CSS630 Student vision for an integrated PGBP graduate program

Proposal for the Initiation of a New Instructional Program Leading to a Graduate Degree in Plant Genetics, Breeding and Physiology (PGBP)

Description of Proposed Program

1. ***Program Overview - Provide a brief overview (approximately 1-2 paragraphs) of the proposed program, including a description of the academic area and rationale for offering this program at the present time. Please include a description of any related degrees, certificates, or subspecialties (concentrations, areas of special emphasis, etc.) that may be offered now or in the foreseeable future.***

Plant genetics, breeding, and physiology are all essential components of plant sciences. Although they are often considered separate disciplines, they are naturally related. Plant genetics enables us to look at genome evolution and architecture, as well as the discovery of gene products in pathways. Plant breeding is the search for improved crop varieties to meet the needs of the growing global population. Plant physiology looks for understanding of pathways, both at the plant and crop community levels, and interactions affecting development. Integrating the three disciplines into one program would create a fundamental knowledge base to better address science and society needs in plant genetics, breeding, and physiology.

We propose an interdepartmental graduate program in Plant Genetics, Breeding, and Physiology (PGBP) offering M.S. and Ph.D. degrees to be available at Oregon State University. Central to the mission of Oregon State University, the philosophy embraced by this integrated program encourages the development of a strong technical knowledge base, application of learning, and professional development. It is essential for us to foster the academic needs of the future scientists in plant genetics, breeding, and physiology to the greatest extent. The strong academic departments of Crop & Soil Science, Forest Science, Horticulture and Botany & Plant Pathology and the Molecular & Cellular Biology Program are available as resources for students in the PGBP major. Our goal is to integrate these disciplines and give our students the best opportunity to use and understand both traditional and novel tools and techniques that are part of the plant science frontiers. The PGBP program will enable students to develop breadth of knowledge through a set of core courses in plant genetics, breeding, and physiology, and depth of knowledge in a specific academic area through completion of focused course work in plant genetics, breeding or physiology.

The distinctive PGBP program at Oregon State University offers students a unique experience enabling them to explore, integrate and contribute to the frontiers in plant sciences. Students will leave the program with a strong academic background and the experiences necessary to compete in the job market as productive scientists. Upon completing their PGBP degrees, graduates may find careers in international, federal, state, or local agencies, as well as opportunities in universities, institutes and corporations in the private sector.

2. *Purpose and Relationship of Proposed Program to the Institution's Mission and Strategic Plan*

a. What are the objectives of the program?

The Plant Genetics, Breeding, and Physiology program objectives will meet the following goals:

Goal 1. Provide an enhanced plant genetics, breeding, and physiology program through the integration of OSU plant science faculty and resource strengths. The implementation of a PGBP program at OSU supports the Strategic Plan Goal 1: *to provide outstanding academic programs that further strengthen our performance and pre-eminence in the five thematic areas.* This will be accomplished with the following:

a. A ***core curriculum of PGBP courses*** will provide a solid knowledge foundation from a combination of core courses and the creation of an integrated capstone course. This will facilitate the development of a cohort of PGBP graduate students.
b. A ***PGBP Seminar Series*** will provide a platform for highly recognized international, national and OSU scholars to present research and interact with faculty, students, and staff.
c. ***Practical Modules*** will teach students the tools and techniques for research.
d. ***Professional Development Modules*** will enable students to develop essential skills for giving oral presentations and preparing posters, writing grants and scientific publications, exploring ethical issues, and discovering career options.

Goal 2. Attract promising graduate students and encourage them in becoming elite scientists in the fields of plant genetics, breeding, and physiology. It is the intent of the PGBP program to attain top students from national and international programs. This goal fulfills the OSU Strategic Plan Goal 2: *to provide an excellent teaching and learning environment and achieve student access, persistence and success through graduation and beyond that matches the best land grant universities in the country.* Strategies to achieve this goal include:

a. ***Competitive Travel Grants*** will be available to students for presenting research findings at national and international meetings, conferences, seminars and training fellowships.
b. A ***Program Website*** offering current and prospective students necessary information about the PGBP program, current faculty, and research projects.
c. ***Collaboration Resources*** from adjunct international, federal, state, community, and university programs will create a network of research opportunities for scholars.

