENTATIVE PUBLICATIONS

R.B.Weart, S. Nakano, P. Zuber and P.A. Levin, "The ClpX Chaperone Modulates Assembly of the Tubulin-like Protein FtsZ," Mol. Microbiol., in press, 2005.

K.N. Erwin, S. Nakano and P. Zuber, "Sulfate-dependent Repression of Genes that Function in Organosulfur Metabolism in Bacillus subtilis Requires Spx," J. Bacteriol., in press, 2005.

S. Nakano, K.N. Erwin, M. Ralle and P. Zuber, "Redox-sensitive Transcriptional Control by a Thiol/disulfide Switch in the Global Regulator Spx," Mol. Microbiol., 55, 498-510, 2005.

M.M. Nakano, P. Zuber and A.L. Sonenshein, "Toxin Gene Regulation in Clostridium," in Strict and Facultative Anaerobes: Medical and Environmental Aspects, M.M. Nakano and P. Zuber, Eds., Horizon Scientific Press, Wymondham, UK, pp. 199-209, 2004.

P. Zuber, "Spx-RNA Polymerase Interaction and Global Transcriptional Control During Oxidative Stress," J. Bacteriol., 186, 1911-1918, 2004.

K.E. Kawulka, T. Sprules, C.M. Diaper, R.M. Whittal, R.T. McKay, P. Mercier, P. Zuber and J.C. Vederas, "Structure of Subtilosin A, a Cyclic Antimicrobial Peptide from Bacillus subtilis with Unusual Sulfur to alpha-Carbon Crosslinks: Formation and Reduction of alpha-Thio-alpha-Amino Acid Derivatives," Biochemistry, 43, 3385-3395, 2004.

S. Nakano, E. KŸster-Sch_ck, A.D. Grossman, and P. Zuber, "Spx-dependent Global Transcriptional Control is Induced by Thiol-specific Oxidative Stress in Bacillus subtilis," Proc. Natl. Acad. Sci. USA, 100, 13603-13608, 2003.

RESEARCH SCIENTISTS

WILLAM ASHER

Ph.D., Environmental Science
and Engineering
Oregon Graduate Center

WENTAI LUO

Ph.D., Environmental Science
and Engineering
Oregon Graduate Institute
of Science & Technology

JIAYI PAN

Ph.D., Institute of Oceanology
Chinese Academy of Science

YINGLONG (JOSEPH) ZHANG

Ph.D., Applied Mathematics
and Fluid Mechanics
University of Wollongong, Australia

JOINT AND ADJUNCT FACULTY

NIRUPAMA BULUSU

Department of Computer Science
Portland State University

JAMES M. CREGG

Keck Graduate Institute
of Applied Life Sciences

JORGE CROSA

Dept. of Molecular Microbiology
and Immunology
Oregon Health & Science University

BERNARD A. FOX

Earle A. Chiles Research Institute
Providence Medical Center

STEPHEN B. HALL

Pulmonary and Critical Care Medicine
Oregon Health & Science University

JAMES J. HUNTZICKER

Center for Professional
Development
OGI School of Science
& Engineering

DAVID A. JAY

Department of Civil and
Environmental Engineering
Portland State University

DAVID MAIER

Department of Computer Science
Portland State University

RICHARD L. STOUFFER

Oregon National Primate Research
Center and Department of
Physiology and Pharmacology
Oregon Health & Science University

JAMES K. HURST

Department of Chemistry
Washington State University

ASLAM KHALIL

Department of Physics
Portland State University

KENNETH ROSENBAUM

Environmental Law Institute
Washington, D.C.

STEWART ROUNDS

U.S. Geological Survey

TODD M. SANDERS

Portland Community College,
Sylvania

PATRICIA L. TOCCALINO

U.S. Geological Survey
Sacramento, California

JOHN C. WESTALL

Department of Chemistry
Oregon State University

RESEARCH ASSOCIATES

MERAY BASTURKMEN

Ph.D., Chemistry
Middle East Technical University

ANDREW T. BAUMAN

Ph.D., Molecular Toxicology
Oregon State University

JOEL BURCHFIEL

B.S. Chemistry
Oregon State University

ADAM S. BONIN

Ph.D., Biology
Portland State University

JUSTIN G. BRODERSEN

M.S., Marine Science
University of South Florida

YANZHEN CUI

Ph.D., Cell & Developmental
Biology
Oregon Health & Science University

KAITLIN GRAMMER

B.S., Geology
University of Alaska-Fairbanks

JON GRAVES

M.S. Oceanography and Marine
Resource Management
Oregon State University

RACHEL A. HENSON

B.S., Environmental Science
University of Idaho

HEATHER M. HOOD

Ph.D., Behavioral Neuroscience
Oregon Health & Science University

LORNE M. ISABELLE

M.S., Chemistry
San Francisco State University

MARY MAYFIELD-GAMBILL

B.S., Microbiology
Oregon State University

JAMES F. MOHAN

M.S., Management in Science
and Technology
Oregon Graduate Institute

JULIA NORMAN

M.S., Environmental Science
and Engineering
OGI School of Science &
Engineering at OHSU

CHARLES SEATON

M.S. Environmental Science
and Engineering
Oregon Graduate Institute of
Science & Engineering

CAROLYN SHEEHAN

B.A. Geography
San Diego State University

ROBERT (BRAD) THOMS

M.S. Environmental Science
and Engineering
OGI School of Science &
Engineering at OHSU

PAUL J. TURNER

B.S. Mathematics
Boise State University

ETHAN VAN MATRE

Software Engineering
Kennedy Western University

RACHEL H. WALDEMER

M.S., Environmental Science
and Engineering
OGI School of Science &
Engineering at OHSU

ROBERT M. WATKINS

B.S., Chemical Engineering
Washington State University

MEI M. WHITTAKER

Ph.D., Biochemistry
University of Minnesota

MICHAEL WILKIN

B.Sc. (Hons),
Oceanography and Geology
University of Southampton, U.K.

MICHAEL ZULAUF

Ph.D., Meteorology
University of Utah

THE DEPARTMENT OF MANAGEMENT IN SCIENCE AND TECHNOLOGY (MST) focuses on educating leaders and managers in a technology-intensive world. All MST courses have a strong technology focus, meeting the educational needs of students working in high-technology industries and/or technology-intensive professions including health care. Our curriculum also emphasizes collaboration and teamwork skills needed to work effectively with people, and the commercialization skills needed to bring new products or services to market.

WHAT SETS MANAGEMENT IN SCIENCE AND TECHNOLOGY APART?

The M.S. in Management in Science and Technology is:

Technology-focused. Our graduate management program is a non-thesis degree program designed for working professionals in technology-creating industries (e.g. semiconductor and software) and technology-leveraging professions (e.g. information systems, materials planning/logistics and health care).

Relevant. Management in Science and Technology courses are taught by faculty with outstanding professional and academic credentials. Faculty have developed their expertise through years of professional work in the private sector as well as in distinguished academic careers. Each class is designed to deliver cutting-edge knowledge about best practices. Managers and executives from the region's high-technology companies visit classes to share their experience with the students. Students and managers alike tell us that the "M.S. in Management classes offer knowledge you can apply Monday morning."

Flexible. We designed the program for working people, making it possible for students to attend intensive weekend or weeknight classes and continue to fulfill their commitments at work and home. Students may begin taking classes in any quarter, and may take individual courses for professional development prior to enrolling in the degree program. In addition, the online delivery of our degree program through eCollege makes it a convenient choice, accessible to students anywhere in the world.

Collaborative. MST courses equip students with the functional expertise and the people skills to manage cross-boundary partnerships effectively. The curriculum and faculty emphasize the development of leadership and communications skills that are critical to collaboration between people from different functions, companies, and countries. Team projects, group exercises and oral presentations are emphasized throughout the curriculum. In addition, small class sizes create an enriched learning experience by promoting interaction and discussions between faculty and students.

Entrepreneurial. The MST program emphasizes entrepreneurship through the integrative Capstone experience, culminating in the Jim Hurd New Venture Business Plan Presentations. Student-formed management teams develop and present business plans to a panel of venture capitalists that evaluates their viability and investment potential.

INDIVIDUAL COURSES FOR CAREER DEVELOPMENT

Each Management in Science and Technology course has been designed as a valuable professional development experience for working professionals. For example, Project Management (MST 512), Becoming an Effective Manager (MST 520) and Leadership and Communication Skills (MST 541) may be taken as stand-alone courses. We encourage non-matriculated students to join our courses for their own career development in specific areas.

ONLINE COURSES AND OFF-CAMPUS CLASSROOMS

The MST Department delivers challenging and engaging versions of its courses online. *U.S. News & World Report* chose MST-Online as one of the "Best of the Online Grad Programs" in 2001. This is an excellent

Department of Management in Science and Technology

MST's 2005 graduates enjoy a moment together at the 2005 Hooding Ceremony held in the Old Library on OHSU's main campus.

option for students facing time pressures or working in locations where travel to campus is not feasible. Courses offered online will have a "D" designation as the section number following the course number.

MST Courses are also offered off-campus at the Wilsonville Training Center, 29353 Town Center Loop East, Wilsonville, OR. and at the Marquam Hill Campus of OHSU. Currently, one or two courses per term are offered at these locations. Please refer to our Web site www.mst.ogi.edu for updated course schedule information. Courses offered at Wilsonville will have a "W" designation as the section number following the course number.

FOR-CREDIT CERTIFICATE PROGRAMS

ADMISSION REQUIREMENTS

- A completed application with $25 nonrefundable application fee
- At least two years of relevant professional experience
- For non-native speakers of English, a score of 625 or better on the TOEFL examination

Individual courses are open to interested persons without the need to matriculate into the degree or certificate programs. Enroll-ment is available to any qualified student.

MANAGEMENT IN SCIENCE AND TECHNOLOGY CERTIFICATE

The Management in Science and Technology department offers a six-course certificate in Management in Science and Technology. The following five courses are required, with an additional management elective course chosen in consultation with a faculty advisor.

CORE COURSES

MST 510	Principles and Trends in Technology Management	3 credits
MST 512	Project Management	4 credits
MST 520	Becoming an Effective Manager	4 credits
MST 571	Managerial and Financial Accounting for Science and Technology	4 credits
MST 573	Technology Marketing: Planning for Market	4 credits
• ELECTIVE:	To be chosen after consultation with faculty advisor	

HEALTH CARE MANAGEMENT CERTIFICATE

The certificate in Health Care Management is designed for working professionals in administration, reimbursement or management roles in health care organizations. The program provides an overview of the financial, policy, organizational and operational environments of health care-related enterprises. Students gain focused skills for designing and managing organizations engaged in the delivery of health care.

The Health Care Management Certificate blends the unique management and planning expertise within the M.S. in Management faculty with those of recognized professionals in the health care community at OHSU and elsewhere.

The program consists of six courses, including four core (required) courses and two elective choices, for a total of at least 20 credits, as listed below.

CORE COURSES

MST 560	The Organization, Financing, and History of Health Care Delivery in the United States	4 credits
MST 561	Managerial and Financial Accounting for Health Care Professionals	4 credits
MST 562	Health Care Program Management	4 credits
MST 563	The Regulation and Legislation of Health Care Delivery	4 credits
• ELECTIVES:	Two of the following courses are required	
MST 507HC	Seminar for Health Care Management	2-4 credits
MST 564	Business Planning and Strategy in the Health Care Industry	4 credits
MST 565	Human Resources in Health Care	4 credits
MST 566	Health Care Information Systems Management	4 credits
MST 567	Health Care Technology – New Medical Advances	4 credits
MST 568	New Trends in Health Care Delivery	4 credits

The following courses from MST and other OHSU departments may also be used as electives, as may other Oregon University System courses, by petition to the department.

MST 512	Project Management	4 credits
MST 520	Becoming an Effective Manager	4 credits
MST 522	Influencing Change in Organizations	3 credits
MST 541	Leadership and Communication Skills	3 credits
MST 542	Business Ethics and Corporate Social Responsibility	3 credits

The general admission requirements for the institution apply to the M.S. in Management in Science and Technology program with the following additions or exceptions:

A minimum of two years of full-time work experience — preferably at the professional, supervisory or managerial level — in a technical, scientific, business or related area.

Recommended TOEFL score of 625 (paper-based test) / 263 (computer-based test) if English is not the applicant's first language. Scores are not required for students who earned an undergraduate degree in the United States, or who have worked for at least two years in an organization conducting business primarily in English.

- GMAT or GRE scores are not required.

Part-time students may apply for admission to the M.S. in Management program during any quarter. Full-time students are strongly encouraged to consult with an advisor for academic planning.

DEGREE REQUIREMENTS

OGI offers a non-thesis M.S. in Management in Science and Technology. All M.S. Students must take the master's degree core sequence, consisting of the following courses or the equivalent (36 credits). The courses listed below are offered both on-campus and online. Either format is acceptable for the M.S. degree. To earn the degree, students must complete a minimum of 52 credits with an average GPA of 3.0 or better.

MANAGEMENT IN SCIENCE AND TECHNOLOGY CORE SEQUENCE

MST 510	Principles and Trends in Technology Management	3 credits
MST 512	Project Management	4 credits
MST 513	Operations Management and Practices	3 credits
MST 520	Becoming an Effective Manager	4 credits
MST 530	Strategic Management and Planning	4 credits
MST 550	Capstone Project: Preparing the Business Plan	2 credits
MST 551	Capstone Project: Delivering the Business Plan	3 credits
MST 571	Managerial and Financial Accounting for Science and Technology	4 credits

MST 572   Financial Management for . . . . . 4 credits
          Science and Technology
MST 573   Technology Marketing: . . . . 4 credits
          Planning for Market
MST 590   Effective Business Writing . . . . . . 1 credit
          for Management

– OR –

MST 591   Effective Business Writing for . . . 1 credit
          Non-Native Speakers

Certain courses are more beneficial when taken earlier rather than later in a student's program of study. It is strongly recommended that students take the following courses as early as possible in their studies:

MST 520   Becoming an Effective Manager
MST 590   Effective Business Writing for Management
– OR –
MST 591   Effective Business Writing for
          Non-Native Speakers

For the best possible **Capstone** experience, students form teams three to six months in advance of the quarters in which they plan to take the Capstone Project (MST 550 and MST 551). MST 550 and MST 551 must be taken in two successive quarters. Capstone should be taken as close to the end of a student's studies as possible. **Prerequisites** are: MST 520, MST 571, MST 573, and instructor approval. The following courses are *strongly recommended* prior to Capstone: MST 530, MST 541, MST 572, MST 574, and MST 590/591.

For students pursuing a **Health Care Emphasis**, the following courses may be substituted for the related core courses:

MST 561 Managerial & Financial Accounting for Health Care Professionals (for MST 571)

MST 562 Health Care Program Management (for MST 512)

MST 564 Business Planning and Strategy in the Health Care Industry (for MST 530)

MST DEGREE ELECTIVES

All M.S. students must take between 4 and 6 elective courses, for a minimum of 16 elective credits, selected from the general list of electives.

MST 509   Commercialization Practicum . . . 4 credits
MST 511   Quality Management . . . . 3 credits
MST 515   Supply Chain Management . . . . 3 credits
MST 516   Global Logistics and . . . . 3 credits
          Financial Management
MST 517   Supply Chain Management: . . . . 3 credits
          Advanced Modeling
MST 521   Managing People . . . . 3 credits
          in Organizations
MST 522   Influencing Change . . . . 3 credits
          in Organizations
MST 523   New Product Development . . . . . 4 credits
MST 531   Software Commercialization . . . . 3 credits

MST 540   International Management in . . . 3 credits
          Science and Technology
MST 541   Leadership and . . . . 3 credits
          Communication Skills
MST 542   Business Ethics and . . . . 3 credits
          Corporate Social Responsibility
MST 544   Strategic Alliances . . . . 3 credits
MST 549   Applied Business Forecasting . . 4 credits
MST 574   Going to Market: Delivering . . . . 4 credits
          Value to Customers and Shareholders

Students may petition the MST department head for elective credit for other OGI, OHSU, OMSE (Oregon Master of Software Engineering), or PSU courses relevant to the theory or practice of management.

By appropriate choice of electives students can create a program of courses that provides depth in their area of interest, such as those examples listed below. **Examples** of possible elective combinations to achieve this depth follow. Other combinations of courses can be selected at the option of the student.

