BIOL 862.3.02
ADVANCED REPRODUCTIVE BIOLOGY OF SEED PLANTS
(TERM 2 OF 2017-18)

INSTRUCTORS: PROFS. ART DAVIS (COORDINATOR) AND J. HUGO COTA-SÁNCHEZ

COURSE DESCRIPTION: A survey of floral diversity, pollination mechanisms, and major breeding systems and reproductive strategies of seed plants, with emphasis on the angiosperms. One important component of this course is the examination of floral biology for reproductive success. With increasing emphasis on crop/seed yields, seed germination, and seedling establishment / recruitment, this course is potentially highly relevant for any graduate student working in the broad realm of reproductive biology of plants. Students from other botanically-related areas (e.g., palaebotany; plant systematics; plant development) may also benefit from this course.

COURSE OBJECTIVES: The aims of this course are to prepare well-rounded students with an excellent knowledge of various aspects of plant reproductive biology, and specifically include:
- To broaden and deepen the student's general knowledge and understanding of floral biology and evolution in relation to plant reproductive systems and strategies, and systems of plant-animal interactions.
- To develop the capacity to conduct meaningful holistic research in laboratory and outdoor settings, and to recognize and provide solutions to significant problems related to floral morphology, pollinators, and successful reproduction.
- To introduce students to experimental laboratory, greenhouse, and field techniques to analyse different aspects of plant reproduction e.g., pollination, pollen viability, pollen-ovule ratios, pollination syndromes.

COURSE PREREQUISITES: BIOL 323.3 (*Plant Systematics and Evolution*) or BIOL 326.3 (*Plant Development*) or equivalent, or instructor's permission. Strong knowledge in concepts of plant biology, floral morphology and development, evolution, genetics, and molecular biology and plant genomes, would be an asset.

WEEKLY LECTURES / GROUP DISCUSSIONS: Fridays (11:00am – 1:00pm) in Biology Rm 149.

MAXIMUM NUMBER OF STUDENTS: 10

REQUIRED COURSE WORK: In addition to attending lectures and participating in group discussions, each student will be required to complete the following activities:
- Lead the discussion of two research papers during the term.
- Conduct a research project based on literature searches on a topic approved by the instructors. This project includes a written term paper, plus an in-class oral presentation of that paper's topic, near the end of the course.

GRADING SYSTEM: **No exams will be given**. The course work and hands-on weekly assignments, class participation, and student research project will be used to evaluate student performance. The proposed assignments and evaluation components are comprehensive and rigorous and will provide students with tools to use, visualize, enhance, and synthesize research information and datasets more effectively in the laboratory and daily academic environment.

The mark breakdown is as follows:

Course components	Percentage of course grade	Deadlines
Leading discussion of research papers	30	Dates on individual basis
Class attendance; participation in discussions	25	Weekly sessions
Oral presentation of term paper's findings	15	Thurs. April 5 (to be confirmed) & Fri. April 6
Written research term paper	30	Monday, April 9, 2018

EXPLANATION OF MARK ALLOCATION AND EXPECTATIONS FOR COURSE COMPONENTS:

Leading Discussion of Research Papers: During the term, each student will present and lead the critical discussion of a total of two research papers. These articles for discussion to be led by individual students will be assigned near the end of the preceding week's session, so that presenters have a week to prepare. A video projector is available for leading article discussions, as required. Two presentations, each worth 15 marks, will yield 30% of the final course grade.

Participation and Discussion: Class attendance is extremely important. It is expected that students will attend all lecture sessions because much of the material will be presented in a planned sequence while working through examples in the research papers. Students are responsible for all material covered in lectures, whether or not it is also posted online. Students are expected to come prepared to participate in the class discussions based on reading material provided by the instructor at least one week in advance. Individual, active participation and engaging, fruitful discussion is expected for the research papers that you do not lead.
Note: Students who are going to be absent from a class are encouraged to contact the instructor to explain their absence.