Goal 3. Enhance funding potential from extramural sources. This goal aligns with OSU Strategic Plan Goal 3: *to substantially increase revenues from private fundraising, partnerships, research grants, and technology transfers while strengthening our ability to more effectively invest and allocate resources.* The creation of unique multidisciplinary research proposals from the PGBP program will attract external funding and provide additional opportunities to increase revenues.

b. How does the proposed program meet the needs of Oregon and enhance the state's capacity to respond effectively to social, economic, and environmental challenges and opportunities?

Oregon's higher education institutions are economic engines preparing students for highly demanding fields such as agriculture, forestry, information technology, engineering and education. The PGBP program, with diverse talents and skills, will provide excellent education and training opportunities for the global community and fuel Oregon's strong agriculture and natural resource economy.

The PGBP program will strengthen Oregon's position as one of the centers of growth and diversity in agriculture and natural resources. It will also maximize the competitiveness of our existing agricultural industries by creating more productive cultivars and applying the most advanced technologies available.

The PGBP program will benefit the state of Oregon by aiding in the growth and development of clean energy sources, biotechnology, and value-added agriculture. In addition, this program will support the natural resources and agriculture that make Oregon a great place to live and work.

3. Course of Study

a. Briefly describe proposed curriculum.

The PGBP program will consist of three core courses, one for each of the disciplines included in the PGBP program: plant genetics, breeding, and physiology. These courses will focus on bringing all entering students up to the same level in each of these subject areas. These will be 3 credit courses, one taught per term.

In addition there will be two 3 credit capstone courses integrating the three disciplines of plant genetics, breeding, and physiology. These courses will build on the material learned in the core courses and focus on how these disciplines are interconnected. The Capstone I course will be theory based and Capstone II will be a group project. There will be a two term seminar series; students are required to attend all seminars and will present at least one non-thesis seminar.

Students will have the opportunity to tailor their course work to meet their personal learning objectives through relevant elective courses and modules. MS students are required to take a minimum of three credits of elective courses and one module, but are not required to select an area of emphasis. The graduate school requires 45 credits for a MS degree, a minimum of 20 credits must be from the PGBP program. PhD students will be required to select an area of emphasis and take six credits of elective courses within

this specified area. They are also required to take two modules. Tutorships are highly recommended. The graduate school requires 108 credits for a PhD degree, a minimum of 24 credits must be from the PGBP program (for structural details of the PGBP program see Appendix I & II).

Core Courses (3 credits)

PLANT GENETICS - Concepts of plant transmission, molecular, and quantitative genetics. Case studies such as - apomixis, self-incompatibility, polyploidy, sex-determination, heterosis, and physiological traits – will be used to demonstrate genetic principles.

PLANT BREEDING - Concepts of centers of origin and diversity, reproduction in plants, heritability, inbreeding and heterosis. Genetic improvement of self-pollinated crops, cross-pollinated crops and asexually reproducing species. Additional topics include an introduction to the statistics principles on which breeding methods are based, breeding for resistance, variety development and release, and biotechnology principles.

PLANT PHYSIOLOGY – Topic covered include plant structure and development, photosynthesis, respiration, water relations, transpiration, gas exchange, plant nutrition and solute transport, and metabolism (protein, lipids and carbohydrates).

Capstone Courses (3 credits)

CAPSTONE I – This course will be theory based, integrating the concepts of genome evolution, gene expression and signal transduction, signaling pathways, developmental regulation and crop improvement.

CAPSTONE II – Students will have course projects that involve aspects of all three PGBP disciplines. This will provide an opportunity to work in integrated groups and develop presentation skills that will prepare them for the competitive job market.

Elective Courses (3 credits)

Genetics

ADVANCED PLANT GENETICS - Concepts include those from the core course and also genetic variation; population and evolutionary genetics; quantitative genetics; and bioinformatics.

EUKARYOTIC GENETICS - Concepts of molecular genetics with an emphasis on gene structure and expression. Topics will include recombinant DNA techniques; eukaryotic gene structure; transcription, translation, and post-translational modifications; genome evolution, and genetic engineering.

PLANT CHROMOSOME BIOLOGY - Exploration of the relationship between chromosome number, structure, and behavior to gene inheritance, organization, and expression. Discussion of chromosome manipulation strategies for genomics research, genetic analysis, and plant breeding.