MANAGING TECHNOLOGY ORGANIZATIONS

MST 509   Commercialization Practicum
MST 511   Quality Management
MST 522   Influencing Change in Organizations
MST 541   Leadership and Communication Skills
MST 542   Business Ethics and Corporate
          Social Responsibility
MST 574   Going to Market: Delivering Value to Customers
          and Shareholders

LEADERSHIP AND COLLABORATION

MST 521   Managing People in Organizations
MST 522   Influencing Change in Organizations
MST 540   International Management in Science
          and Technology
MST 541   Leadership and Communication Skills
MST 542   Business Ethics and Corporate
          Social Responsibility
MST 544   Strategic Alliances and Acquisitions

COMMERCIALIZATION AND INNOVATION

MST 509   Commercialization Practicum
MST 521   Managing People in Organizations
MST 523   New Product Development
MST 531   Software Commercialization
MST 544   Strategic Alliances and Acquisitions
MST 574   Going to Market: Delivering Value to
          Customers and Shareholders

MANAGING OPERATIONS

MST 511   Quality Management
MST 515   Supply Chain Management
MST 516   Global Logistics and Financial Management
MST 517   Supply Chain Management: Advanced Modeling
MST 541   Leadership and Communication Skills
MST 549   Applied Business Forecasting

MANAGING IN THE SOFTWARE INDUSTRIES

CS 516   Introduction to Software Engineering
MST 521   Managing People in Organizations

MST 523   New Product Development
MST 531   Software Commercialization
MST 540   International Management in Science
          and Technology
MST 541   Leadership and Communication Skills

HEALTH CARE MANAGEMENT

MST 541   Leadership and Communication Skills
MST 562   Health Care Program Management
MST 563   The Regulation and Legislation of Health
          Care Delivery
MST 564   Business Planning and Strategy in the
          Health Care Industry
MST 565   Human Resources in Health Care

FACULTY

JAMES J. HUNTZICKER

Professor and Department Head
Ph.D., Physical Chemistry
University of California,
Berkeley, 1968
jimhz@admin.ogi.edu

REPRESENTATIVE PUBLICATIONS:

B.J. Turpin, J.J. Huntzicker, "Identification of Secondary Organic Aerosol Episodes and Quantitation of Primary and Secondary Organic Aerosol Concentrating During SCAQS," Atmospheric Environment, **28**, 3061, 1995.

B.J. Turpin, J.J. Huntzicker, S.V. Hering, "Investigation of Organic Sampling Artifacts in the Los Angeles Basin," Atmospheric Environment, **29**, 3527 1994

MARIANNE KOCH

Visiting Associate Professor
Ph.D., Human Resource
Management
and Industrial Relations
Columbia University, 1989
kochm@ohsu.edu

RESEARCH INTERESTS

The human side of technology transfer; work/family policies and practices; coaching faculty in the development and teaching of e-learning courses.

REPRESENTATIVE PUBLICATIONS:

D.B. Drake, N.A. Steckler, and M.J. Koch, "Information Sharing in and across Government Agencies: The Role and Influence of Scientist, Politician, and Bureaucrat Subcultures," *Social Science Computer Review*, **22**, No. 1, Spring, 2004.

M. Koch and D Moshavi, "The Adoption of Family-Friendly Policies in Family-Owned Firms: Paragon or Paradox," Proceedings of the 2001 Southern Management Association Annual Meeting, New Orleans, LA, 2001.

M. Koch and G. Hundley, "The Effects of Unionism on Recruitment and Selection Practices," *Industrial Relations*, **36**(3), 349–370, 1997.

M. Koch and R. McGrath, "Improving Labor Productivity: Human Resource Management Policies Do Matter," 1996, *Strategic Management Journal*, **17**, 335–354, 1996. (Awarded an Anbar Electronic Intelligence Citation of Excellence Award for 1997).

M. Koch, L. Long, and A. Meyer, "Adoption of Innovations in Hospitals: Exploring the Validity of a Multi-Stage Model," forthcoming, International Journal of Technology Management; also in *Academy of Management Best Papers Proceedings*, August 1996.

M. Koch. "Hiring Practices and Labor Productivity," Garland Publishing, New York, 1995.

JACK RAITON

Senior Fellow
MBA, Finance and Statistics
University of Washington, 1967
raitonj@ohsu.edu

Having previously served as chief financial officer of Planar Systems and as corporate controller of Tektronix, Jack brings a wealth of high-level management experience in local industry to the MST department. He is active in the leadership of the American Electronics Association and Financial Executives International, and serves on the Advisory Boards of Compli, Inc, StoriedLearnings, and two high tech start-ups. Jack earned his BS in Mathematics from Oregon State University in 1966 and his MBA in Finance and Statistics from the University of Washington in 1967. He attended Harvard University's Advanced Management Program, and passed the CPA exam in 1979.

AREAS OF EXPERTISE

Performance measurement, capital structure, stock options and incentive plans, forensic accounting.

NICOLE A. STECKLER

Associate Professor
Ph.D., Organizational Behavior
Harvard University, 1990
steckler@ohsu.edu

RESEARCH INTERESTS

Information-sharing across organizational boundaries; leading organizational change; interpersonal communication and influence in organizations; and tools for diagnosing and improving leadership effectiveness.

REPRESENTATIVE PUBLICATIONS

D.B. Drake, N.A. Steckler, and M.J. Koch, "Information Sharing in and across Government Agencies: The Role and Influence of Scientist, Politician, and Bureaucrat Subcultures," *Social Science Computer Review*, **22**, No. 1, Spring, 2004.

N.A. Steckler and N. Fondas, "Building Team Leader Effectiveness: A Diagnostic Tool," *Organizational Dynamics*, **23**, 20–35, Winter/Spring 1995.

J. White, S. Jacobson, R. Jacques, N. Fondas and N.A. Steckler, "You Just Don't Understand: Gendered Interaction and the Process of 'Doing' Organizational Scholarship," *Journal of Management Inquiry*, **4**(4), 370–379, December 1995.

N.A. Steckler and A. Donnellon, "Review of Peter K. Manning's 'Organizational Communication'," *Academy of Management Review*, **18**, 374–377, 1993.

N.A. Steckler and R. Rosenthal, "Sex Differences in Nonverbal and Verbal Communication with Bosses, Peers, and Subordinates," *Journal of Applied Psychology*, **70**, 157–163, 1985.

N.C. Ware, N.A. Steckler and J. Leserman, "Undergraduate Women: Who Chooses a Science Major?" *Journal of Higher Education*, **56**, 73–84, 1985.

ADJUNCT FACULTY

JEAN-CLAUDE BALLAND, PH.D.
JCB Associates

LARRY BUNYARD
Tektronix, Inc.

GREG CHARLES
Applied Business Forecasting, LLC

SUSAN COOMBES
Legacy Health Systems

LESLIE COPLAND
Waggener Engstrom

LINDA CRAFTS
Cumulus Resources LLC

AARON CRANE
Salem Hospital

GEORGE DOCHAT
ESI

TOM FLORA, D.ED.
OHSU

RICHARD FOURNIER
Business Computer Institute

DAVID GARTEN
Independent Consultant

ROBERT HARMON
Portland State University

JOHN HENGEVELD
Mentor Graphics

JILL KELLY, PH.D.
Women's Journal

RITA LAXTON-BENZAN, PH.D.
PacifiCorp

KATHY LONG HOLLAND
LongSherpa/Eco-D

ROY MAGNUSSON, M.D., MBA
OHSU

SUZANNE MALEK
Independent Consultant

KATHY MANGEL DAVIS
Professionally Speaking

MICHAEL MCLEAN
AC Transit

DEIRDRE MENDEZ, PH.D.
Foreign Business
Management Consultants

**MARGARET (MELODY)
MONTGOMERY, R.N., MBA**
OHSU

MICHAEL NEAL, PH.D.
Independent Consultant

PAUL NEWMAN, PH.D.
Cooper Mountain Research, Inc.

JEFF OLTMANN
Synergy Professional Services

JODY PETTIT, PH.D.
Oregon Healthcare
Quality Corporation

JESSE REEDER
Leadership Dynamics

ADRIAN ROBERTS, PH.D.
Independent Consultant

THOI TRUONG
CNF

JOHN WALLNER
Tektronix, Inc.

COURSE DESCRIPTIONS

Effective Fall quarter 2003, the OGI School has renumbered many of its courses to better align course numbers with the Oregon Health & Science University standard numbering scheme. To assist in relating the new course numbers to courses offered in the past, a course number crosswalk is available online at www.ogi.edu/graduate_edu/schedule/crosswalk.cfm.

5xx Graduate courses offered primarily in support of master's programs. May be used towards a doctoral program as appropriate.

6xx Graduate courses offered primarily in support of doctoral programs. May be used towards a master's program as appropriate.

Master's and certificate students should register for the 5xx class and doctoral students should register for the 6xx class when available.

BIOMEDICAL ENGINEERING

BME 501 M.S. Non-Thesis Research
Supervised project research for Master's students who are not pursuing a thesis.
Variable and repetitive credit

BME 502/602 Independent Study
Independent study allows a student to work one-on-one with a faculty member on selected topic(s) of interest. Registering for independent study requires pre-approval from the faculty member and the student's academic department.
Variable and repetitive credit

BME 503 M.S. Thesis Research
Supervised original research towards a thesis for the Master's degree. *Variable and repetitive credit*

BME 504/604 Professional Internship
Professional internship credits provide students an opportunity to earn credit for relevant work experience in industry. Students gain valuable industrial experience that allows them to both apply the knowledge gained in the classroom and prepare for careers following graduation. Students on F-1 or J-1 visas must obtain prior written approval for internships from OGI's Office of International Students and

Scholars before enrolling. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
Variable and repetitive credit

BME 505/605 Readings in Biomedical Engineering
This course is designed to teach critical evaluation of information in the field of Biomedical Engineering. Students will read articles and papers on timely topics related to the student's area of interest. Students will be required to present a summary of the readings to the class.
0 credit/term, repetitive

BME 506/606 Special Topics
Special topics courses are offered in areas of particular relevance to the research interests of faculty or in response to industry needs. Special Topic courses are subject to change and are offered intermittently.
Variable and repetitive credit

BME 507/607 Biomedical Engineering Seminar
This seminar course will feature presentations and discussions on topics in biomedical engineering that exemplify the wide range of applications of biomedical engineering to science and medicine. The goals are to provide the students with an overview of the diverse opportunities for research and application, to foster development of critical analysis and thinking, and to stimulate creative problem solving and research planning.
0 credit/term, repetitive

BME 517/617 Systems Physiology
Systems Physiology provides a medical problem-oriented introduction to major physiological systems with which biomedical engineers are involved. The course is intended to provide an understanding of normal physiological functions, methods for systems analysis, and information about the development of devices, drug delivery systems, and processes that may compensate for abnormal functions. An emphasis will be placed on understanding physiological systems from an engineering perspective. Coverage will include, among others, the circulatory, nervous, pulmonary, and urogenital systems.

The course will assist the prospective biomedical engineers in guiding their research that addresses unmet medical needs and improve their productivity with the ultimate purpose of benefiting patients, improve human health and quality of life. We will discuss how and why some of the human body's functional systems are organized and synchronized. We will touch on the relevant anatomy, but our focus (foci) will stay on physiological functions that can break down and manifest as prevalent disease and/or frequent cause death. We include lectures by clinical and research scholars and work on specific and narrow topics in depth. The key feature of the course will be discussion of medical problems that can or could be addressed using the tools of biomedical engineering
3 credits

BME 522/622 Biomedical Optics I: Tissue Optics
Light propagation in tissue: This course treats light transport in scattering and absorbing media such as biological tissue. Light transport is modeled using a variety of theories and computational techniques,

including Monte Carlo simulations and approximate solutions of the radiative transport equation. Steady-state and time-dependent problems are treated. Spectroscopy and fluorescence measurements are introduced. Optical imaging techniques are presented. Students learn the basics required for design of optical devices for therapy and diagnostics.
3 credits

BME 523/623 Biomedical Optics II:
Laser Tissue Interactions
Physics of laser-tissue interactions: The course treats the immediate physical processes that accompany the absorption of light by biological tissues, including photochemical reactions, heating and tissue coagulation, vaporization, creation of plasmas, and production of stress waves in tissue. Such processes are modeled using finite-difference techniques. Applications in medicine and biology are discussed. Prerequisite: BME 522/622 Biomedical Optics I, or permission of instructor.   *3 credits*

BME 524/624 Biomedical Optics III: Engineering Design
The students work as a team in preparing five business plans throughout the quarter. Each business plan is devoted to a potential medical device or protocol using optical technologies. The team is divided into a CEO, scientific officer, marketing manager, regulatory affairs manager, and manufacturing manager. The roles are rotated amongst the students for each business plan. Feasibility studies are conducted in a laboratory exercise designed by the students. The team formally presents a business plan every two weeks. Prerequisite: BME 523/623 Biomedical Optics II, or permission of instructor.   *3 credits*

BME 525/625 Biomedical Photomechanics
This course is a graduate-level introduction to the use of optical techniques for addressing issues in solid and fluid mechanics in the biomedical environment. The course emphasizes both theoretical and practical aspects of the use of light for evaluating displacements, strains, flows and motions in biological tissues and structures. Suggested prerequisites: Physical and/or geometrical optics, mathematics through differential equations, MATLAB programming skills .   *3 credits*

BME 526/626 Computational Approaches to Laser Interactions with Biological Tissues
Lasers and light from alternative conventional sources interact with biological tissues or other complex media through photochemical, photothermal and photomechanical mechanisms. This course will employ computational methods to simulate interaction of lasers with tissues. Compartmental modeling will model photochemical interactions. Green's function and finite difference techniques will model thermal and water diffusion, surface evaporation, and explosive vaporization. Arrhenius rate process calculations will model thermal damage, thermoelastic expansion and velocity potential models will simulate pressure wave generation and propagation, spallation/cavitation models will model initiation and growth of laser-induced material defects leading to fragmentation. These methods provide a tool kit for handling a wide variety of laser effects in biological tissues.   *3 credits*

BME 527/627 Computational Approaches to Light Transport in Biological Tissues

Understanding the movement of light through complex biological tissues or other complex media is the first step in design of optical devices or clinical protocols in medical applications of lasers and light. This course will use various computational methods to simulate such light propagation: (1) wave theory to discuss the early loss of coherence and polarization as light initially enters tissue; (2) small angle scattering to discuss the transition of ballistic photons into scattering photons; (3) Monte Carlo simulations to discuss a variety of issues in energy propagation, including irregular boundary conditions; (4) diffusion theory to predict light fields distant from sources; (5) perturbation theory to approximate optical heterogeneities with absorption and scattering properties that vary from the background medium properties. These methods provide a tool kit for handling a wide variety of optical problems encountered in design of optical systems involving tissues.   3 credits

BME 528/628 Physical and Geometrical Optics

First-order Gaussian optics and thin-lens system layout. Photometric theory applied to optical systems. Topics include: the eye, magnifiers, microscopes, matrix optics, Seidel aberrations, scalar diffraction theory; Fresnel and Fraunhofer diffraction, and interferometry .   3 credits

BME 541/641 Mechanical Properties of Tissues I

This course introduces the application of continuum mechanics to biological tissues. A rigorous derivation of stress and strain tensors, the theory of elasticity and the theory of visco-elasticity are presented. The bulk of the course focuses on the development of pseudo-strain energy density functions to describe the hyper-elastic behavior of biological tissues. Suggested Prerequisites: Mathematics through differential equations, some familiarity with linear algebra and matrix manipulations, MATLAB programming skills.   3 credits

BME 542/642 Mechanical Properties of Tissues II

This course is a direct continuation of BME 541/BME 641. The mechanical behavior of specific biological tissue types, including hard and soft tissues, is discussed in detail. A rigorous introduction to experimental and computational fluid dynamics is presented, along with discussions regarding the influence of fluid flows on the mechanical behavior and remodeling of biological and engineered tissues.   3 credits

BME 543/643 Advanced Tissue Engineering Techniques

This course is designed to teach the techniques necessary to perform advanced research in Tissue Engineering. Techniques include the latest in imaging, stem cell isolation, growth factor treatments and mechanical stimulation of engineered tissues. Prerequisites: BME 511/611 Molecular and Cellular Biology for Biomedical Engineering, BME 541/641 Biomaterials I, and BME 542/642 Biomaterials II.   3 credits

BME 544/644 Advanced Biomaterials

This course is a seminar-style course in which students critically evaluate key papers in the biomaterials literature. Specifics topics will change with developments in the field as well as with the students' interests. Students may take this course more than once. Prerequisites: BME 541/641 Biomaterials I and BME 542/642 Biomaterials II.   3 credits

BME 545/645 Biocompatibility: Host-Implant Interactions

This course provides the student with a firm understanding of how the body reacts to implanted biomaterials at the cell, tissue, organ, and systemic levels. In addition, specific characteristics that hinder or improve the biocompatibility of materials will be addressed. Prerequisites: BME 511/611 Molecular and Cellular Biology for Biomedical Engineering and BME 542/642 Biomaterials II.   3 credits

BME 561/661 Neuronal Control Systems

This course explores various neuronal control systems from an engineering perspective. Topics include: control system theory; neuronal plasticity and state dependence; sympathetic nervous system control of cardiovascular functions, temperature, and respiration; and vestibulooculomotor control.   3 credits

BME 562/662 Motor Control

This course is intended to introduce the student to simple and complex mechanical, electronic, and digital control systems using human and animal skeleto-muscular systems and robotics as model systems. The course will consist of three parts: first, the physiology and neural control of the neuromuscular system; second, control problems faced in designing robots with complex mechanical systems and the relation to problems faced by the mammalian motor control system; third, background and design of clinical devices and procedures for motor disorders, including stroke, spinal cord injury, balance disorders, and neuroprostheses.   3 credits

BME 564/664 Methods in Neuromedicine

This course includes topics on methods related to the diagnosis, treatment and intraoperative assessment of the nervous system in humans. Topics include: electrical stimulation (neuronal excitability, diagnostic testing of nerves and brain structures, surgical monitoring, neuronal rehabilitation, and functional electrical stimulation); safety (coupling to biological tissues, excitotoxicity, neuronal vulnerabilities, and special considerations with disease states); drug targeting; blood brain barrier; and basic neuro-imaging.   3 credits

BME 565/665 Introduction to Computational Neurophysiology

This The brain is remarkable in its ability to derive complex patterns from relatively simple sensory input. Even a single neuron is capable of a tremendous range of behavior in response to different stimuli. In spite of similarities in the biophysical structure of neurons across the brain, differences in biochemical signals and connectivity between neurons result in remarkably different functionality across brain regions. In this course students will explore how neurons communicate through electrical signals, how information transmission between neurons occurs, and how connectivity between neurons determines activity patterns and results in specialized behavior.