Written Research Term Paper: This component entails an exhaustive investigation on a topic unconnected to a student's ongoing thesis research project. This will be a topic agreed upon by each student and the course instructors during the second week of the term. The purpose of this written project is that each student develops an in-depth understanding of a particular area dealing with the reproductive biology of plants. It is expected that the student conducts an extensive literature search and compiles, in the standard research-article format, a written term paper with relevant information pertaining to the approved/assigned subject.

In general, the outcome of this assignment will be writing up a review in the form of a short research paper (maximum 15 double-spaced pages including any figures and tables, plus literature cited). This review will include a brief introduction (maximum 2 pages) outlining the biological research question(s) or objectives being addressed. A discussion of compiled

information/data, analytical methods (if any), and conclusion(s), are required. This completed term research paper is **due for submission on Monday, April 9, 2018**, but students will be required to submit a preliminary structural draft of their term paper on **Monday, February 26, 2018**, to comprehensively outline the structure of the manuscript for the instructors. This process will allow the instructors to provide feedback at an intermediate stage, about the organization, content, and effective use of the information.

The following aspects will be considered in the evaluation of the submitted term paper:
• Style, clarify, and quality of scientific writing and ability to capture the reader's interest.
• A clear description of the problem being investigated / reviewed.
• Thoroughness of the literature review, exploration of the topic, and analytical methods used.
• Interpretation of the data gathered from the literature.
• The strength of the discussion should be a critical and clear description of the problem being investigated / reviewed.

There is a course policy for assignments received after the due date. A late assignment will have a 5% deduction to the mark per 24-hour period or part thereof, that the assignment is late. However, there may be some flexibility concerning a due date, if the instructors are consulted and informed of the extenuating circumstances in advance of the due date.

Oral Presentation of the Term Paper's Findings: Each student will give a 25-minute oral presentation (20 minute talk plus 5 minute question period) on the research topic investigated within the term paper. Student presentations are normally held in the final two weeks of the term. However, this term, the Good Friday (public holiday) occurs on March 30, 2018. Accordingly, and subject to finalization with the students, for this term we may proceed with 3-4 student presentations on each of **Thursday, April 5 (time also to be confirmed) and Friday, April 6, 2018**. Each student presentation should be prepared and delivered as if the student is participating in a mini scientific symposium. Thus, the talk should include an introduction, objectives, (possibly some methodology, for certain topics), major results, inferences/discussion, and conclusions.

The following aspects will be considered in the evaluation of the oral presentation:
• Style, clarify, and technical quality of the scientific talk.
• Organization, structure/content, and conclusions of the presentation.
• Mannerisms – eye contact, pace, audibility.
• Ability to answer questions arising from the audience.

ACADEMIC HONESTY: This course will conform to the academic standards of the College of Graduate and Postdoctoral Studies. For details on university policy, students must consult and read:
http://www.usask.ca/secretariat/student-conduct-appeals/academic-misconduct.php

TENTATIVE SCHEDULE OF COURSE TOPICS AND IMPORTANT DATES

Fri. January 12 – Organizational Meeting

Fri. January 19 – Introduction – importance of reproductive biology in plant systematics;
(HCS) Alternation of generations; bryophytes through angiosperms – general overview.

Fri. January 26 – The angiosperm flower: origin and evolution.
(HCS) The role of the flower in the predominance of angiosperms.
Students should define the research topic for their term paper

Fri. February 2 – Floral diversity and pollination. Pollination syndromes and their
(HCS) evolution; Diversity of pollination syndromes in selected plant families.

Fri. February 9 – Flowering phenology; Plant breeding systems and diversity, including
(ARD) herkogamy, dichogamy; heterostyly; monoecy, dioecy and their variations.

Fri. February 16 – Incompatibility systems; Self-pollination and cleistogamy; Pollen form
(ARD) and function; the stigma; pollination biology (abiotic, biotic) and gene flow.