POPULATION AND EVOLUTIONARY GENETICS - Genetic polymorphisms, inbreeding, genetic drift, population subdivision and gene flow, mutation and selection. Population genomics.
CHLOROPLAST AND MITOCHONDRIAL GENETICS - Structure, expression, and interactions of the plant nuclear, chloroplast and mitochondrial genomes. Critical examination of the current literature on gene regulation, mobile genetic elements and biotechnology in higher plants.
BIOINFORMATICS - Key ideas from the genomics and bioinformatics revolution. Current topics in molecular phylogeny and comparative genomics are covered, including the identification of gene super families, early cellular evolution, environmental genomics, and enzyme evolution.
GENETIC ENGINEERING AND ETHICS - Lectures and class-led discussions dealing with transformation, cloning, and ethics of genetic engineering related to plant breeding.
FOREST TREE GENETIC - Genetic and improvement of forest trees: population structure, selection methods, and basic tools for breeding.
PLANT TISSUE CULTURE – Principles, methods and applications of plant tissue culture. Theory based course touching on the topics of callus culture, somaclonal variation, micropropagation, anther culture, somatic hybridization, and transformation.

Breeding
ADVANCED PLANT BREEDING - Pedigree, bulk, single-seed descent, doubled haploid, backcross, testcross, mass, and half-sib, S1, and S2 family breeding methods; breeding hybrids and selecting sources of alleles for developing superior hybrids; the nature and consequences of genotype by environment interactions; marker-assisted backcross and inbred line breeding; quantitative trait locus mapping; random linear models; designing and analyzing cultivar, line, and family selection experiments.
BREEDING FOR RESISTANCE - Principles and practices of breeding for insects, diseases and environmental stress resistance. Concepts are illustrated using Pacific Northwest crops.
PLANT EVOLUTION, GENE CONSERVATION, AND GERMPLASM RESOURCES - Centers of diversity, geographic patterns of genetic variation, measures of genetic diversity, gene conservation methods and programs.
VARIETY DEVELOPMENT AND RELEASE - An introduction to principles and practices of seed-based genetic delivery systems. Systems required to produce high quality seed, marketing, PVP, interaction with growers and industry.
BIOMETRIC PROCEDURES IN PLANT BREEDING - Analysis, interpretation and application of experimental designs used in plant breeding. Recitation provides experience with widely used statistical software programs.
CURRENT TOPICS IN PLANT BREEDING - Reading and discussion of literature relevant to current and timely topics in applied plant breeding.
CROP BREEDING TECHNIQUES - Hands-on field class involving crossing-block development, crossing techniques, breeding trials

Physiology
ADVANCED PLANT PHYSIOLOGY - Roles of hormones, inhibitors,

phytochrome, and circadian rhythms in the regulation of growth and development of seed plants. The biochemistry of growth substances and phytochrome; effects of physical environment upon specific growth and developmental events and the salient biochemical changes correlated with those events.
CROP PHYSIOLOGY- Plant population, management practices, nutrient management, irrigation
PHLOEM TRANSPORT- Phloem transport, sink-source relations.
STRESS PHYSIOLOGY- High and low temperatures, drought, water excess, anoxia, salinity stress as they relate to photosynthesis, water relations and gas exchange.
PLANT STRESS AND CROP YIELD - High and low temperatures, drought, water excess, anoxia, salinity stress as they relate to plant growth and crop yield.
SEED BIOLOGY - Embryogenesis, dormancy and seed germination.
PHYSIOLOGY OF WOODY PLANTS -The structure, growth and physiological processes of trees and shrubs.
ADVANCED PLANT NUTRITION - Factors influencing nutrient absorption and plant composition with an emphasis on plant physiology and soil chemistry. Diagnostic approaches to determining nutritional status are discussed in detail. Current efforts to enhance nutritional efficiency are explained.
PLANT AUTECOLOGY - The nature of the environment and plant responses to major environmental factors; physiological plant ecology. Field trip.
PHOTOSYNTHESIS AND PLANT BIOCHEMISTRY - Biochemical processes relevant to plants with particular emphasis on photosynthesis and carbon and nitrogen metabolism.
PLANT WATER RELATIONS - Factors and mechanisms affecting water use by terrestrial plants. Effects of water deficits. Measurement methods and their interpretation.