This course uses a hands-on approach to develop and explain concepts from computational neurophysiology. The course has two goals: to help students understand how computational models can be used to analyze, explain and predict the physiological behavior of neurons and assemblies of neurons; and to provide students with an opportunity to use current research tools to investigate the concepts underlying these computational models. The course will include a very brief review of relevant concepts from cellular neurophysiology (action and membrane potentials, channels, etc.) and of mathematical concepts needed to understand the material. Topics to be covered include Hodgkin-Huxley models of simple and complex morphologies; central pattern generators; models of simple invertebrate circuits; integrate-and-fire and spike-response neuron models for use in network models; models of neural development, ocular dominance and orientation columns; and rate versus spike-timing dependent plasticity. This course will be of interest to students in engineering and mathematics with an interest in neuronal modeling, as well as to neuroscientists who would like to understand more about the role of computational models in neurophysiology. A solid math background is needed; some programming (in MATLAB) will be required.   3 credits

BME 567/667 Visual Sensory Systems

In this course, the anatomy, physiology and function of visual systems are examined with emphasis on the dynamic processing of visual inputs and on technological approaches to functional analysis and on methods for diagnosis of eye diseases. Topics to be covered include optics, anatomy of the eye, retinal physiology, signal processing, plasticity, perception, functional assessment with complex visual stimuli and evoked potentials, and new developments in visual prosthetic systems.   3 credits

BME 568/668 Auditory and Visual Processing by Human and Machine

Interaction between humans and machines could be greatly enhanced by machines that could communicate using human sensory signals such as speech and gestures. Knowledge of human information processing including audition, vision, and their combination is, therefore, critical in the design of effective human-machine interfaces. The course introduces selected phenomena in auditory and visual perception, and motor control. Students learn how to interpret empirical data, how to incorporate these data in models, and how to apply these models to engineering problems. The anthropomorphic (human-like) signal processing approach is illustrated on engineering models of perceptual phenomena.   3 credits

BME 569/669 Analytical Electron Microscopy for Biomedical Engineers

This course will introduce the biomedical engineering student to scanning and transmission electron microscopy analysis and characterization techniques applied to the broad range of materials used in modern biotechnology. Operating principles of electron microscopes, imaging and analysis volume resolutions will be covered. Electron beam/specimen interactions will be shown to be the basis of imaging and analysis. Secondary, transmission and backscatter electrons as well as characteristic X-rays produced by these interactions generate signals as the beam position is changed on the specimen which all provide qualitative and quantitative information on the micron, submicron and nanoscales if necessary. Specimen preparation techniques for hard and soft tissues, composites, plastics, ceramics, metals and semiconductors will also be covered. The techniques will include cryo-drying, critical point drying, focused ion beam milling, microtoming, electropolishing, mechanical polishing and various coating techniques for non-conductors. The student will learn to recognize artifacts of specimen preparation and examination. Operation and effective use of the scanning electron microscope in a student defined research project are major goals of the course. It is expected the student will work on materials important in the students research program. 3 credits

BME 571/671 Speech Systems

Speech is one of the most natural means for communication and carries information from many sources. The explosive growth of communications and computer technologies puts new demands on techniques for machine extraction of information content of speech signals, for its storage or transmission, and for reconstruction of the speech signal from its parametric representation. The course covers techniques for processing of speech signal used for speech coding and synthesis, enhancement of degraded speech, speech recognition, speaker recognition, and language identification. 3 credits

BME 581/681 Fourier Analysis

Fourier analysis is used in nearly every field of engineering, including biomedical engineering. It provides a unifying mathematical approach to the study of networks, electrical and mechanical systems, linear systems, image and signal processing, as well as many other systems. This course will provide a solid introduction to application of Fourier theory in biomedical engineering. Topics include: convolution and correlation; Fourier theorems; Numerical transforms; Sampling and series; Discrete Fourier transform and the FFT; Related transforms. Prerequisites: one year of calculus. 3 credits

BME 582/682 Nature and Analysis of Biomedical Signals

This course will explore the physiological origins of signals that are used medically to monitor biological functions. The signals will include arterial and venous blood pressures, electrocardiogram, electroencephalogram, electromyogram, and pulse oximetry. Topics will include medical instrumentation, signal processing, and modeling. Prerequisites: EE 581/681. 3 credits

BME 601 Prequalifying Ph.D. Research

Supervised Ph.D. research prior to passing the department's qualifying exam.
Variable and repetitive credit

BME 603 Ph.D. Dissertation Research

Research toward the dissertation for the Ph.D. degree occurring after passing the qualifying exam.
Variable and repetitive credit

COMPUTER SCIENCE & ENGINEERING

CS 501 M.S. Non-thesis Research

Supervised research for up to 6 credits as a component of the non-thesis master's degree. Students are required to produce concrete research deliverables, including a final report equivalent to a CS technical report. Each 3 credits of CS 501 may count as one class to fulfill the M.S. non-thesis graduation requirements. Variable and repetitive credit

CS 502/602 Independent Study

Independent study allows a student to work one-on-one with a faculty member on selected topic(s) of interest. Registering for independent study requires pre-approval from the faculty member and the student's academic department. A maximum of 6 credits of independent study may be applied to the MS CSE degree. Variable and repetitive credit

CS 503 M.S. Thesis Research

Research toward the thesis for the M.S. degree.
Variable and repetitive credit

CS 504/604 Professional Internship

These courses provide an opportunity to earn credit for relevant work experience in industry. Students gain valuable industrial experience that allows them to both apply the knowledge gained in the classroom and prepare for careers in computer science. A written report must be submitted to the CS faculty advisor at the end of the experience. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
Variable and repetitive credit

CS 506/606 Special Topics

Under this number, we offer courses of particular relevance to the research interests of faculty or in state-of-the-art subjects of interest to the community. 3 credits

CS 511/611 Principles of Compiler Design

This course introduces the basics of building a compiler using a multiphase translation process. It covers lexical analysis, parsing and translation to abstract syntax using modern parser generator technology. It discusses binding of identifiers and symbol table organization, and a variety of intermediate representations that are suitable for back-end analysis. It investigates back-end transformations and optimizations for a number of languages. Other topics include type checking, static analysis and basic run time support. Compiling is essentially a process of symbolically manipulating program representations represented by tree and graph-like data structures. Because of this, we will use tools that facilitate symbolic manipulation and definition of such structures as parser and lexical generators, and tools for generating code from pattern-based descriptions. Prerequisite: CS 533 3 credits

CS 512/612 Compiling Functional Languages

A project-oriented course on the theory and design of a compiler for a typed, functional programming language. Topics include understanding a formal definition of programming language semantics, compiling pattern analysis, lifting abstractions, continuation-passing style of implementation, abstract machines, code generation and address assignment, register allocation and assignment on general-register machines, run-time storage administration, data-flow analysis and code improvement. Prerequisite: CS 511. 3 credits

CS 513/613 Introduction to Operating Systems

A study of the design and implementation of modern operating systems. The course concentrates on operating system kernel design and includes the following topics: concurrent processes, interprocess communication, synchronization, scheduling, resource allocation, memory management, the concept of virtual memory and the required underlying hardware support, secondary storage management, file systems and security. We will use the Linux operating system to ground the discussion of abstract concepts. Interested students will be encouraged to read the Linux source code for discussions in class. 3 credits

CS 514/614 Introduction to Database Systems

A survey of database management systems (DBMS) capabilities. The course covers topics on how to use a DBMS, including: database design, data dependencies and normalization, and SQL (including embedded SQL). The course also introduces topics on how DBMS systems are implemented, including: secondary storage structures, relational algebra, query processing, query optimization, transactions, and recovery. The course focuses on relational database systems and the SQL query language. Students participate in a small project to design, populate and query a database. Prerequisites: Data structures, discrete mathematics and mathematical logic or equivalent understanding of these topics. 3 credits

CS 515/615 Distributed Computing Systems

This course concentrates on distributed computing from a systems software perspective. Major topics include communications middleware (remote procedure call, remote method invocation and causal broadcast), operating system support, distributed file systems, distributed transaction processing, load balancing, distributed programming languages and systems, fault-tolerance and replication algorithms, distributed timing issues and distributed algorithms. Prerequisites: CS 513, Introduction to Operating Systems as well as a basic understanding of computer communications problems and protocols.
3 credits

CS 516/616 Introduction to Software Engineering

Software engineering is concerned with the ways in which people conduct their work activities and apply technology to produce and maintain software products and software-intensive systems. Issues of concern include specification, design, implementation, verification, validation and evolution of software artifacts. Related topics include software metrics, project management, configuration management, quality assurance, peer reviews, risk manage-ment and process improvement. This course presents an integrated view of these topics and related issues. It is an essential course for anyone working in development, maintenance, management or related areas in a software organization.   3 credits

CS 517/617 Software Process Engineering

This course is concerned with examining and improving the software development processes, including the technical, managerial and cultural processes, used by organizations to develop and maintain high-quality software systems in a timely and economical manner. Various process models, including the SEI Capability Maturity Models, the ISO SPICE model, the Team Software Process, and the Personal Software Process are studied and con-trasted. Tailoring of process models to fit local situations and various approaches to software process improvement are presented. Students select and complete term projects that address topics in software process improvement.   3 credits

CS 518/618 Software Design and Development

Contemporary, object-oriented software design, using the Java programming language. An introduc-tion to the eXtreme Programming software development methodology, which is based upon the principle that change is inevitable and successful software designs undergo continual evolution. Techniques to be covered include program refactor-ing, automated unit testing, pair programming, participatory design and managing short product development cycles. These principles and techniques will be illustrated in a term-length project that pro-vides design and implementation experience.
3 credits

CS 519/619 Object-Oriented Analysis and Design

This course presents an integrated set of techniques for software analysis and design based on object-oriented concepts. The techniques focus on producing the artifacts and work products, expressed in UML, appropriate for the analysis and design phases of the software development lifecycle. We adopt a use case model for requirements and a responsibility-driven approach for the development of object models. Design patterns and frameworks are also emphasized. Note that CS 529/629 Object-Oriented Programming is intended as a follow-on course for CS 519/619.   3 credits

CS 520/620 Software Architecture

The architecture of a software system specifies the components, visible properties of the components, and the structural and behavioral relationship among the components of that system. Design pat-terns are now commonly used to define the language

for solving architectural problems and for docu-menting the solutions. Different architectural design patterns, such as pipes and filters, layers, and OO frameworks, solve different problems and can be harmful if applied in the wrong context. Software architecture strongly influences system perform-ance, reliability, safety, security, and other quality-of-service attributes. Software architecture can also facilitate software reuse and the develop-ment of product families. In this course, we will learn a core vocabulary of published architectural patterns and develop skill in recognizing and apply-ing these patterns. In addition, we will examine case studies of large systems architecture development and evolution. Lectures will provide structure and points of view missing from the textbook. The course will encourage recognition and discussion of contro-versial ideas from the literature on software architecture. Students will learn heuristics for design and evaluation of software architectures. Coursework will emphasize frequent small tests and a hands-on project to gain skill in collaborating and reasoning about architectures.   3 credits

CS 521/621 Introduction to Computer Architecture

This course provides a broad introduction to com-puter architecture. It covers a large amount of material in moderate depth, providing a good under-standing of the basic issues in computer system design. Specifically, the course covers instruction set design, pipelining, the memory hierarchy, I/O systems, networking issues and multiprocessors. Example systems include the Intel x86, MIPS and DEC Alpha processors. Prerequisites: Experience writing software, preferably with some C or assem-bler programming. NOTE: Computer architecture has become a quantitative science, so there will be considerable algebraic manipulation involved in the performance analysis component of the course.
3 credits

CS 522/622 Advanced Computer Architecture

This course is a follow-up to CS 521/621. It covers advanced computer architecture topics such as SMP (Shared Memory Multiprocessors) and NUMA (Non-Uniform Memory Access) Architectures. It also looks at new trends in designing high-performance clusters with examples. Specific topics to be cov-ered include: fundamentals of parallel architectures (communication paradigms, programming models, etc.), snoopy-based multiprocessors (cache coherency, bus designs, multilevel caches, etc.), directory-based multiprocessors (NUMA and hybrid architectures), interconnection networks (routing, switch designs, virtual lanes, etc.). Examples of commercial and prototype architectures such as IBM NUMAQ, InfiniBandTM and ServerNet. Prerequisite: CS 521/621.   3 credits

CS 524/624 TCP/IP Internetworking Protocols

This course provides an overview of the structure and algorithms used in the TCP/IP networking pro-tocols that make up the foundation of the Internet. Protocols and technologies covered will include an introduction to the link layer, ARP, IP, ICMP, UDP, TCP, routing protocols and application protocols and systems like the DNS, NFS, SMTP, FTP, HTTP and

multicasting protocols and applications. Provides architectural insight into protocol design issues and operating system implementation techniques, typi-cally in terms of the Berkeley UNIX socket programming model. Provides socket programming experience with the client/server model. Provides experience reading Internet RFC's and/or drafts. Prerequisites: Familiarity with the functions of a modern multiuser operating system such as is cov-ered in CS 513/613 or PSU's CS 533; familiarity with C programming on modern UNIX computers.
3 credits

CS 528/628 Cryptography

This course covers the major modern cryptographic techniques — the core technology for the area of information security. We start with an overview of classical cryptography and information theory. Then we examine in-depth the most widely used cryptosystems: symmetric systems such as DES (Data Encryption Standard) and AES (Rijndael, the new standard), and public-key systems, notably RSA. Discrete log systems and standard digital sig-nature schemes are also covered, including elliptic curve cryptography. The course should be accessi-ble to anyone who is willing to encounter some number theory.   3 credits.