February 19-23 – Study Break during Term 2

Mon. February 26 – Preliminary structural draft of term paper is due

Fri. March 2 – Floral rewards; Biology of floral and extrafloral nectaries; Examples of plant
(ARD) insect interactions involving pollination.

Fri. March 9 – Assessing pollination success in ecosystems; pollination ecology and some
(ARD) examples.

Fri. March 16 – Asexual and sexual reproduction; double fertilization and seed formation;
(HCS) vivipary, with special attention to certain families (e.g., Cactaceae).

Fri. March 23 – Local field trip to tour Plant Gene Resources of Canada, Agriculture & Agri-Food Canada, Saskatoon (Dr. Axel Diederichsen, Mr. Dallas Kessler).

Fri. March 30 – Public Holiday (Good Friday)

Thurs. April 5(?) (*time TBA*) and Fri. April 6 – Student oral presentations about term papers

Mon. April 9 – Final draft of the term paper is due

SUGGESTED / SUPPORTING LITERATURE FOR THIS COURSE

Almeida, O.J.G., J.H. Cota-Sánchez, and A.A.S. Paoli. 2013. The systematic significance of floral morphology, nectaries, and sugar nectar concentration in epiphytic cacti of tribes Hylocereeae and Rhipsalideae (Cactaceae). *Persp. Plant Ecol. Evol. Syst.* 15: 255-268.

Barrett, S.C.H. 2006. *Ecology and evolution of flowers* [electronic resource] / (Eds.) L.D. Harder, S.C.H. Barrett. Oxford Univ. Press, New York, U.S.A.

Barrett, S.C.H. 2008. Major evolutionary transitions in flowering plant reproduction: An overview. *Int. J. Plant Sci.* 169: 1-5.

Barrett, S.C.H. 2010. Understanding plant reproductive versatility. *Phil. Trans. R. Soc. B.* 365: 99-109.

Baskin, C.C., and J.M. Baskin. 2001. *Seeds: Ecology, biogeography, and evolution of dormancy and germination.* Academic Press, San Diego, CA.

Batygina, T.B. 2005. Sexual and asexual processes in reproductive systems of flowering plants. *Acta Biol. Cracoviensia, Series Botanica* 47: 51-60.

Batygina, T.E. (Ed.) 2009. *Embryology of flowering plants: terminology and concepts*. Three vols: Flower (Vol. 1), Seed (Vol. 2), and Reproductive Systems (Vol. 3). Enfield, NH, Science Publ.

Bradford, K., and H. Nonagaki (Eds.) 2007. Seed development, dormancy, and germination. *Annual Plant Review* Vol. 27. Blackwell Pub., Oxford, U.K.

Burger, W.C. 1981. Why are there so many kinds of flowering plants? *Bioscience* 31: 572-581.

Buzgo, M., P.M. Soltis, S. Kim, and D.E. Soltis. 2005. The making of the flower. *Biologist* 52: 149-154.

Caswell, W.D., and A.R. Davis. 2011. Pollen and ovule production, floral nectary structure, and nectar secretion dynamics in tristylous *Lythrum salicaria* L. *Plant Syst. Evol*. 294: 127-145.

Charlesworth, D. 2006. Evolution of plant breeding systems. *Current Biology* 16: R726-R735.

Cook, C.D.K. 1988. Wind pollination in aquatic angiosperms. *Ann. Missouri Bot. Garden*. 75: 768-777.

Cota-Sánchez, H.H., O.J.G. Almeida, D.J. Falconer, H.J. Choi, and B. Lewis. 2013. Intriguing thigmonastic (sensitive) stamens in the Plains Prickly Pear, *Opuntia polyacantha* (Cactaceae). *Flora* 208: 381-389.

Culley, T.M., S.G. Weller, and A.K. Sakai. 2002. The evolution of wind pollination in angiosperms. *Trends Ecol. Evol.* 17: 361-369.

De Jong, T., and P. Klinkhamer. 2005. *Evolutionary ecology of plant reproductive strategies*. Cambridge Univ Press, Cambridge, U.K.