Modules (1 credit)

Concepts and Theory Modules
ADVANCED BIOINFORMATICS
DEVELOPMENTAL GENETICS
GENE CONSERVATION
PLANT REPRODUCTION
POLYPLOIDY
GENETIC VARIATION IN NATURAL POPULATIONS
PLANT INTRODUCTIONS
HYBRIDIZATION
GENETIC FIELD TESTS
FLOWERING INDUCTION
ADVANCED SIGNAL TRANSDUCTION
PLANT DEFENSE
TROPISMS
CURRENT TOPICS IN PLANT PHYSIOLOGY

Hands-on Modules
BIOINFORMATICS

PHYLOGENY
MOLECULAR MARKERS
DNA FINGERPRINTING
PLANT TISSUE CULTURE
PLANT GENETIC ENGINEERING
VARIETY TRIAL RATING
ASEXUAL REPRODUCTION IN PLANTS
PRACTICAL STRESS PHYSIOLOGY

Professional Development Modules
ORAL AND POSTER PRESENTATIONS
WRITING GRANTS AND SCIENTIFIC PUBLICATIONS
EXPLORING ETHICAL ISSUES
DISCOVERING CAREER OPPORTUNITIES
REGULATIONS AWARENESS
BUDGET AND FINANCIAL PLANNING

b. Provide a discussion of any nontraditional learning modes to be utilized in the new courses, including, but not limited to: (1) the role of technology and (2) the use of career development activities such as practica or internships.

The PGBP program will create innovative and enhance existing resources by implementing new teaching methods that exploit the existing knowledge of OSU faculty. We will also provide opportunities for graduate students, such as competitive awards to visit domestic and international research programs. By involving a wide range of departments, we are creating an interdisciplinary curriculum, which will utilize faculty and resources across campus. The PGBP program will increase opportunities for collaboration within OSU and beyond by providing environments conducive to communication and networking. We will include non-traditional learning modes such as:

- **Modules**- three week courses that will focus on topics not needing a full 10-week course. Modules will cover a range of topics from broad to specific and from theory to practical.
- **Tutorships**- two to three week programs where students are paired up with specialists within Corvallis. This is similar to job shadowing. The intent of these programs is to expose students to different research programs and work environments. For example, students with field based thesis research will be encouraged to take tutorships in a lab environment and vice versa.
- **Exchange programs**- students will have the opportunity to visit other institutions within academia and industry, both domestic and international.
- **Field trip courses**- students will take field trips to regional experiment stations, universities, and industry groups to gain a better understanding of the range of applications of their academic knowledge.
- **Professional development**- courses will be available for topics such as preparing and giving seminars, writing grant proposals, and writing for peer reviewed publications.

c. What specific learning outcomes will be achieved by students who complete this course of study?

Students in the Plant Genetics, Breeding and Physiology program will:

- Increase breadth of knowledge in plant genetics, breeding, and physiology; and a depth of knowledge in a focused area of plant sciences.
- Cultivate collaborative experiences with adjunct facilities on campus.
- Prepare for the workforce though real-life practice and performance experiences.
- Incorporate traditional and novel tools in plant science disciplines.
- Develop a supportive resource network among the graduate students, faculty, and staff of numerous departments and disciplines.

4. Recruitment and Admission Requirements

a. Is the proposed program intended primarily to provide another program option to students who are already being attracted to the institution, or is it anticipated that the proposed program will draw students who would not otherwise come to the institution.

The PGBP program will be a new program that strives to bring together people and resources across OSU to provide a structured degree program for plant genetics, breeding and physiology. This will attract students, not otherwise interested in OSU, that are interested in a multi-disciplinary approach to plant sciences. Students currently enrolled in some of the participating departments may also be attracted to the PGBP program.

b. Will any enrollment limitation be imposed? If so, please indicate the specific limitation and its rationale. How will students be selected if there are enrollment limitations?

Priority will be for fall only enrollment in order to coincide with the structure of the program's core and capstone courses. Admission will be throughout the year.

5. Evidence of Need

a. What evidence does the institution have of need of the program? Please be explicit. (Needs assessment information may be presented in the form of survey data; summaries of focus groups or interviews; documented requests for the program from students, faculty, external constituents, etc.)