CS 529/629 Object-Oriented Programming

This course provides a rigorous introduction to the concepts behind object-oriented programming. It is for students who are already familiar with the con-cept of object-orientation and with object-oriented analysis and design techniques. One way to learn this background material is by taking CS 519/619, Object-Oriented Analysis and Design. In CS 529, students gain a thorough understanding of incre-mental programming, type-safety, polymorphism, encapsulation and set-based abstraction, and apply these concepts through a variety of programming projects. We study several programming languages, including Java and Smalltalk, so students are exposed to different realizations of these concepts and gain an appreciation for the programming lan-guage design space. We also look at published object-oriented design patterns and see how they can be implemented in different object-oriented pro-gramming languages. Students may be required to read appropriate research papers, complete several short programming assignments, complete a sub-stantial programming project and write some short essays. Prerequisite: CS 519/619 or equivalent.
3 credits

CS 532/632 Analysis and Design of Algorithms

An introduction to the design and analysis of algo-rithms. The course covers design techniques, such as dynamic programming and greedy methods, as well as fundamentals of analyzing algorithms for correctness and time and space bounds. Topics include advanced sorting and searching methods, graph algorithms and geometric algorithms. Other areas vary from year to year and may include computational geometry, matrix manipulations, string and pattern matching, set algorithms, polynomial computations and the fast Fourier transform. Prerequisites: Data structures and dis-crete mathematics.   3 credits

CS 533/633 Automata and Formal Languages

Automata and Formal Languages Automata theory introduces fundamental models that are used over and over again in computer science for programming languages, in compiler construction and in algorithms. These models are a valuable part of the repertoire of any computer scientist or engineer. This course introduces progressively more powerful models of computation, starting with finite automata and moving to stack and tape (Turing) machines. It also presents the regular, context-free, recursive and recursively enumerable languages and shows how they correspond to the various models of computation and to generation mechanisms such as regular expressions and grammars. The emphasis is on understanding the properties of these models, the relationships among them and how modifications such as nondeterminism and resource bounds affect them. The course includes application of these concepts to problems arising in other parts of computer science. Prerequisite: Discrete mathematics.
3 credits

CS 534/634 Domain Specific Languages

Domain specific languages (DSLs) have recently become a "hot topic." They have been proposed as a medium to capture the similarities and differences that occur in a family of software products. They are a mechanism for the representation, optimization, and analysis of such families. Among the benefits to using domain-specific languages is user relevance. A significant advantage is gained by expressing application concepts in a language designed around those concepts. DSL designs are also user-modifiable. User-specified changes can be incorporated into fielded systems without compromising the integrity of the whole system. A DSL design of a component remains directly connected to the executing code. And last, DSLs provide a language with which design ideas can be communicated and design principles taught. A barrier to the widespread adoption of domain-specific languages is the ability to systematically design, develop, and implement domain-specific languages. Good domain-specific languages are mathematically sound and computer readable. This course introduces students to the techniques used to design sound and usable DSLs. It teaches the abstraction techniques used to make such designs easy to modify and evolve, and the implementation techniques used to embed such designs into an underlying system. Recent events have added a wealth of written material that the class will draw from for inspiration and guidance. Papers will be selected from the January 1997 DSL workshop held in conjunction with POPL, the October 1997 Usenix Conference on Domain Specific Languages, and the Usenix Domain Specific Language Conference held on Oct. 3-5 in Austin, Texas. The class is structured around student-led discussions of the literature and lectures by the instructor. There are reading and programming assignments and a project. Prerequisites: Undergraduate-level knowledge of programming languages and compilers, ability to think abstractly.
3 credits

CS 536/636 Functional Programming

In functional programming, we shift our focus from data objects and their representations to functions that act on data. Programs are formulated as compositions of functions, rather than as sequences of statements. This leads to a programming methodology that is quite different from that learned in using statement-oriented languages. This course introduces the student to functional notation, recursion, higher-order functions, reasoning about functions and polymorphic-type systems. Functional programming languages are known for their increased productivity and reliability, due in part to the higher levels of abstraction provided by functional languages. Course is taught by lecture with small weekly programming assignments. Experience is gained by programming in the functional language Haskell or one of its close derivatives. Recent advances in functional programming languages allow them to use updatable state in a safe manner and to cause effects on the real world. Students gain experience by writing programs using these features to program interactive window-based programs using an embedded "widget" library.
3 credits

CS 541/641 Database Implementation

This course explores the internals of relational database management systems. This course will give students a strong grounding in the design tradeoffs and implementation issues that are addressed by large relational database systems. The course will also help DBA's understand how the tuning parameters of commercial databases can affect performance, and will help database application programmers to create applications better tuned to take advantage of the database internals. Typical topics discussed include file and index implementation, buffer management, query processing, cost-based query optimization, concurrency control, transaction processing, and logging and recovery implementations. The class includes hands-on programming assignments. Prerequisite: CS 514; UNIX and C/C++ programming experience is recommended.
3 credits

CS 542/642 Object Data Management

A variety of products for managing object data have emerged in the marketplace. Object-oriented database systems and persistent programming languages have been joined by object-relational databases and middleware component technologies, such as Enterprise Java Beans. Other storage engines, such as LDAP and XML servers, have an object flavor. This course begins with the concepts in types, data models and languages that underlie object data management. It then looks at example prototype and commercial systems, and examines design dimensions such as data model, persistence, encapsulation, hierarchies, query languages and transactions. It touches on application development and data management issues and concludes with treatment of software architecture, implementation and benchmarking techniques. Students will do a project using a current product. Prerequisite: CS 514 or other introductory database course.
3 credits

CS 543/643 Foundations of Database Systems

This class is designed to build an understanding of database formalisms that appear in research papers and other sources, evaluate and understand the benefits of particular formalisms, and develop formalisms. This course covers the mathematical foundations of database data models and query languages. Topics, covered at varying levels of depth, include query formalisms and their equivalence, query transformation, semi-structured data models, dependencies and normal forms, logic and deductive databases, data language complexity, treatment of incomplete information, complex-value models, semantic models and classification, and temporal databases. Students will have regular homework assignments, a midterm exam, and a presentation on an assigned topic or a final exam. Prerequisites: CS514/614.
3 credits

CS 544/644 XML Data Management

In this course we will discuss the new data management problems that arise with XML. We will cover techniques and systems that address these problems, offering insights into the advantages and drawbacks of various solutions. Students will have a choice of various kinds of projects to work on, including new research problems and improvements on published results.
3 credits

CS 547/647 Statistical Pattern Recognition

Theory and practice of statistical pattern recognition. Students will learn fundamental theory and practices that are common to a broad range of pattern recognition applications and technologies, and apply principles to real-world examples. The emphasis is on developing theoretical and practical tools that provide grounding in pattern recognition problems and methods, rather than on showcasing particular technologies. The course will benefit those whose work may use any of a variety of recognition technologies in broad-ranging applications such as speech and image processing, data mining, finance. Topics include: random vectors, detection problems (binary decision problems), likelihood ratio tests, ROC curves, parametric and non-parametric density estimation, classification models, theoretical error bounds and practical error estimation through cross-validation. Maximum likelihood and Bayesian parameter estimation, model-based clustering, feature extraction for dimensionality reduction and for classification.
3 credits

CS 550/650 Spoken Language Systems

Spoken language systems will revolutionize how people interact with machines, replacing the keyboard and mouse with natural conversations. These systems will act like helpful human assistants and teachers for information access, commercial transactions, and learning. You'll review the state of the art in building spoken language systems. You will gain hands-on experience using toolkits for building such systems, as well as learn the technologies needed for next-generation systems, such as robust parsing, semantic processing, dialogue management, and agent architectures. Class projects will be done using the CSLU toolkit, Tcl/Tk, and VoiceXML.
3 credits

CS 551/651 Structure of Spoken Language

Speech is considered a key component in the future of human-computer communication. However, the success of speech recognition and text-to-speech synthesis systems depends on development of the technology as well as further research advances. Research and development of spoken-language technology is facilitated by an understanding of the acoustic and symbolic structure of language, as well as the capabilities and limitations of current systems. This course will present some of what is known about speech in terms of phonetics, acoustic-phonetic patterns, and models of speech perception and production. The goals are for the student to understand how speech is structured, understand and identify acoustic cues (especially in different phonetic contexts), and understand how this information may be relevant to automatic speech recognition or generation systems. 3 credits

CS 552/652 Hidden Markov Models for Speech Recognition

Hidden Markov Model-based technology is widely used in today's speech recognition systems. This course is an introduction to speech recognition using HMM technology. Topics include dynamic time warping, Markov Models and Hidden Markov Models (discrete, semi-continuous, and continuous), vector quantization, Gaussian Mixture Models, the Viterbi search algorithm, the Forward-Backward training algorithm, language modeling, and speech-specific adaptations of HMMs. The course is focused on understanding these fundamental technologies and developing the main components of speech recognition systems. Prerequisite: C programming experience. 3 credits

CS 553/653 Speech Synthesis

This course will introduce students to the problem of synthesizing speech from text input. Speech synthesis is a challenging area that draws on expertise from a diverse set of scientific fields, including signal processing, linguistics, psychology, statistics, and artificial intelligence. Fundamental advances in each of these areas will be needed to achieve truly human-like synthesis quality and advances in other realms of speech technology (like speech recognition, speech coding, speech enhancement). In this course, we will consider current approaches to sub-problems such as text analysis, pronunciation, linguistic analysis of prosody, and generation of the speech waveform. Lectures, demonstrations, and readings of relevant literature in the area will be supplemented by student lab exercises using the Festival text-to-speech system and other hands-on tools. 3 credits.

CS 559/659 Machine Learning

This course provides a broad introduction to techniques for building computer systems that improve through experience. It provides both conceptual grounding and practical experience with several learning systems. The course provides grounding for advanced study in statistical learning methods, and for work with adaptive technologies used in speech and image processing, robotic planning and control, diagnostic systems, complex system modeling, and iterative optimization. Topics include: learning paradigms and concept learning, decision trees, artificial neural networks, statistical sampling and empirical error estimation, Bayesian learning (including an introduction to belief networks), clustering, principal and independent component analysis, generalization theory, memory-based (instance) techniques, evolutionary computation, and reinforcement learning. Students will gain practical experience implementing and evaluating systems applied to pattern recognition, prediction, and optimization problems. Prerequisites: Some experience with multi-variate calculus and linear algebra, at least one high-level programming language, and an elementary undergraduate course in probability and statistics. 3 credits.

CS 560/660 Artificial Intelligence

This course surveys the foundations and applications of symbolic approaches to artificial intelligence. The approach emphasizes the formal basis of automated reasoning and includes an introduction to programming in Prolog. Fundamentals covered include search, knowledge representation, automated inference, planning, nonmonotonic reasoning and reasoning about belief. Applications include expert systems, natural language processing and agent architectures. 3 credits

CS 562/662 Natural Language Processing

This course covers key algorithms and modeling techniques for processing human language sequences, which are needed for applications such as Automatic Speech Recognition and Machine Translation. Both statistical and symbolic approaches to modeling natural language phonology, morphology, and syntax are presented, along with widely used algorithms for efficiently learning and applying different kinds of natural language grammars. There is an emphasis on algorithms and data structures that scale up to handle very large real-world data sets, such as newswire text. The course includes several challenging hands-on programming assignments. Prerequisite: CS 560 or equivalent. C/C++ programming experience is highly recommended, as is familiarity with regular expressions. 3 credits

CS 564/664 Introduction to Human-Computer Interaction

This course emphasizes the user experience of computing, which centers on an understanding of real users and the specific tasks they need to accomplish when computing. In the pursuit of optimal user support, a multidisciplinary approach to system design and evaluation is stressed. The course reviews basic methods, terminology, viewpoints, and activities in the broad field of human-computer interaction. It includes user interface principles, design guidelines, and practical issues in user interface design as well as user interface evaluation criteria and metrics. Students gain hands-on experience by implementing and evaluating graphical, verbal, and multimodal user interfaces. An introduction to this topic is essential for everyone working in the field of computer science. 3 credits

CS 565/665 Advanced Topics in Human-Computer Interaction

This course reviews advanced topics and current research in the field of human-computer interaction, surveys key research challenges that exist, and discusses emerging trends in next-generation system design. Topics include advanced research and design methods, new recognition-based and multi-modal interfaces, conversational interfaces and animated character design, mobile interfaces, ubiquitous and tangible interfaces, adaptive interfaces, advanced user modeling and design for universal access, and other key issues. Topics are covered from a broad multidisciplinary perspective, with an emphasis on real-world users and usage contexts. In addition to weekly classroom lectures, guest lectures, and discussion, this class includes a hands-on practicum component in which students participate in state-of-the-art research and interface design to complete a team project. Pre-requisites: CS564 or instructor's consent. 3 credits

CS 567/667 Developing User-Oriented Systems

This course explores a range of issues and methods needed to design and evaluate user-oriented software applications. Topics focus on field, ethnography, and participatory design methods, user laboratory studies, and usability testing. Students will experience a range of methods and tools that help uncover opportunities, breakdowns, and interactions that affect the design and use of computer systems. Students are challenged to evaluate the underlying perspectives of the various approaches and determine which approach or combination of approaches works best for particular problems. They apply the methods in field and classroom exercises and produce a real-world project. The intended result is to make students more effective not only at gathering relevant user-based information, but also at integrating it into the development process. 3 credits

CS 568/668 Empirical Research Methods

This course introduces principles of experimental design and data analysis for empirical research. Topics include the goals and logic of experimental design, hypothesis formation and testing, probability and sampling theory, descriptive statistics, correlation and regression, basic parametric and nonparametric tests of statistical significance (e.g., Binomial, t-test, chi-square, analysis of variance), standard designs for single- and multi-factor experiments, and strategies of scientific investigation (e.g., Exploratory vs. Directed). The course is fundamental for anyone who plans to conduct independent research or needs to evaluate critically the research of others. Students participate in designing and analyzing data to answer scientific questions and present the results of these activities both orally and in writing. 3 credits

CS 601 Ph.D. Pre-qualifying Research

Ph.D. supervised research activity. Variable and repetitive credit

CS 603 Ph.D. Dissertation Research
Research toward the dissertation for the Ph.D. degree.
Variable and repetitive credit

ENVIRONMENTAL AND BIOMOLECULAR SYSTEMS

EBS 501 M.S. Non-Thesis Research
Supervised research as a component of the M.S. non-thesis degree. The plan of research and final deliverables must be approved by the research advisor and the SPC. Deliverables include a written report and/or seminar given as part of EBS 507A. A maximum of 8 credits from EBS 501 may be applied to a degree. Variable and repetitive credit

EBS 502/602 Independent Study
Typically involves a scholarly and critical review of an advanced scientific topic by one or more students together with one or more faculty members. Requirements of the student typically include a written review paper and/or a seminar to be given as part of EBS 507A/607A - EBS 507B/607B - EBS 507C/607C. Selection of this course for credit and the topic to be investigated must be approved by the SPC. Variable and repetitive credit

EBS 503 M.S. Thesis Research
Research toward the M.S. thesis degree.
Variable and repetitive credit

EBS 504/604 Professional Internship
Professional internship credits provide students an opportunity to earn credit for relevant work experience in industry. Students gain valuable industrial experience that allows them to both apply the knowledge gained in the classroom and prepare for careers following graduation. Students on F-1 or J-1 visas must obtain prior written approval for internships from OGI's Office of International Students and Scholars before enrolling. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
Variable and repetitive credit

EBS 506/606 Special Topics
Special topics courses are offered in areas of particular relevance to the research interests of faculty or in response to industry needs. Special Topic courses are subject to change and are offered intermittently. Variable and repetitive credit

EBS 507A/607A EBS Department Seminar
Weekly seminars by invited guests. Public visitors are welcome. Schedules are available on the World Wide Web at www.ebs.ogi.edu/seminars/, or by request at info@ebs.ogi.edu. 1 credit, repetitive

EBS 507B/607B Student Seminar: Metallobiochemistry
Presentations and discussions of selected topics from the recent literature and of ongoing research projects in the department. 2 credits, repetitive

EBS 507C/607C Student Seminar:
Molecular Biology/Biochemistry
Presentation and discussion of journal articles from the recent literature in molecular biology, genetics and biochemistry. 2 credits, repetitive

EBS 510/610 Aquatic Chemistry
General acid/base concepts (mono- and polyprotic systems); pH; making activity corrections; numerical calculations; titration concepts as applied to natural systems; buffer intensity; dissolved CO_2 chemistry; acidity and alkalinity in open CO_2 systems; minerals and their role in controlling natural water chemistry; solubility characteristics of oxide and hydroxides; introduction to redox chemistry in natural systems; pe-pH diagrams. 4 credits

EBS 511/611 Advanced Aquatic Chemistry
Role of complexing ligands in solution chemistry; redox chemistry in natural systems; pe-pH diagram construction and use; solid/solution interfacial considerations; the electrical double layer; and selected advanced topics. Prerequisite: EBS 510/610.
4 credits

EBS 512/612 Biochemistry I: Proteins and Enzymes
Primary, secondary and tertiary structure of proteins; enzyme mechanisms; enzyme kinetics.
4 credits