Friedman, J., and S.C.H. Barrett. 2008. A phylogenetic analysis of the evolution of wind pollination in the angiosperms. *Int. J. Plant Sci.* 169: 49-58.

Friedman, J., and S.C.H. Barrett. 2009. Wind of change: new insights on the ecology and evolution of pollination and mating in wind-pollinated plants. *Ann. Bot*. 103: 1515-1527.

Frohlich, M.W 2003. An evolutionary scenario for the origin of flowers. *Nature* 4: 559-566.

Glover, B.J. 2007. The evolution of flowers. In: *Understanding flowers and flowering - an integrated approach*. Oxford Univ Press, Oxford, U.K.

Johri, B.M., and P.S. Srivastava. 2001. *Reproductive biology of plants*. New York: Springer-Verlag: New Delhi : Narosa Pub. House.

Kearns, C.A., and D.W. Inouye. 1997. *Pollinators, flowering plants, and conservation biology*. *BioScience* 47: 297-307.

Kenrick, P., and P.R. Crane. 1997. The origin and early evolution of plants on land. *Nature* 389: 33-39.

Moza, M.K., and A.K. Bhatnagar. 2007. Plant reproductive biology studies crucial for conservation. *Current Science* 92: 1207.

Nicolson, S.W., M. Nepi, and E. Pacini (Eds.) 2007. *Nectaries and nectar*. Springer-Verlag, Dordrecht, Netherlands.

Orndurff, R. 1969. Reproductive biology in relation to systematics. *Taxon* 18: 121-133.

Reekie, E.G., and F.A. Bazzaz (Eds.) 2005. *Reproductive allocation in plants*. Elsevier Academic Press, Amsterdam.

Renoult, J.P., A. Valido, P. Jordano, and H.M. Schaefer. 2013. Adaptation of flower and fruit colours to multiple, distinct mutualists. *New Phytol*. doi: 10.1111/nph.12539.

Richards, A.J. 1978. *The pollination of flowers by insects*. Linnaean Soc. Symp. Series, No. 6. Academic Press for the Linnaean Society of London, London, U.K.

Richards, A.J. 1997. *Plant breeding systems*. 2nd edition. New York: Chapman & Hall, New York, U.S.A.
Sekercioglu, C.H. 2011. Functional extinctions of bird pollinators cause plant declines. *Science* 331: 1019-1020.
Shivanna, K.R., and V.K. Sawhney (Eds.). 1997. *Pollen biotechnology for crop production and improvement.* Cambridge Univ. Press, Cambridge, U.K.
Soltis, D.E., A.S. Chanderbali, S. Kim, M. Buzgo, and P.S. Soltis. 2007. The ABC model and its applicability to basal angiosperms. *Ann. Bot*. 100: 155-163.
Soltis, P.S., D.E. Soltis, M.W. Chase, P.K. Endress, and P.R. Crane. 2004. The diversification of flowering plants. In: *Assembling the tree of life* (Eds. J. Cracraft, M.J. Donoghue). Oxford Univ. Press, Oxford, U.K.
Spetch, C.D., and M.E. Barlett. 2009. Flower evolution: The origin and subsequent diversification of the angiosperm flower. *Ann. Rev. Ecol. Evol. Syst*. 40: 217-243.
Steussy, T.F. 2004. A transitional-combinational theory for the origin of angiosperms. *Taxon* 53: 3-16.
Stephens, D.T., D.E. Levesque, and A.R. Davis. 2012. Pollen-ovule ratios in seven species of *Vaccinium* (Ericaceae) and stamen structure in *Vaccinium myrtilloides* and *V. vitis-idaea*. *Botany* 90: 599-614.
Wist, T.J., and A.R. Davis. 2013. Evaluation of inflorescence visitors as pollinators of *Echinacea angustifolia* (Asteraceae): Comparison of techniques. *J. Econ. Entomol*. 106: 2055-2071.