Oregon State University is unique in having such a great number of faculty active in plant genetics, breeding and physiology research in a diverse range of plants, ranging from annual agronomic crops to perennial trees. Faculty members in these disciplines are represented in the Colleges of Agriculture, Science, and Forestry, as well as the USDA-Forest Service and -Agricultural Research Service. Although the disciplines of plant genetics, breeding and physiology are considered separate entities, recent developments in genomics and evolving national needs make it critical to bring them together and recognize their natural association.

Erosion in the number of plant physiology faculty has led to a recommendation to discontinue the Plant Physiology Program. Plant genetics and breeding faculty are dispersed in the Botany and Plant Pathology, Crop and Soil Science, Forest Science, Horticulture Departments, Molecular and Cellular Biology Program, and Federal agencies. To maximize effectiveness and impact, the PGBP program at OSU needs to transcend departmental boundaries and integrate disciplines. The current departmental structure is mostly species/crop/commodity-based, whereas our proposed model is concept-based. Our program will attract high caliber graduate students by increasing the quality of curriculum and student mentoring, enhancing genomics at OSU through the melding of plant genetics and plant physiology, and recruiting and retaining outstanding faculty.

b. Are there any other compelling reasons for offering the program?

Although some universities incorporate plant breeding with genetics, or plant physiology with genetics, most domestic or international universities do not integrate plant genetics, breeding and physiology (Appendix III provides a preliminary survey of international and domestic plant science programs). Integrating these disciplines at OSU will not only provide an excellent opportunity for graduate students to gain professional training in the three areas of study, but will increase the competitiveness of OSU as a leader in plant science research in the United States and around the world.

This new program will attract highly competitive scholars who demonstrate the potential for great academic success. While our primary focus will be at the academic level, we will also have an emphasis in the diffusion of knowledge to growers, biotechnology companies, high school scholars and the general public. This will strengthen our position as a leading land grant university, promoting OSU into the top ten institutions in plant science.

Integration of Efforts

6. Similar Programs in the State

a. List all other closely related OUS programs.

There are no other OUS graduate programs that are directly related to what the PGBP program will provide. The PGBP program will complement the education provided by other OUS undergraduate programs. Students with a Bachelor in Crop and Soil Science (Eastern Oregon University), or a Bachelor in Biology (Portland State University, University of Oregon, Southern Oregon University, and Western Oregon University) are encouraged to join our program.

Resources

7. Faculty

a. Identify program faculty, briefly describing each faculty member's expertise/specialization. Separate regular core faculty from faculty from other

departments and adjuncts. Collect current vitae for all faculty, to be made available to reviewers upon request.

Kevin Gene Ahern. Senior Instructor. Department of Biochemistry and Biophysics. http://oregonstate.edu/dept/biochem/faculty/faculty.html

Sonia R. Anderson. Professor. Department of Biochemistry and Biophysics. Characterization of proteins, protein-protein interactions, fluorescence. http://oregonstate.edu/dept/biochem/faculty/anderson.html

Michael Blouin. Associate Professor. Zoology Department. Molecular studies of kinship, gene flow, and population subdivision; evolution of life history and morphometric traits; various taxa. http://oregonstate.edu/~blouinm/index.htm

Barbara J. Bond. Professor. Department of Forest Science. Forest Tree Physiology. http://www.cof.orst.edu/cof/fs/

Tom G. Chastain. Associate Professor. Department of Crop and Soil Science. Crop physiology of grass seed crops. http://cropandsoil.oregonstate.edu/people/faculty.php?ID=2

Tony H.H. Chen. Professor. Department of Horticulture. Biotechnology, Stress and post harvest physiology. http://oregonstate.edu/dept/hort/faculty/ChenNewFormat.htm

Neil W. Christensen. Professor. Department of Crop and Soil Science. Soil Fertility, Plant Nutrition. http://cropandsoil.oregonstate.edu/people/faculty.php?ID=29

Sabry Elias. Assistant Professor (Sr. Res). Department of Crop and Soil Science. OSU Seed Laboratory.