EBS 513/613 Biochemistry II:
Introduction to Molecular Biology
DNA replication, RNA synthesis and protein synthesis; genetic code; gene regulation. 4 credits

EBS 514/614 Biochemistry III:
Metabolism and Bioenergetics
Metabolism of carbohydrates, lipids and amino acids; bioenergetics; photosynthesis; oxidative phosphorylation. 4 credits

EBS 518/618 Metals in Biochemistry
Comprehensive study of the chemistry and biochemistry of metal ions in biological molecules and living systems. Topics include metalloprotein structure, metal ion specificity, biological oxidation mechanisms, metal ion catalysis in enzymes, metal ion transport and gene regulation. 4 credits

EBS 520/620 Coordination Chemistry
Structures and stabilities of transition metal coordination compounds with mono- and multi-dentate ligands; coordination compounds as models for biological metal centers; strategies for synthesis of transition metal complexes. 4 credits

EBS 523/623 Chemical Group Theory
Properties of mathematical groups; symmetry properties of molecules; symmetry groups, representations, and character tables. Applications of group theory to the study of structure and spectroscopy of organic and inorganic molecules; Hückel molecular orbital theory; ligand field theory; electronic spectroscopy and vibrational spectroscopy.
4 credits

EBS 525/625 Bioenergetics and Membrane Transport
Critical evaluation of the chemiosmotic theory with specific reference to oxidative phosphorylation, photophosphorylation and metabolite transport. Biochemical mechanisms of energy transduction common to bacterial and mitochondrial respiration, and bacterial and plant photosynthesis are reviewed. 4 credits

EBS 528/628 Enzyme Structure, Function and Mechanisms
Provides an in-depth analysis of the structural origins of protein interactions and catalysis that are the basis for biological function. The course develops the basic principles of structural biology through an overview of X-ray crystal structures and folding processes, acquainting the students with computational resources for protein structure analysis. The structural foundation is expanded into a detailed investigation of enzyme active sites, including the application of kinetic approaches to understanding enzymatic reaction mechanisms. 4 credits

EBS 530/630 Introduction to Bioinformatics
Primary literature of computational biology and hands-on experience in data manipulation from local and remote databases. 3 credits

EBS 535/635 Distribution and Fate of Organic Pollutants
Discussion of the physico-chemical processes that control the partitioning of organic chemicals in the environment. This introductory course considers all environmental compartments, water, soil and air, and partitioning between those phases. Recommended prerequisite: EBS 510/610.
4 credits

EBS 537/637 Chemical Degradation and Remediation
A thorough introduction to the transformation reactions that contribute to the fate of organic substances in the environment. The course covers pathways, mechanisms and kinetics of hydrolysis, oxidation, reduction, elimination, conjugation, etc. Treatment is balanced to reflect the importance of these processes in all types of environmental waters ranging from engineered systems to groundwater, surface water, rain and fog. Recommended preparation: EBS 510/610, 511/611 and/or 535/635.
4 credits

EBS 538/638 Air Pollution:
Origins, Chemistry and Control
This course will focus on tropospheric air pollution with particular emphasis on the urban and regional scales. It will discuss the following items: basic structure of the atmosphere and relevant meteorological considerations; sources of tropospheric air pollutants; atmospheric photochemistry; the ozone, oxide of nitrogen and hydrocarbon chemical cycles; chemistry of toxic organic compounds in the atmosphere; gas and aqueous phase chemistry of sulfur dioxide; size distributions, lifetimes, origins and formation mechanisms of aerosols; measurement and control of atmospheric pollutants. 3 credits

EBS 540/640 Instrumental Methods in Biophysics I

Theory and application of physical techniques to problems in biochemistry. Optical, fluorescence, circular dichroism, infrared and Raman spectroscopy of chromophoric groups. Magnetic susceptibility and nuclear magnetic resonance of metalloproteins.

4 credits

EBS 541/641 Instrumental Methods in Biophysics II

Investigation of physical techniques particularly useful for studying metalloproteins. Electron paramagnetic resonance, electron spin echo, magnetic circular dichroism and X-ray absorption spectroscopy. The course has significant "hands-on" exposure to both instrumentation and computer simulation techniques.   4 credits

EBS 547/647 Uncertainty Analysis

A survey of basic probability concepts followed by introductions to several statistical advanced techniques that play an important role in environmental data analysis. Topics may include distribution functions, propagation of error, hypothesis testing, analysis of variance, experimental design, sampling theory, regression analysis, time-series analysis and spatial statistics techniques. The course provides a balance of theory and application using environmental data sets.   4 credits

EBS 550/650 Environmental Systems Analysis

Introduction to techniques of systems analysis applied to environmental quality management. Emphasis is on development and application of mathematical models with computer simulation and optimization. Analysis includes efficient computational algorithms and search techniques. Linear and separable programming applied to evaluate management alternatives. Applications to air, water, solid and hazardous waste management. Prerequisites: Computer programming and calculus.   4 credits

EBS 555/655 Computational Fluid Dynamics

This course describes advanced topics in computational fluid dynamics, including specialized discrete methods (e.g., for advection-dominated problems), formal analysis of stability and accuracy, and selected simulations of complex environmental and biological systems. Prerequisites: Advanced calculus and EBS 545/645.   4 credits

EBS 560/660 Introduction to Environmental Observation and Forecasting Systems

This course introduces environmental observation and forecasting systems and their application toward the enhanced understanding and management of natural resources. Emphasis is on estuaries and coasts. Students are exposed to a novel, cross-disciplinary culture for understanding and interacting with environmental systems. This culture relies heavily on "real-time" generation of modeling and observational data, which are integrated and distributed through information networks designed to bring the right environmental information at the right time to the right user. Prerequisite: Instructor permission.   4 credits

EBS 561/661 Introduction to Spatial Sciences

Students will learn theoretical and practical applications of geo-spatial sciences within the context of Environmental Sciences and Engineering. Geographic Positioning Systems (GPS) will be studied while performing practical, hands-on laboratory experiments using the latest in GPS equipment. Classroom discussions will focus on relating location on the Earth's surface to a common graticule. Horizontal and vertical datum, theoretical spheroids and ellipsoids, geoids and map projections will be discussed. Spatial relationships, or analysis, of continuous and categorical data will be addressed through the application of standard statistics and probability. ARCVIEW, a popular Geographic Information System (GIS) software tool, will be stressed.   4 credits

EBS 562/662 Introduction to Remote Sensing of the Environment

This course will explore the acquisition, analysis and visualization of remotely sensed data. The physics behind the collection of remotely sensed data will be introduced as will both airborne-platform and satellite-platform sensors. Fundamentals of aerial photogrammetry, single-band, and multispectral and thermal infrared data will be addressed. Concepts of image statistics, radiometric and geometric corrections, spatial filtering and special transformations like the Normalized Difference Vegetation Index are explored. Supervised and Unsupervised classification schemes will be discussed as will change detection. The course pedagogy is designed to address the needs of the advanced Environmental Science and Engineering graduate student. While there is no prerequisite, the course incorporates many topics from EBS 561/661, "Introduction to Spatial Science." It is therefore recommended that students who are unfamiliar with classification methods and the fundamental concepts of Geographic Information Systems complete EBS 561/661 or equivalent.   4 credits

EBS 570/670 Groundwater and Watershed Hydrology

Hydrologic cycle, principles of unsaturated and saturated flow in the subsurface; characterization of groundwater/surface interactions, water balance, modeling of watershed-scale processes.

4 credits

EBS 571/671 Groundwater Modeling

Applied groundwater modeling using the finite difference method. Introduction to numerical methods for solving the partial differential equations for saturated and unsaturated subsurface flow. Model execution and calibration. Prerequisite: EBS 570/670.   4 credits

EBS 572/672 Contaminant Hydrology

Processes controlling subsurface contaminant movement in porous and fractured media, including groundwater flow, dispersion, diffusion, sorption, and degradation. Parameter estimation, mathematical and laboratory modeling of aquifers is also covered.   4 credits

EBS 573/673 Modeling in Contaminant Hydrogeology

This course is designed to be taken concurrently with EBS 572/672. It emphasizes the hands-on use of common mathematical models for groundwater flow and transport (e.g., MODFLOW/MODPATH/MT3D/RT3D) to examine real groundwater contamination problems. Prerequisite: EBS 572/672.

4 credits

EBS 574/674 Introduction to Environmental Forecasting Systems

This course addresses the composition and novel uses of observation and forecasting systems towards the enhanced understanding and management of natural resources. Students are exposed to a novel, cross-disciplinary culture for understanding and interacting with environmental systems. This culture relies heavily on "real-time" generation of modeling and observational data, which are integrated and distributed through information networks designed to bring the right environmental information at the right time to the right user. Prerequisite: Instructor permission.   4 credits

EBS 575/675 Transport Processes

The aim of this class is to introduce fluid dynamics to graduate students. The basic properties of fluids and fluid motion will be studied and the students will be introduced to the equations governing fluid dynamics. Emphasis of the class will be on physics. Mathematical concepts when needed will be reviewed,   4 credits

EBS 578/678 Methods in Estuarine Oceanography: Field Observation

This course covers the fundamentals of estuarine and coastal oceanographic data collection using vessels and remotely moored equipment. Topics include vessel logistics and sampling, navigation systems, interfacing of instruments with personal computers, types of moorings and their deployment and recovery, and telemetry .   4 credits

EBS 580/680 Physics of Pacific Northwest Coastal Ecosystems

This course considers the impacts of climate, hydrology, and coastal, estuarine and fluvial circulation on Pacific Northwest coastal ecosystems. Special attention will be given to human impacts on ecosystem through alteration of their physical context. Examples will include downstream effects of water withdrawal, the interaction of climate change and climate cycles with salmonids and the coastal upwelling ecosystem, and the interaction of microbes, particles, consumers and estuarine circulation in estuarine turbidity maxima. Prerequisites: EBS 575/675 Transport Processes.   4 credits

EBS 581/681 Ecosystem Management and Restoration

This course will provide an overview of ecosystem management and restoration at the local and regional scale. It will follow the hydrologic cycle from upland watersheds through streams, rivers and estuaries to the ocean and will track important system parameters such as water flow and temperature.

4 credits

EBS 583/683 Environmental Law and Regulation
A survey of environmental law and regulation concepts essential to practicing scientists and engineers. Topics covered include the theory and practice of environmental regulation, environmental litigation, and legislation including Superfund (CERCLA), the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), the Clean Air Act, and the Toxic Substances Control Act (TSCA).　　　　3 credits

EBS 585/685 Advanced Molecular Biology
An in-depth study of the molecular mechanisms governing the replication, recombination, transcription, and translation of genetic material. Emphasis is placed on experimental approaches that have led to our understanding of these fundamental processes.　　　　4 credits

EBS 586/686 Molecular Genetics of Development
A focused study of selected topics examining the regulation of gene expression during cellular differentiation. Emphasis is placed on the molecular nature of cell-cell interactions and the genetic control of complex cellular responses to developmental and environmental stimuli.　　　　4 credits

EBS 587/687 Molecular Cell Biology
The techniques of molecular biology have created an explosion in knowledge of cell structure and function. This course examines the following topics: cellular organization; cell signaling; cell differentiation; cell evolution. Knowledge of the cell is obtained through combining core readings and lectures with student-led discussions of primary research papers.　　　　4 credits

EBS 590/690 Environmental Microbiology
Introduction to environmental microbiology, with emphasis on the role of microbes in the environment and in remediation processes. Microbes and their interaction and activities in soil and aquatic environments will be discussed, as well as elemental cycling as influenced by microbes. Microbially mediated transformation of organic pollutants, transformation kinetics and remediation technologies will be considered. In 2003-2004, may be offered in combination with EBS 593/563. 4 credits

EBS 593/693 Biodegradation and Bioremediation
A process-oriented survey of microbially mediated transformations of organic pollutants. Transformations occurring in the natural environment as well as in remediation technologies are considered. Emphasis is on the pollutant properties, microbiological factors, and medium properties that determine the pathways and kinetics of biodegradation. Recommended preparation: EBS 590/690.　　　　4 credits

EBS 596/696 Principles of Toxicology and Risk Assessment
This course applies toxicological principles to both human and ecological risk assessments. The principles and methodologies for risk assessments are presented within a regulatory context. Topics include hazard identification, exposure assessment, dose-response relationships, deterministic and probabilistic risk assessments, responses of various receptors to different contaminants, and environmental management decisions.　　　　3 credits

EBS 598/698 Current Topics in Proteomics
Proteomics is a new area of molecular biology which aims to identify and map the total protein complement of a genome. It expands the scope of biological investigation from studying single proteins to systematically studying all proteins. Proteomics has broad applications in disease diagnosis, drug discovery, and agriculture. The key technologies used in proteomics are 2-dimensional gel electrophoresis, mass spectrometry (ESI-MS, MALDI-TOF), imaging, and database. This course will focus on electrophoresis, mass spectrometry, and applications, using lectures, student seminars, and literature readings.　　　　3 credits

EBS 601 Ph.D. Prequalifying Research
Research toward the dissertation for the Ph.D. degree before completing the comprehensive examinations.　　　　Variable and repetitive credit

EBS 603 Ph.D. Dissertation Research
Research toward the dissertation for the Ph.D. degree after completing the comprehensive examinations.　　　　Variable and repetitive credit

ELECTRICAL ENGINEERING COURSES

EE 501 M.S. Nonthesis Project Research
Supervised project research for master's students who are not pursuing a thesis. A student's academic department may have additional requirements or restrictions. Please contact your academic department for further details.
　　　　Variable and repetitive credit

EE 502/602 Independent Study
Independent study allows a student to work with a faculty member on selected topic(s) of interest. Registering for independent study requires preapproval from the faculty member. A maximum of 6 credits of independent study may be applied towards an MS EE degree.
　　　　Variable and repetitive credit

EE 503 M.S. Thesis Research
Research toward the thesis for the M.S. degree.
　　　　Variable and repetitive credit.

EE 504/604 Professional Internship
Professional internship credits provide students an opportunity to earn credit for relevant work experience in industry. Students gain valuable industrial experience that allows them to both apply the knowledge gained in the classroom and prepare for careers following graduation. Students on F-1 or J-1 visas must obtain prior written approval for internships from OGI's Office of International Students and Scholars before enrolling. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
　　　　Variable and repetitive credit

EE 506/606 Special Topics
Special topics courses are offered in areas of particular relevance to the research interests of faculty or in response to industry needs. Special Topic courses are subject to change and are offered intermittently.　　　　Variable and repetitive credit.

EE 511/611 Analytical Scanning Electron Microscopy
This course introduces the operation and theory of SEM and covers sources, lenses, accelerating voltage, detectors, image formation, beam-specimen interactions, beam-produced signals, the combined effects of signal-to-noise ratio and spot size in determining resolution, and stereo imaging SEM. The process of specimen preparation, metallo-graphic grinding and focused ion beam-produced transverse cross sections, planar sections, coating techniques for nonconductors, sampling of powders, and isolation of contaminants are some of the topics covered. Students are encouraged to work on materials they provide. The course covers the operation of energy dispersive X-ray detectors, qualitative analysis, quantitative analysis, elemental mapping, spectrum artifacts, and contaminant and compound identification. The lecture portion of this course can be presented on site at companies in a 6-week period. Corresponding lab sessions are done at OGI. A project requiring operation of the SEM at the students' convenience during the remainder of the quarter and a written report is the basis for a grade.　　3 credits

EE 512/612 Focused Ion Beam Technology
This course covers operation and theory of a FIB workstation, including ion sources, accelerating voltage, electrostatic lenses, beam-material interactions, resolution, beam intensity distribution, beam produced signals, detectors, metal and oxide deposition, and enhanced etch. FIB-produced site-specific SEM transverse cross sections, the location and sectioning of micron and sub-micron scale structures on the surface and buried in multi-layered stacks or bulk materials, cross sections in metals, semiconductors, ceramics, and composites are covered. The location and sectioning of micron and submicron surface and buried structures to create electron transparent foils with little or no damage in metals, semiconductors, ceramics, and composites, and artifacts of specimen preparation are presented. Ion beam lithography and microfabrication of structures on the micron and sub-micron scales are also covered. This course uses a combination of lectures and hands-on practice to cover these topics. The lecture portion of this course can be presented on site at companies within a six-week period. Corresponding lab sessions are done at OGI. A project requiring operation of the FIB at the student's convenience during the remainder of the quarter and a written report is the basis for a grade.　　　　3 credits

EE 513/613 Transmission Electron Microscopy
Electron microscopy is a continually evolving discipline that has developed a wide range of techniques to solve specific problems. This course is designed to help the student develop a broad appreciation and knowledge of the important techniques for the

analysis of crystalline and amorphous materials. Modern transmission electron microscopes can give the investigator detailed information of crystal structure, crystal defects and quantitative local chemistries on a nanometer scale. This information is often critical to the understanding of material properties. Principles, methods and application of transmission electron microscopy to crystalline materials are covered as well as the construction and design of electron microscopes, electron diffraction, reciprocal lattice and Ewald Sphere construction. Kinematic and dynamic theories of image formation will be introduced. Combining lectures with hands-on laboratory practice, students will be instructed in the use of sample preparation equipment and an analytical transmission electron microscope. Students will be expected to carry out basic experiments on selected materials that illustrate fundamental concepts covered of the lecture. The lecture portion of this course can be presented on site at companies within a six-week period. Corresponding lab sessions are done at OGI. A project requiring operation of the SEM at the student's convenience during the remainder of the quarter and a written report are the basis for a grade.

3 credits

EE 539 Computer-Aided Analysis of Circuits

This course covers the algorithms and techniques for the formulation and solution of circuit equations for large scale circuits. Topics covered include introductory concepts in network topology, circuit equation formulation (MNA and Sparse Tableau). Solution of circuit equations: Gaussian elimination, pivoting and numerical conditioning, sparsity, and the ordering of circuit equations. Linear AC and DC networks. Analysis of linear transient networks with an emphasis on stability, error and accuracy analysis using various integration methods. Solution of nonlinear and transient problems for networks including both linear passive and multi-terminal nonlinear devices. Frequency domain (AWE) techniques for VLSI interconnections and applications to timing analysis and clock networks. Sensitivity analysis of networks. Coverage of harmonic balance techniques for RF simulation. Simulation of lossy transmission lines and circuit simulation of S parameter blocks. Brief review of circuit optimization and statistical design techniques. The implementation of device models in circuit simulators and convergence issues is also covered. Assignments stress computer-aided implementation techniques and give students a hands on feel of how a large scale circuit simulation program works.

4 credits

EE 546/646 Design of Digital Communication Circuits

Digital communications concepts including transmission, media, encoding, and synchronization. Review of BJT and CMOS circuit design and analysis. Amplifiers, filters, amplitude control, equalization. Phase locked loops, clock and data recovery. Transmitter and receiver design. Networks. Project: complete design of a serial optical link.

4 credits

EE 550/650 Introduction to Electronics and Instrumentation

Review of fundamental electronics components and design: passive components, RC circuits, power supplies, bipolar and FET transistor circuits, basic op amp circuits, RC circuits, frequency domain and time domain response, basic digital logic components. Introduction to PSpice circuit simulation. Practical advice on component selection and circuit design. Equipment and circuit demonstrations in class. Weekly homework includes circuit analysis and gradually more complicated PSpice circuit simulation problems. The course material continues in the following term with EE551/EE561 "Advanced Electronics and Instrumentation.

4 credits

EE 551/651 Advanced Electronics and Instrumentation

uilds on the introductory concepts from EE550/561. Feedback theory, op amp limitations, precision op amp circuits. Noise, interference, grounding and shielding, low-noise techniques. Op amp circuit design and noise calculation. Analog to digital and digital to analog converters, sampling theory. Phase-locked loops, lock-in amplifiers. Practical advice on component selection and circuit design. Equipment and circuit demonstrations in class. Homework includes PSpice circuit simulation problems and a final design project.

4 credits

EE 557 Computer-Aided Analysis Of Circuits

This course covers the algorithms and techniques for the formulation and solution of circuit equations for large scale circuits. Topics covered include introductory concepts in network topology, circuit equation formulation (MNA and Sparse Tableau). Solution of circuit equations: Gaussian elimination, pivoting and numerical conditioning, sparsity, and the ordering of circuit equations. Linear AC and DC networks. Analysis of linear transient networks with an emphasis on stability, error and accuracy analysis using various integration methods. Solution of nonlinear and transient problems for networks including both linear passive and multi-terminal nonlinear devices. Frequency domain (AWE) techniques for VLSI interconnections and applications to timing analysis and clock networks. Sensitivity analysis of networks. Coverage of harmonic balance techniques for RF simulation. Simulation of lossy transmission lines and circuit simulation of S parameter blocks. Brief review of circuit optimization and statistical design techniques. The implementation of device models in circuit simulators and convergence issues is also covered. Assignments stress computer-aided implementation techniques and give students a hands on feel of how a large scale circuit simulation program works.

EE 561/661 Analog Integrated Circuit Design

Design techniques for analog integrated circuits. Silicon bipolar and JFET analog integrated circuit design. Technology overview, device structures, Ebers-Moll equations, hybrid-pi model. Single-stage amplifiers, current sources, active loads, output stages. Operational amplifiers, bandgap references, frequency response, feedback, stability. Design project.

4 credits

EE 562/662 Digital Integrated Circuit Design

Design techniques for digital integrated circuits. Silicon bipolar and MOS digital integrated circuit design. Technology overview, device structures, modeling. Standard logic families. NMOS and CMOS logic design. Regenerative circuits and memory. Design project.

4 credits

EE 563/663 Analog CMOS Integrated Circuit Design

Design techniques for CMOS analog integrated circuits. Technology overview and models. Single-stage amplifiers, current sources, biasing, active loads, class AB output stages. Low-voltage design, bandgap references, operational amplifiers, frequency response, compensation. Design project.

4 credits

EE 564/664 High Speed Interconnect Design

Analysis, design, and measurement of digital interchip interconnects operating at multi-gigabits per second. Topics include: transmission line analysis, timing analysis, measurement equipment and techniques, lossy and coupled transmission lines, frequency domain analysis, differential signaling, equalization, modulation techniques, and design methodology. A design/research project is used to give students practical insight into high-speed differential signaling challenges.

4 credits

EE 565/665 Introduction to Wireless Integrated Circuit Design

Analog integrated circuit design for wireless communications. Transistor models, biasing, distortion, matching networks, noise modeling, low noise amplifiers, mixers, power amplifiers. Design project.

4 credits

EE 570/670 Advanced Logic Design

This course constitutes a basic introduction to the design and implementation of computer logic. Basic principles of discrete logic will be presented, including Boolean algebra, finite-state machine design, logic minimization and optimization using both hand-compiled (Karnaugh maps) and EDA tool based techniques. Students will apply logic design techniques to PLD (Programmable Logic Devices) and FPGA (Field Programmable Gate Array) devices. In addition, students will learn the basics of Verilog (HDL) Hardware Description Language. The last part of the course will include a Verilog HDL design project using the ModelSim logic simulator. This course or its equivalent is a prerequisite to all other Computer Engineering (EE) Design courses.

4 credits

EE 570/670 Advanced Logic Design

This course constitutes an introduction to the design and implementation of computer logic. Basic principles of discrete logic will be presented, including Boolean algebra, finite-state machine design, logic minimization and optimization using both hand-compiled (Karnaugh maps) and EDA tool-based techniques. Students will apply logic design techniques to PLD (Programmable Logic Devices) and FPGA (Field Programmable Gate Array) devices. In addition, students will learn the basics of Verilog

hardware description language. The last part of the course will include a Verilog design project using the ModelSim logic simulator. This course or its equivalent is a prerequisite to all other Computer Engineering (EE) Design courses. 4 credits

EE 571/671 System On a Chip (SOC) Design with Programmable Logic

Programmable logic, such as FPGA and PLD devices, has become a major part of digital design. Recent advances in semiconductor technology have made it possible to implement an entire system on a single chip. This course will discuss tools and techniques for designing, validating and implementing System-on-Chip (SoC) designs using programmable logic. Designs are first expressed in Verilog hardware description language (HDL), simulated to verify design correctness, then synthesized to logic primitives, and finally placed and routed into a programmable logic device. The course has a project orientation - students will take designs from concept to HDL description and validation through synthesis and then to programmable device implementation. Industrial EDA tools will be used. Prerequisites: EE570/670 required or consent of instructor.
4 credits

EE 572/672 Advanced Digital Design – Timing Analysis and Test

This course focuses on timing and design-for-test topics in FPGA and ASIC design and implementation. The course uses industrial EDA tools. Topics covered include fundamentals of digital system timing, multi-clock design issues such as synchronization and clock domain boundary crossing, metastability and synchronization failure, timing-driven logic synthesis, static timing analysis, skew and jitter analysis, clock distribution, phase- and delay-locked loops, faults in digital systems, scan testing and automated test pattern generation. Prerequisites: EE 571/671 required or consent of instructor. 4 credits

EE 573/673 Computer Organization and Design

Basic computer organization: Memory hierarchy, including caches, pipelining, computer arithmetic, number representation, floating point arithmetic processors, controllers, input/output, buses, DMA. Data formats, addressing modes, instruction sets, and microcode. This course bridges the gap between the Computer Engineering and Design courses and CSE 521/621 Introduction to Computer Architecture. Prerequisites: EE 570/670 recommended, or taken concurrently. 4 credits

EE 574/674 CMOS Digital VLSI Design I

An introduction to CMOS digital IC design covers basic MOS transistor theory; operation of basic CMOS inverter; noise margins; switch level modeling of MOS devices; capacitive characteristics of MOS devices; introduction to device fabrication, design rules and layout issues; power consumption; gate design/transistor sizing; pass transistors and complimentary pass transistor logic; dynamic domino and precharge/discharge circuits; memory element design (RAM/ROM/flip-flops) and subsys-tem design (adders, multipliers, etc.). An understanding of basic digital design concepts is assumed. Lab exercises use industry-standard design tools. Laboratories include circuit validation and characterization. Prerequisite: EE 570/670.
4 credits

EE 575/675 CMOS Digital VLSI Design II

Concentration on advanced digital VLSI circuit design techniques. Architecture and micro-architecture of VLSI components, clocking schemes, input/output circuits, and special functional blocks such as random access memories, read only memories and programmable logic arrays. The course covers design tradeoffs, especially considering cost, power and performance. The course devotes a considerable amount of time to layout, parasitics and performance verification. Introduction to design and verification tools with hands-on experience. Prerequisites: EE 574/674, familiarity with MOS transistor operation; computer architecture and organization; logic design. 4 credits

EE 577/677 Applied Hardware Verification

This course is application-oriented and covers practical aspects of functional hardware verification for complex ASIC and FPGA designs. It introduces the student to a variety of state-of-the art hardware design verification methods, beginning with traditional functional simulation, then moving on to assertion-based verification methodology and concluding with a subset of formal verification techniques. Topics covered include functional simulation, coverage metrics, testbench design and automation, event- and assertion-based verification, property specification language, and formal methods including model checking and logical equivalence checking. Students will do functional simulation, assertion-based, and property specification language lab exercises using the ModelSim digital simulator. Prerequisites: EE570/670 required or consent of instructor. 4 credits

EE 580/680 Linear Systems

This course introduces the State Variable representation of linear dynamical systems and studies a large body of State Space techniques to reveal both inner structure and external behavior of the systems modeled in this way. The course develops a general framework for time-varying linear systems, but places major emphasis on the time-invariant systems, whose structure and dynamics are knowable to the very utmost detail. Both continuous-time and discretetime linear systems are studied. The course provides a strong body of foundational material, which is utilized in virtually all applications-specific areas pertaining to system analysis/design and signal/information processing. The major topics covered are: canonical realizations, equivalent systems, canonical transformations, canonical decompositions, solution of state equations, stability, controllability and observability, design of asymptotic observers, state-feedback compensation schemes. Linear Quadratic Regulator and Kalman Filter are also introduced. 3 credits

EE 581/681 Introduction to Signals, Systems and Transforms

This course provides the essential mathematical tools and analytical techniques for the analysis of continuous-time and discrete-time systems. Basic signal and system characteristics, linearity, time-invariance, convolution and correlation are first examined from the time domain perspective. We then proceed to study a family of transforms - Fourier Series, Fourier Integral Transform, Laplace Transform, Discrete Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT) and z-Transform which take the study of these systems to a deeper level and introduce useful properties which the time perspective alone does not reveal. Basic applications in information processing, communication and control fill out the mathematically derived results. A greater portion of the syllabus in EE 581/681 is allotted to continuous time signals/systems than to discrete time signals/systems, because the latter are taken up in detail in other information processing courses, particularly EE 582/682. A goal of the presentation this course is to impart the essential unity of all the transforms and the almost perfect correspondence of approach in continuous-time and discrete-time contexts. This course is a useful pre-requisite or co-requisite to EE 582/682 and all other courses in the information processing area.
3 credits

EE 582/682 Introduction to Digital Signal Processing

The representation and processing of signals and systems in the discrete or digital domain is the preferred mode in today's computer and information driven technologies. DSP provides the core building block from cell phones to modems, HDTV to video conferencing, or from speech recognition to MP3 audio. This classes covers the fundamental concepts and mathematics including representation and analysis of discrete time signals and systems, Z-Transforms, Discrete-Time Fourier Transform (DTFT), and the Discrete Fourier Transform (DFT), sampling and windowing techniques pertaining to discrete time processing of continuous signals, analysis and design of recursive (IIR) and nonrecursive (FIR) digital filters, and applications of the Fast Fourier Transform (FFT) to convolution, spectral analysis, and audio processing. Prerequisite: EE 581/681 or equivalent. 3 credits

EE 583/683 Information Theoretic Signal Processing

Information theoretic and other higher order statistical measures have recently become popular in statistical and adaptive signal processing. This course will review the basics of information theory including standard definitions of entropy, density divergence, and mutual information. Sample-based estimation strategies for these quantities will be presented in detail and applications of these principles in adaptation and signal processing algorithm design will be demonstrated on relevant signal processing problems. These practical problems will include independent components analysis, blind deconvolution, and blind source separation, image registration, clustering, data dimensionality reduc-

tion, and feature ranking. The students who complete this course will obtain familiarity with the important concepts of information theory in the context of signal processing and machine learning as well as how to employ these concepts to solve significant problems of interest. 3 credits

EE 584/684 Introduction to Image Processing

This course covers basic image processing principles and techniques with a brief introduction to machine vision. Students acquire theoretical and working knowledge of image processing approaches including image representation, transform methods, image filtering, multi resolution representation, edge detection, texture characterization, and motion analysis. This course demonstrates application of these methods to image enhancement, image restoration, and image compression, with emphasis on image quality metrics based on human visual perception. Selected areas in machine vision include image segmentation, elementary techniques in pattern recognition, and object representation. Numerous examples show how to apply these techniques. Prerequisite: EE 582/682. 3 credits

EE 585/685 Introduction to Digital Video Processing

This course introduces digital video processing for multimedia systems. It begins with video capture, image formation, analog and digital video signals and standards, and spatio-temporal sampling. Subsequent topics include motion estimation, segmentation and tracking, video filtering and video standards conversion. Students are familiarized with video compression techniques and standards (JPEG, MPEG2, H.261, H.263), and model-based video quality estimation. Students will gain working knowledge of these video techniques through class projects. Familiarity with digital signal processing and transform methods is desirable. Prerequisite: EE 584/684. 3 credits

EE 586/686 Adaptive and Statistical Signal Processing

The field of adaptive filters and systems constitutes an important part of statistical signal processing. An adaptive system alters or adjusts its defining parameters in such a way that it improves performance through contact with the environment. Adaptive filters are currently applied in such diverse fields as communications, control, radar, seismology, and biomedical electronics. This course will cover the theory and applications of adaptive linear systems. Topics include Wiener filters, least squares, steepest descent, LMS, RLS, Newton's method, FIR and IIR adaptive structures, and Kalman filters. Applications covered include noise canceling, signal enhancement, adaptive control, adaptive beam-forming, system identification, and adaptive equalization. The theory also lays the foundation for study in nonlinear signal processing with neural networks and will be introduced in the later half of the class. This course should be of interest to electrical and computer engineers specializing in signal processing and the information sciences. This course should also be taken as background for additional classes offered in artificial neural networks, connectionist models, and machine learning.