John Fowler. Assistant Professor. Botany and Plant Pathology. Plant cell biology and development. http://www.bcc.orst.edu/bpp/faculty/fowler/index.html

Lisa M. Ganio. Assistant Professor. Department of Forest Science. Statistics, Biometrics, Study Design. http://www.cof.orst.edu/cof/fs/

Stephen Giovannoni. Professor. Director Molecular and Cellular Biology Program. Microbiology. Molecular Evolution, Ribosomal RNA, Microbial Ecology. http://www.cgrb.oregonstate.edu/mcb/faculty/giovannoni/index.html

Everett M. Hansen. Professor. Department of Forest Science. Forest pathology, the biology and management of forest tree diseases; diseases of trees in nurseries; population biology of forest fungi. http://www.cof.orst.edu/cof/fs/

Patrick M. Hayes. Professor/Associate Head. Department of Crop and Soil Science. Barley breeding and products. Development of winter and spring habit malting and feed quality cultivars, molecular marker map construction and selection; doubled haploid production; genetic diversity; genetics of cold tolerance; cooperative technology transfer projects in applied molecular biology. http://cropandsoil.oregonstate.edu/people/faculty/Hayes.htm

Glenn T. Howe. Assistant Professor. Forest Genetics. Department of Forest Science. Physiological, ecological, and molecular genetics of forest trees, gene conservation, tree improvement. http://www.cof.orst.edu/cof/fs/

Victor L. Hsu. Professor. Department of Biochemistry and Biophysics. NMR spectroscopy, DNA structures and binding proteins. http://oregonstate.edu/dept/biochem/faculty/hsu.html

P. Andrew Karplus. Professor. Department of Biochemistry and Biophysics. Protein structure-function relations, protein crystallography, flavoenzymes, enzyme catalysis. http://oregonstate.edu/dept/biochem/faculty/karplus.html

Jennifer G. Kling. Professor/Senior Research. Department of Crop and Soil Science. Plant Breeding and Genetics (maize and barley). International Agriculture. http://cropandsoil.oregonstate.edu/people/faculty.php?ID=14

Carol A. Mallory-Smith. Professor. Department of Crop and Soil Science, and Department of Horticulture. Weed science. http://cropandsoil.oregonstate.edu/people/faculty.php?ID=16

Shawn A. Mehlenbacher. Professor. Department of Horticulture. Nut and tree fruit breeding and genetics http://oregonstate.edu/dept/hort/faculty/MehlenbacherNewFormat.htm

Gary F. Merrill. Professor. Department of Biochemistry and Biophysics. Thioredoxin, redox control of transcription, p53 regulation, cell cycle control, deoxynucleotide synthesis, yeast and mammalian systems. http://oregonstate.edu/dept/biochem/faculty/merrill.html

David W. S. Mok. Professor. Department of Horticulture. Genetics, Cytokinins, Interspecific gene transfer of legumes. http://www.cgrb.orst.edu/mcb/faculty/mokd/index.html

George D. Pearson. Professor. Department of Biochemistry and Biophysics. Viral DNA replication, genetics, recombination, sequence conversion. http://oregonstate.edu/dept/biochem/faculty/pearson.html

Indira Rajagopal. Instructor. Department of Biochemistry and Biophysics.

Oscar Riera-Lizarazu. Assistant Professor. Department of Crop and Soil Science. Cereal genetics and cytogenetics. http://cropandsoil.oregonstate.edu/people/faculty.php?ID=20

Carol J. Rivin. Associate Professor, Botany and Plant Pathology. Molecular genetics of maize; genetic programs controlling plant development; regulation of gene expression during embryogenesis. http://www.bcc.orst.edu/bpp/faculty/rivin/index.html

Michael M. Schimerlik. Professor. Department of Biochemistry and Biophysics. Enzyme kinetics and mechanisms, signal transduction, and protein folding. http://oregonstate.edu/dept/biochem/faculty/schimerlik.html

William E. Winner. Professor. Botany and Plant Pathology Department. Analysis of plant-environment relationships; responses of plants to environmental stresses. http://www.bcc.orst.edu/bpp/faculty/winner/index.html

Thomas J. Wolpert. Professor. Botany and Plant Pathology. Biochemistry and molecular biology of host-parasite interactions. http://www.bcc.orst.edu/bpp/faculty/wolpert/index.html

8. Facilities, Equipment, and Technology

a. What resources for facilities, equipment, and technology, beyond those now on hand, are necessary to offer this program? Be specific. How does the institution propose that these additional resources will provided?