Prerequisites: EE 582/6821 plus an undergraduate level course in probability and statistics. 3 credits

EE 587/687 Data and Signal Compression

The need for signal and data compression is ubiquitous in image, video and speech processing, finance and computational science. Where data stores become very large (e.g. video, finance, earth science), the need is not met by simple lossless file compression schemes, and we must turn to sophisticated coding techniques. This course addresses both the theoretical basis and practical algorithms for data and signal compression. Topics include lossless entropy-based coding, including Huffman and Lempel-Ziv, and lossy compression techniques including scalar quantizers, transform coding (Karhunen-Loeve, DCT and nonlinear transform codes), predictive coding, vector quantization, adaptive codes and wavelets. The relation between compression schemes and probabilistic data modeling is emphasized in conjunction with each technique. Application to speech, image and video coding are discussed. Students will have the opportunity to design compression schemes for such diverse applications as earth science data, finance, speech or video, depending on their interests. Prerequisites: Undergraduate calculus, introductory probability and statistics, some programming experience. 3 credits

EE 588/688 Introduction to Biomedical Imaging

This course introduces imaging and analysis methods in medicine and biology. It is intended for students and researchers in biomedical engineering, computer and electrical engineering, physics and other engineering disciplines as well as medical professionals and students who would like to attain a basic understanding of medical imaging. The course is intended to provide the basic understanding of both the image formation and relevant image processing techniques. The course will introduce the physics and phenomenology of image formation for a variety of image modalities that include X-ray, computer tomography (CT), magnetic resonance imaging (MRI), nuclear imaging (PET, SPECT) and ultra sound. Subsequently, students will be introduced to the techniques for image representation, processing and analysis. Specific topics include image reconstruction, image enhancement, segmentation, registration, characterization, pattern recognition interpretation and visualization. The course will also briefly address issues related to image-based diagnosis, intervention and therapy. This course includes weekly lectures, home work, journal article review sessions and a final project. 3 credits

EE 589/689 Foundations of Computer Vision

This course provides an overview of computer vision. Computer vision deals with the problem of recovering information about the world from one or more images. This course covers the basic problems and techniques of computer vision, including the process of image formation (lighting and camera models), multiview geometry (stereo, affine and projective reconstruction), robust estimation, probabilistic models, segmentation, tracking and

object recognition. Although the course will be a general survey, sufficient detail will be given for students to be able to build useful applications. Particular mention will be made of health-related applications such as medical image segmentation, image retrieval in digital libraries, or unobstrusive patient monitoring. The course does not cover image processing aspects (such as image filtering, Fourier transforms, image pyramids, edge detection, image enhancement, restoration and compression), which are covered in course EE584 "Introduction to image processing". 3 credits

EE 590/690 Digital Communication I

Communications system models for various modulation and demodulation band limited base-band systems. Optimum detection, source encoding/decoding. Waveform communications and signal space representation. Pre-requisite: undergraduate course in digital or analog communications.

3 credits

EE 591/691 Digital Communication II

Channel noise and capacity. Typical random and fading channels, optimum filters and signal design. Probability of error in noisy band limited channels for different modulations. Optimal design of BFSK, BPSK, QPSK, m-QAM, CPM modulators and demodulators via MAP and ML techniques. Phase lock loops and Costas detectors. Energy-bandwidth tradeoffs in digital modulation. Pre-requisite: EE 590/690 or permission, and statistics with probability. 3 credits

EE 592/692 Digital Communication Systems

Convolutional and RS coding, Viterbi decoding. Multi-path fading and its effects on performance and diversity signaling. Synchronization architectures. Spread spectrum. Channel equalization. Pre-requisite: EE591/691 or equivalent or permission.

3 credits

EE 593/693 Analytical Techniques in Statistical Signal Processing and Communications

Development of the mathematical techniques needed to analyze systems involving random variables and/or stochastic processes with particular application to communications and instrumentation. Topics include Bayes Theorem (discrete and continuous forms), Tchebycheff inequality, Chernoff Bound, Central Limit Theorem, stationary processes and linear systems, mean square estimation, Poisson process, Gaussian process, Markoff process, and series representations. MATLAB and the MATLAB Statistics Tool Box are used in this course.

3 credits

EE 601 Prequalifying Ph.D. Research

Supervised research participation. Pre-qualifying Ph.D. research prior to passing qualifying examination. Variable and repetitive credit

EE 603 Ph.D. Dissertation

Research toward the dissertation for the Ph.D. degree. Variable and repetitive credit

GENERAL EDUCATION COURSES

GEN 515/615 Scientific Proposal Writing

Scientific Proposal Writing focuses on how to write a thesis proposal or a grant application, using an NIH grant application as the vehicle. All course assignments are geared toward writing sections of the thesis proposal (grant application). By the end of the course, each student will be expected to produce a draft of his or her thesis proposal or a grant application, modeled after an NIH grant application and based on the students own thesis research plan or ongoing research. Prior to enrolling, students will need to have completed sufficient preliminary research to have preliminary data suitable for their proposals; they also need to be far enough along in their studies to be ready to design their research plan. The class is not open to auditors. Pre-requisites: Passing score on a Scientific Writing Diagnostic and instructor approval.   3 credits

GEN 569/669 Scholarship Skills

Scientific results have little value if they are not communicated clearly or are disconnected from prior work in a field. This course teaches students to research, write, present and review effectively for the computer sciences. It emphasizes learning by doing, and students have frequent writing and presentation assignments. Students learn how to locate and organize background materials, how to write clearly about technical topics, how to organize Web content, the structure and stylistic conventions of scientific documents (such as conference abstracts, journal papers, theses and proposals), how to prepare and deliver short and long presentations, the refereeing process, and how to prepare and respond to a review. This course is required for Ph.D. students and strongly recommended for master's students, especially those pursuing the thesis option. It also is useful for professionals who must write or speak to a technical audience.   3 credits

APPLIED MATHEMATICS

MATH 511/611 Introduction to Discrete Numerical Methods

This course provides an introduction to discrete numerical methods. Lectures cover the theory and application of methods for the numerical solution of initial-value, boundary-value and mixed initial-boundary- value problems by finite differences, weighted residuals, numerical integration and finite elements. Prerequisite: Calculus.   3 credits

MATH 517/617 Probability and Statistics

This course provides an introduction to probability, statistical inference and statistical analysis. The aims of the course are to provide scientists and engineers with a comprehensive introduction to essential concepts in probability and statistics, and for students to gain proficiency in applying these concepts to data analysis. Topics include exploratory data analysis, sampling distribution theory, confidence intervals, hypothesis testing, maximum likelihood estimation, linear regression, goodness-of-fit, ANOVA, and parametric and non-parametric tests. The primary analysis tool for this course is Excel.   3 credits

MATH 519/619 Engineering Optimization

This course introduces advanced numerical optimization methods for quantitative work in science and engineering. The course will cover important traditional methods for constrained and unconstrained multivariate optimization, including line search methods and gradient-based techniques, as well as linear, quadratic and dynamic programming. In addition, more heuristic techniques such as genetic algorithms, differential evolution and simulated annealing will also be presented. The primary programming tool for this course is Matlab. Some knowledge of linear algebra and multivariate calculus is required, as is a basic grasp of probability and statistics.   3 credits

MATH 530/630 Probability and Statistical Inference for Scientists and Engineers

This course will introduce fundamental concepts underlying statistical data display, analysis, inference and statistical decision making. The topics include presentation and description of data, basic concepts of probability, Bayes theorem, discrete and continuous probability distributions, estimation, sampling distributions, classical tests of hypotheses on means, variances and proportions, maximum likelihood estimation, Bayesian inference and estimation, linear models, examples of nonlinear models and introduction to simple experimental designs. One of the key notions underlying this course is the role of mathematical modeling in science and engineering with a particular focus on the need for an understanding of variability and uncertainty. Examples are chosen from a wide range of engineering, clinical and social domains. Prerequisites: Applied Mathematics.   3 credits

MANAGEMENT IN SCIENCE AND TECHNOLOGY

MST 502 Independent Study

Independent study allows a student to work one-on-one with a faculty member on selected topic(s) of interest. Registering for independent study requires pre-approval form the faculty member and the student's academic department.
Variable and repetitive credit

MST 506 Special Topics

Special topics courses are offered in areas of particular relevance to the research interests of faculty or in response to industry needs. Special Topic courses are subject to change and are offered intermittently.
Variable and repetitive credit

MST 507HC Seminar for Healthcare Management

A Healthcare Management student participation seminar on a topical paper or product.   2 credits

MST 509 Commercialization Practicum

This hands-on practicum focuses on commercializing emerging technologies. Students learn the entrepreneurial development skills necessary to move a new technology from "mind to market." Student teams, working with emerging technologies held by OHSU, produce assessments and plans for bringing a new technology to market. Teams determine the commercial viability of a product by looking at the market and business channel options as well as the technical feasibility. Students gain an understanding of strategic considerations in the product commercialization process, how to determine market viability and technology and market timelines, application of intellectual property issues in the product commercialization process, and determination of how to reach the customer. M.S. in Management students may be able to extend work from this practicum into their MST 550/MST 551 Capstone project.   4 credits

MST 510 Principles and Trends in Technology Management

This course focuses on how companies choose, develop and/or acquire the technologies that they use to design, manufacture, deliver and support profitable products. Students look at these practices from three different (but related) perspectives, namely the R&D manager, the product line manager, and the vice president of marketing. The course examines the issues in managing technology throughout its lifecycle, from research and development, through product development, and on into the marketplace. Technologies of interest span electronics, information technology, biosciences, materials, energy and environment. The focus is on today's "emerging technology" environment of rapid innovation, short time cycles and rapid price reductions.   3 credits

MST 511 Quality Management

This course is about managing quality in today's competitive environment. The focus is on the issues that quality managers face and the principles, strategies, methods, and tools that might be used to build an effective quality system. The class examines how management systems impact the delivery of quality, and considers the roles of process management and quality systems for building and sustaining quality. The emphasis of this class is on management practice rather than the technical or engineering attributes of quality.   3 credits

MST 512 Project Management

This course briefly reviews essential tools of traditional project management, followed by an examination of advanced concepts and techniques, including politics, communications, customer satisfaction, dealing with change, managing complexity, team-based solutions, managing managers and dealing with risk. The traditional tools of project management, such as CPM and PERT, are examined in the context of these much more critical issues that determine the success or failure of almost all technology projects. Since effective communication is so crucial to project management, the course includes sessions of instruction and coaching on effective presentation skills.   4 credits

MST 513 Operations Management and Practices

This course introduces the study of business process management in the operation of a firm. Students learn systems thinking and systems analysis skills with an emphasis on the understanding of current process performance as well as learning practices to enable higher levels of performance. Given the increasing trend toward contracting out many operational functions, the course also introduces key concepts of value chain management. The course instills two distinct perspectives: that of a process management consultant equipped with the right skills to help their business become more competitive, and that of a senior operations executive who needs to be knowledgeable about how their organization works.   3 credits

MST 515 Supply Chain Management

This course focuses on the strategic aspects of supply chain management. Supply chain management is the management of processes across complex networks of companies that while independent are in reality interdependent. Therefore, the ability of a company to generate high profits in an uncertain economy is often a direct result of the effectiveness of its supply chain. Supply chain management is a system approach to managing the entire flow of information, materials, products and funds to and from suppliers and end-customers.   3 credits

MST 516 Global Logistics and Financial Management

This course emphasizes operations and logistics in firms that source, produce, distribute and market in multiple nations. The management of logistics in such firms differs from its domestic counterpart along several key dimensions. First, the company must be able to identify and analyze factors that differ across nations and that influence the effectiveness of the logistics function. In addition, because of the distances involved, transportation and distribution are of greater significance. Finally, these geographically dispersed facilities and markets must be integrated and managed to enhance the strategy of the business unit. Therefore, some sessions will focus on cross-national decisions and others on managing across nations. This course is built on a robust financial foundation to help students to develop analytical skills required for managers in companies committed to global markets doing business across borders.   3 credits

MST 517 Supply Chain Management: Advanced Modeling

This course introduces optimization in supply chain modeling. The emphasis is mainly on large-scale real-world supply chain distribution network design. The major skills taught are problem definition, model formulation, and solution analysis. Students use commercial software such as SAILS and GSCM for large mixed-integer programming, and GAMS for hands-on mathematical modeling. Other topics of the course focus on how to manage financial uncertainty under market chaos using real options methodology with Crystal Ball Monte Carlo-based software.   3 credits

MST 520 Becoming an Effective Manager

This course develops participants' ability to understand and influence human behavior within technology-intensive organizations. Students learn to manage themselves, manage one-on-one relationships at work, manage their careers, and manage teams, all using ethical approaches to building coalitions and influencing others without formal authority. A major emphasis in the course is the practice of "reframing" - the ability to rethink and re-conceptualize a situation so as to widen one's perspective and available responses. Reframing is an important skill for managing people and projects in fast-changing organizations that are creating or using new technologies. Participants learn and practice setting and managing agendas (while juggling multiple demands), building and sustaining networks (while satisfying various stakeholders), and taking productive, ethical action (while honoring the values and culture of the organization).   4 credits

MST 521 Managing People in Organizations

This course focuses on the professional management of people, including the fundamentals of recruiting, hiring, motivating, rewarding and appraising workers. The course focuses on how human resource (HR) management can create value and deliver results. Participants will examine the relationship between an organization's HR practices and the organization's effectiveness and competitive success. HR systems must be designed to fit each organization and group of people; all managers must know and practice good HR management for the organization to be successful. After completing the course, students will have mastered a variety of best practices for managing people at work.   3 credits

MST 522 Influencing Change in Organizations

This course focuses on designing effective organizations and managing change in organizations in which engineering, manufacturing, and/or scientific technologies are critical. Tools for assessment and redesign of organizations are emphasized. The course pays special attention to organizing for lateral coordination and integration, as this is a required capability in technology-intensive organizations. Topics also include: change methodology; roles in a change initiative; competencies and mind-sets required to effectively lead change; and the impact of change on people and organizations. Students are encouraged to design their own organizational change using a combination of the frameworks. Taking MST 520 first is recommended.   3 credits

MST 523 New Product Development

This course is aimed at managing innovation and creativity while at the same time achieving reliable robust products that hit market objectives aligned with the company's business strategy. Learning how to bring new products to market that hit pricing/cost targets, on a predictable competitive launch date, with winning performance criteria, is the primary goal for this class. By the end of the course, students will be able to put together a product concept

definition, carry out a pro forma financial analysis, and produce a product specification. Additional topics include identifying and managing the technological and programmatic risks associated with a new product, and understanding the trade-off between cycle time and product quality risks.   4 credits

MST 530 Strategic Management and Planning

This course focuses on the analysis of fast-changing competitive environments and on the decision-making process leading to the formulation and implementation of strategy. The class explores using time, knowledge, and technology as competitive advantages, managing strategic change, and developing strategic plans for a future that cannot be known with certainty. Several different models for strategy formulation such as game theory, portfolio analysis, the "Five-Forces", and "Competing on the Edge" will be examined. As the ultimate test of strategy in the business world is running a company, class teams will play a computer simulation of operating a multi-product business in a dynamic, competitive environment. Prerequisites: MST 572, MST 573, MST 520 or instructor permission.   4 credits

MST 531 Software Commercialization

This course investigates the rapidly changing software industry, and how to work in and run a commercial software company. The course provides real-world perspective on the current issues involved in creating and commercializing software. Because the business models for hardware and software companies are quite different, the course focuses on the special problems of marketing, entrepreneurship, globalization, and alliances experienced by software firms. Special attention is given to the creation of value, standardization, and competitive strategy for high-volume software markets. One class project will probe issues and current trends in the software industry, and another will conduct a strategic assessment of a selected software company.   3 credits

MST 540 International Management in Science and Technology

Topics in this course include trends in the conduct of international business, the international business environment, the operation of multinational enterprises, international technology transfer, and the special considerations associated with managing on the international level. The course is constructed to give students a grounding in both theoretical and hands-on aspects of international business. Course readings and lectures will focus on international trade theory, history and trends. Classroom discussions involve problem-solving exercises in which students develop skills for dealing with real world problems in international management. The group international management projects give students an opportunity to work as members of a team to accomplish international business objectives.   3 credits

MST 541 Leadership and Communication Skills

Effective interpersonal communication is the core competency from which we build the skills of per-

sonal influence, coaching, conflict resolution, personal awareness, and leadership. This course helps students develop interpersonal communication and negotiation skills for effective leadership. The focus is on personal skill building through effectively influencing in-class working groups. The course explores six leadership styles to discover where and when each is most effective. Students discover and assess their negotiations skills based on five standard negotiation styles. Personal reflection and learning are required for maximum skill development.