To successfully implement the PGBP program the following resources will be needed: a central office with PGBP-dedicated staff and increased communication and cooperation between academia, federal, state, private, domestic and international groups. The central office may initially be funded through extramural funds such as teaching or program development grants.

Appendix I. Outline of MS PGBP program

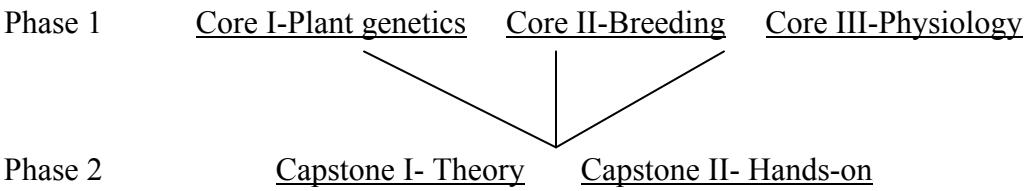

Table for MS students

PGBP COURSE	***OTHER COURSES***	***TOTAL CREDITS***	***TERM (example 2004-2006)***
Phase 1: Core I	Elective	9	Fall 2004
Phase 1: Core II	Elective	9	Winter 2005
Phase 1: Core III	Elective, module	7	Spring 2005
Phase 2: Capstone I	Seminar/module, elective	7	Fall 2005
Phase 2: Capstone II	Seminar/module, elective	7	Winter 2006
	Total Credits:	33 non-thesis	

Phase 1

Phase 1 will consist of three courses; one for each of the disciplines included in the PGBP program: plant genetics, breeding, and physiology. These courses will focus on bringing all entering students up to the same level in each of these subject areas. These courses will focus on the graduate-level topics related to plant science within the three disciplines. These courses take into account that students come from differing academic backgrounds. Phase 1 courses will be at an advanced level and assume that students already have a basic knowledge of biology. These will be 10-week courses. Only one course will be taught per term. For example, plant genetics in the Fall term, breeding in the Winter term, and physiology in the Spring term. This will allow students to also take supporting courses such as statistics, biochemistry, etc.

MS students will not be required to select an area of emphasis. During Phase 1 they will take either electives or modules in addition to the Core courses.

Phase 2

There will be two courses that focus on integrating the three disciplines of plant genetics, breeding, and physiology. These courses will build on the material learned in the Phase 1 Core courses and aim to teach students how these disciplines are interconnected. The Capstone I course will be more theory based material. The Capstone II course will be the hands-on group project. This course will also allow students the opportunity to develop group work and presentation skills that will prepare and make them more competitive in the job market. Students will have course projects that involve aspects of all three disciplines (design and management of a research program with specific objectives). These will be 10-week courses. Only one course will

be taught per term (Capstone I in the Fall and Capstone II in the Winter). The theory based course will come before the hands-on course to give students the necessary background to complete the projects.

Phase 2 will also include the seminar series. There will be two terms of seminar: Fall and Winter. This will leave Spring term open for projects with field research. Students will be required to attend all seminars, but will only present in one term. Students will only sign up for credit during the term they present. Students can choose which term to present, but MS students will be given priority for Fall term.

Students will have the opportunity to tailor their course work to meet their personal learning objectives through relevant elective courses and modules. For each of the two types of courses (elective and module) a list will be available that students will select from. MS students will be required to take a minimum of three credits of elective courses and one module.