3 credits

MST 542 Business Ethics and Corporate Social Responsibility

This course focuses on ethical dilemmas, social issues and responsibilities, and government regulations and influences. First, the course examines different frameworks for individual decision making in an organizational setting. Next, the impact of organizational policies and practices, and the words and actions of managers on the behavior of individuals within those organizations is examined. Finally, the course focuses on the relationships between organizations and the societies in which they operate, examining the perspectives of multiple stakeholders including government regulators, community representatives, customers, employees, managers, and stockholders.   3 credits

MST 544 Strategic Alliances

Alliances have become an essential strategic element in growing a business. This course studies the structure of various types of alliances, and go into detail about best practices (what works) as well as unsuccessful practices (what doesn't work). Guest speakers from industry bring in live examples of alliance experience. The class looks at a variety of companies as well as industries and geographies in order to understand the key issues in alliance development from several perspectives. The overall goal of the course is for the student to understand how an alliance fits into overall strategy, different types and characteristics of alliances, and best practices in the planning, selection, negotiation, and operation of alliances.   3 credits

MST 549 Applied Business Forecasting

This web-based course emphasizes generating and implementing business forecasts. It is designed for students who want to know how forecasts are actually developed and utilized, emphasizing modern statistical methods that are widely used to generate business forecasts. Specific applications to business include forecasting sales, production, inventory, macroeconomic factors such as interest rates and exchange rates, and other aspects of both short- and long-term business planning. Topics include a statistical review, data considerations, model selection, moving averages and exponential smoothing, regression analysis, time-series decomposition, Box-Jenkins (ARIMA) models, optimal forecast combination, and forecast implementation. Anybody seeking to enhance his or her understanding of business forecasting from an applied perspective would benefit from taking this course. Knowledge of basic

statistics and regression analysis is highly recommended, but not required.   4 credits

MST 550 Capstone Project: Preparing the Business Plan

This is the first of a two-course sequence (followed by MST 551) that must be taken in two successive quarters. Entrepreneurship is, by its very nature, an integrative exercise. When designing and building companies, small teams must holistically integrate many discrete business skills in a very fluid, chaotic environment. This two-part course presents students with the opportunity to put all of their business skills to the test as they work with actual high technology or healthcare startups, meet veteran entrepreneurs and startup experts, and prepare and pitch business plans. Experiencing the opportunity to "bridge the gap between theory and practice" is one of the goals of this course. Students take away a methodology for identifying and analyzing entrepreneurial opportunities throughout their careers. The course emphasizes business formation from the point of view of the founders/senior executive team and explores the behaviors, talents, skills and experiences that can be acquired to prepare future senior executives. Capstone course students will plan, research, prepare and present a business plan in teams of 3 to 5 members. Presentation of the plan will be in both written and oral form. The course is limited to matriculated degree students who are close to completion of their studies. MST 550 and MST 551 must be taken in two successive quarters. Prerequisites: MST 520, MST 571, MST 573, and instructor approval. MST 530, MST 541, MST 572, MST 574, MST 590/1, are strongly recommended prior to Capstone.   2 credits

MST 551 Capstone Project: Delivering the Business Plan

This is the continuation of a two-course sequence (beginning with MST 550) that must be taken in two successive quarters. Capstone course students will plan, research, prepare and present a business plan in teams of 3 to 5 members. Presentation of the plan will be in both written and oral form. Prerequisite: MST 550.   3 credits

MST 560 The Organization, Financing, and History of Health Care Delivery in the United States

There are increasing demands for administrators and managers who understand the complexities of the healthcare field and can provide effective leadership in these organizations. Besides specialized knowledge needed for a particular service area, or product line, each manager must understand the broader environment in which they work. This course provides a historical context for the current system: the current economic drivers, political pressures, ethical issues, and the roles of insurance and pharmaceutical companies. In addition, the course introduces students to the technological changes - both administrative and clinical - that will influence service delivery. Finally, a section of the course focuses on important issues in healthcare that influence the field at the time the course is presented.

4 credits

MST 561 Managerial and Financial Accounting for Health Care Professionals

Principles of managerial and financial accounting are developed and used to examine difficult strategic and operational decisions confronting healthcare professionals. The course provides the healthcare decision maker with the necessary tools in managerial and financial accounting theory and concepts to make better financial management decisions on the job, as well as to make sound judgments regarding financial analyses performed by others. Topics include the interpretation of the income statement, balance sheet and cash flow statements, with a particular concern for how to analyze these statements, using financial ratios and other analytic tools. Students acquire an understanding of the complexities of cost behavior. The financial management decision-making processes addressed include financial projections, cost behavior, cost-volume-profit analyses, special decisions such as make-or-buy, costing, cost allocation and pricing. Students gain an enhanced conceptual and technical understanding of the managerial planning and control process, including strategic planning, operational budgeting, and capital budgeting and net present value analysis.

4 credits

MST 562 Health Care Program Management

This course focuses on the skills and tools needed to manage and develop a health care program, with detailed emphasis on business planning, program design, scheduling, and resource management, including human resources, capital equipment, and software infrastructure. Students gain an understanding of the basic tools of project management and how, when, and where those tools may apply to health care improvement or development projects. Upon completion of the course students will be able to establish a project plan that will permit the successful meeting of the objectives within the cost, time and available resource constraints.   4 credits

MST 563 The Regulation and Legislation of Health Care Delivery

The course reviews how governmental and non-governmental organizations influence health care delivery. Special emphasis is placed on current regulatory and legislative initiatives. Participants gain an increased understanding of the federal and state regulatory/reporting framework within which healthcare is delivered and the role of accreditation bodies within that framework. The course provides examples of the evolution of new legislative initiatives, both at the federal and state level, in order to demonstrate the complexity and impact of regulatory oversight on healthcare delivery. Guest lectures provide the perspectives of experienced authorities in areas of Risk Management, Legislation, Environmental Safety, Healthcare Law, Internal Audit, Medicare Reimbursement, and Healthcare Compliance.   4 credits

MST 564 Business Planning and Strategy in the Health Care Industry

The strategic management and planning of health care functional units, clinics and hospitals in today's

fast-changing technology intensive environments is extremely challenging. The class focuses on analyzing, planning, decision-making, formulation of strategy and its implementation in a world where "growing" today's organization into an essentially unknowable future is essential for long-term success. The course examines the major drivers towards change in the health care environment, approaches to empowering the consumer in health care management, and the changing value proposition for health care. Students examine potential scenarios for the future of health care, the potential major drivers, and the question of who the "customer" really is in health care. Invited speakers who are strategic decision makers in the health care industry share their expertise with the class. 4 credits

MST 565 Managing People in Health Care Organizations

This course focuses on the management of people in healthcare organizations. This course is designed to provide the knowledge and tools for healthcare managers to manage people in all aspects of their work: recruiting, hiring, motivating, and managing performance, conflict and change. In addition, aspects of the external environment that affect how people are managed in the workplace, including employment laws and regulations and labor unions will be examined. The general objective of this course is to provide the healthcare manager with current thinking, theory, and best practices for the management of people in healthcare organizations in order that s/he can be a better manager of people. 4 credits

MST 566 Health Care Information Systems Management

This course is aimed at health professionals, both administrators and health care providers, who more and more find themselves needing to understand how to manage the high technology systems, tools and products that have become such an integral part of the health delivery spectrum. Today's health practitioner has to use technology to find medical information and use accounting systems, personnel systems, health insurance company systems, inventory systems, patient billing systems, purchasing systems, as well as input and retrieve data. This course focuses on the business of health care and how to understand, use and manage technology and systems in a medical environment. The overall goal is to give students a conceptual framework for understanding how to use technology to reduce costs and improve productivity, efficiency and effectiveness in their current and future work situations. 4 credits

MST 567 Health Care Technology — New Medical Advances

Highlighting the role of technology and its influence on treatment and health care delivery in the US, this course includes the role of medical technology suppliers in shaping delivery as well as decision-making and strategy for acquisition of new technology. 4 credits

MST 568 New Trends in Health Care Delivery

This course surveys timely topics in health care (e.g. Compliance, Patients Rights, Patient Safety, health care and he Internet, B to B Internet transactions, etc.). It is taught by a specialist in the appropriate field and focuses on practical knowledge needed by managers. 2-4 credits

MST 571 Managerial and Financial Accounting for Science and Technology

This course offers a survey of financial and managerial accounting, intended to provide students with a basic background of accounting principles as they are used in decision-making. Financial accounting, which is prepared for external users, represents the base of information that is generated by companies. Managerial accounting, which is prepared by and for internal users, follows different rules and principles because it is relevant to strategic decision-making: what to make or buy, when and what to invest in, what costs are relevant, and what the long-term direction of the company will be. Topics include the analysis of financial statements, the accounting equation and accounts, understanding cash flows and the cash flow statement, the nature of costs, and capital budgeting. 4 credits

MST 572 Financial Management for Science and Technology

This course offers a survey of financial management concepts intended to prepare you with a basic background of modern corporate finance, the decision-making process used by financial managers of large and growing corporations, and the analytical tools to measure achievement of financial and operational objectives that result from an integrated structural approach. Topics include a review of accounting statements and cash flows, value and capital budgeting, risk and the capital asset pricing model, capital structure, leverage, dividend policy, long-term debt financing, short-term financial planning, cash and credit management, performance management and economic value added. Special topics include mergers and acquisitions, defensive tactics, and financial distress. Prerequisite: MST 571. 4 credits

MST 573 Technology Marketing: Planning for Market

The course is designed to provide an advanced understanding of the marketing process for technology-based products and organizations, from opportunity identification to product introduction and market development. The course is articulated around three core areas: 1) how to create value for the customers, 2) how customers and value change along the technology adoption lifecycle, and 3) how to develop competitive advantage. Particular emphasis is placed on the front end of the marketing process: understanding what customers value and then developing strategies and offerings that capitalize on that knowledge. A wide range of topics is explored: how to identify value opportunities, how disruptive innovation becomes accepted by the market place, how values change along with time, how to segment and select markets, how to understand and outmaneuver competitors, how to develop a marketing strategy that creates strong competitive advantage, and last but not least, how to price products and go to market. 4 credits

MST 574 Going to Market: Delivering Value to Customers and Shareholders

The course provides an understanding of the tools, mechanics and management of operational marketing implementation processes in high-technology environments. Integrating lectures, class discussions, case studies, videos and individual papers and team projects, the course emphasizes developing the detailed implementation plan to bring products or services to market. The goal is to show how to turn strategy into practice by implementing the marketing plan begun in MST 573, developing the specifics of a product or service's business model and persuasively outlining the blueprint of the business case. The course drills down into the operational specifics of pricing, promotion, sales, advertising and customer relationship management, e-business and web marketing, supply chain and distribution logistics, channel alliance building and implementation standards, metrics and controls. This course complements and completes the marketing knowledge and expertise gained through MST 573, which is a prerequisite. 4 credits

MST 590 Effective Business Writing for Native Speakers

Tailored to meet the individual writing needs of management professionals, this course reviews and practices standard conventions in grammar and punctuation, and innovative stylistics using a highly interactive format. The course addresses both electronic (email) and traditional (letter, summary, report) managerial writing tasks with the goal of clearer, more concise business communication. This course is designed for native and bilingual speakers of English with native-level skill in written English. 1 credit

MST 591 Effective Business Writing for Non-native Speakers

Tailored to meet the individual writing needs of management professionals, this course reviews and practices the English grammar, punctuation, and stylistics that challenge the advanced-level non-native and bilingual speaker of English. Using a highly interactive format, this course addresses both electronic and traditional managerial writing tasks with the goal of clearer, more concise business communication. 1 credit

OREGON MASTER OF SOFTWARE ENGINEERING

OMSE 500 Principles of Software Engineering

I In this course you will study alternative software development models and processes. This course will cover the actual benefits of these models and processes as well as the problems that can arise. You will learn how to choose appropriate models for actual projects and then customize the processes to produce the best combination of control, quality, and rapid product development. You will also consider how software processes can be reviewed and improved on a continuous basis using improvement models such as the Software Engineering Institutes Software Capability

Maturity Model, their Integrated Maturity Model, and the ISO SPICE Model. 3 credits

OMSE 511 Managing Software Development

This course provides the knowledge and skills needed to plan, organize, lead and control software projects. Topics include planning and estimating, measuring and controlling, and achieving results in environments that include a great deal of ambiguity and contradictory information. Quantitative measures and risk management will be emphasized. Students will prepare project plans for real or hypothetical software projects; to include effort, cost and schedule estimates and risk management plans. Prerequisite: OMSE 500. 3 credits

OMSE 513 Professional Communication Skills for Software Engineers

This course examines the leadership skills that make all the difference when software is developed by a team. Using individual assignments and group projects, you will learn the skills you need to make effective presentations and write persuasive proposals. You will also learn the skills you need to (1) conduct efficient meetings (keep everyone focused), (2) resolve disputes (be a good listener), (3) work successfully in a team environment (suppress the urge to dominate), and (4) make ethical decisions when faced with conflicting goals (be true to personal values). Prerequisite: OMSE 500. 3 credits

OMSE 521 Using Metrics and Models to Support Quantitative Decision Making

This course will cover how metrics can be combined with formalized decision models to support decision-making by software project leaders and managers. It provides the knowledge and skills needed to apply quantitative tools to make decisions in situations where a great deal of uncertainty exists. You will learn to recognize decision-making opportunities in the software development process, and be equipped to address them in a scientific, organized manner using all appropriate information sources. Prerequisite: OMSE 500. 3 credits

OMSE 522 Modeling and Analysis of Software Systems

Abstract models are used to formalize specifications of software systems. Formalized reference specifications serve as a basis for the design of software implementations and for validating critical properties of software systems. This course provides the fundamental mathematical concepts needed to understand abstract models of software and to reason about them as well as examples of how they are applied. Prerequisite: OMSE 500. 3 credits

OMSE 525 Software Quality Analysis

This course covers processes, methods and techniques for developing quality software, for assessing software quality and for maintaining quality. Course material emphasizes the tradeoffs between software cost, schedule time and quality; the integration of quality into the software development process; formal review and inspection methods; principles of testing and test planning; module design for testability; and maintaining quality while supporting existing software. Prerequisite: OMSE 500. 3 credits

OMSE 531 Software Requirements Engineering

This course covers the principles, tools and techniques for requirements elicitation, specification and analysis. The focus is on understanding the role of requirements in system development and maintenance, goals of the requirements phase, essential difficulties of specifying requirements for real systems, and effective methods, tools and techniques. The course covers techniques for formally modeling and specifying software requirements with hands-on experience as well as the role of prototyping in validating requirements. Prerequisite: OMSE 500. 3 credits

OMSE 532 Software Architecture and Domain Analysis

This course covers the principles and methods of the architectural design of complex software systems. You will study the 1) major architectural styles, 2) strengths and weaknesses of each style, 3) application of domain analysis, 4) impact of platform dependence and independence, 5) relation of software architecture to requirements, 6) domain analysis and the architectural design process, and 7) products in a real-world context. Prerequisite: OMSE 500. 3 credits

OMSE 533 Software Design Techniques

This course covers the principles of software design and a survey of design methods, techniques and tools. In-depth and hands-on study of at least one method such as object-oriented design as applied to a realistic industrial problem. It examines the effects of design decisions on the functional and nonfunctional properties of the software (e.g., ease of understanding, maintainability, reuse) and how software engineering principles are applied to make appropriate trade-offs. Students also examine the design process and products in context, including the effect of design decisions on function, quality, cost and schedule. Prerequisite: OMSE 500. CSE students may not receive credit for both CS 519/619 and OMSE 533 because there is significant overlap in content. 3 credits

OMSE 535 Software Implementation and Testing

Covers implementation and testing topics including 1) coding techniques and styles, 2) module packaging principles, 3) creating testable and maintainable code, 4) code reviews and inspections, 5) specification-based (black-box) testing and structural (clear box) testing and 6) test planning test tools, and test administration. 3 credits

OMSE 551 Strategic Software Engineering

This course introduces the principles, methods, and tools for strategic software development. The tools include (1) long-term process modeling and improvement, (2) developing programs as families of systems, (3) systematic approaches to code generation, and (4) the reuse of non-code products including requirements and design. Prerequisite: OMSE 500. 3 credits

OMSE 555 and OMSE 556 Software Development Practicum I and II

The Development Practicum provides an opportunity for students to apply the knowledge and skills gained in other courses as they synthesize a solution to a significant, realistic, and practical problem. Students work to analyze a problem, develop a software concept, plan a software development effort, define requirements, and implement a solution. Students will work closely with OMSE program faculty and, where possible, reviewers from industry to apply advanced software engineering techniques to a disciplined development of a realistic product and evaluate the results. 3 credits each