Appendix II. Outline of PhD PGBP program

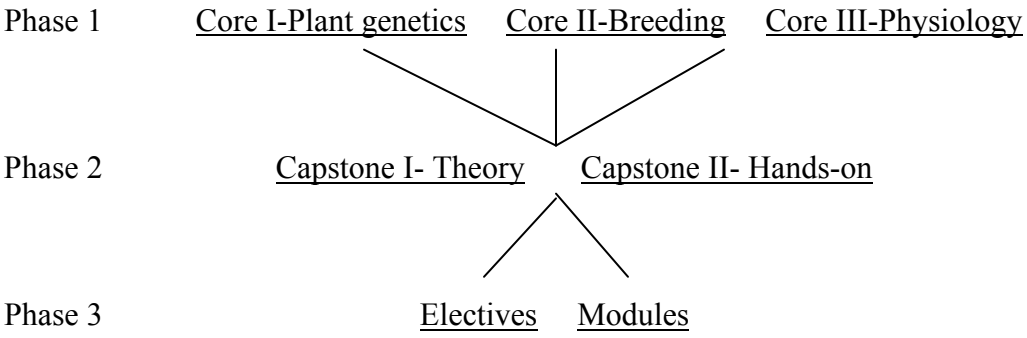

Table for PhD students

PGBP COURSE	***OTHER COURSES***	***TOTAL CREDITS***	***TERM (example 2004-2007)***
Phase 1: Core I	Electives	10	Fall 2004
Phase 1: Core II	Electives	10	Winter 2005
Phase 1: Core III	Module and elective	7	Spring 2005
Phase 2: Capstone I	Seminar/module, elective	7	Fall 2005
Phase 2: Capstone II	Seminar/module, elective	7	Winter 2006
Phase 3:	Elective or modules	3-7	Spring 2006
Phase 3:	Elective or modules	3-7	Fall 2006
Phase 3:	Elective or modules	3-7	Winter 2007
	Total Credits:	Minimum 36 non-thesis	

PhD PGBP Outline

Phase 1

Phase 1 will consist of three courses; one for each of the disciplines included in the PGBP program: plant genetics, breeding, and physiology. These courses will focus on bringing all entering students up to the same level in each of these subject areas. These courses will focus on the graduate-level topics related to plant science within the three disciplines. These courses take into account that students come from differing academic backgrounds. Phase 1 courses will be at an advanced level and assume that students already have a basic knowledge of biology. These will be 10-week courses. Only one course will be taught per term. For example, plant genetics in the Fall term, breeding in the Winter term, and physiology in the Spring term. This will allow students to also take supporting courses such as statistics, biochemistry, etc.

PhD students will select an area of emphasis and begin taking the appropriate electives, as well as the Core courses.

Phase 2

There will be two courses that focus on integrating the three disciplines of plant genetics, breeding, and physiology. These courses will build on the material learned in

the Phase 1 Core courses and aim to teach students how these disciplines are interconnected. The Capstone I course will be more theory based material. The Capstone II course will be the hands-on group project. This course will also allow students the opportunity to develop group work and presentation skills that will prepare and make them more competitive in the job market. Students will have course projects that involve aspects of all three disciplines (design and management of a research program with specific objectives). These will be 10-week courses. Only one course will be taught per term (Capstone I in the Fall and Capstone II in the Winter). The theory based course will come before the hands-on course to give students the necessary background to complete the projects.

Phase 2 will also include the seminar series. There will be two terms of seminar: Fall and Winter. This will leave Spring term open for projects with field research. Students will be required to attend all seminars, but will only present in one term. Students will only sign up for credit during the term they present. Students can choose which term to present, but MS students will be given priority for Fall term.

Tutorships will be highly recommended in Phase 2. PhD students will be recommended to take one tutorship. Tutorships can be taken year-round and when academic credit is awarded is flexible.

Phase 3

Phase 3 will overlap with Phases 1 and 2. Students will have the opportunity to tailor their course work to meet their personal learning objectives through relevant elective courses and modules. For each of the two types of courses (elective and module) a list will be available that students will select from. PhD students will be required to take six credits of elective courses within their area of emphasis and two modules.

Appendix III. Preliminary Survey of International and Domestic Plant Science Programs

Table 1. Countries that provide integrated plant genetics, breeding and physiology:

Plant breeding and physiology	Plant breeding and genetics
Aristotle University of Thessaloniki, Greece	G.B. Pant University of agricultural and technology, India
Hebei Agricultural University,China	

Table 2. States that provide integrated plant genetics, breeding and physiology:

Plant physiology and genetics	Plant breeding and genetics	Plant breeding genetics and molecular physiology
University of Tennessee, Knoxville	University of Wisconsin – Madison	University of Nebraska Lincoln
	Michigan State University, East Lansing	
	Ohio State University, Columbus	
	University of Illinois at Urbana – Champaign	
	Colorado State University, Fort Collins*	

*also integrated with Genomics, Biotechnology