Biology 115 – Plant Developmental Biology – Auxin - Fall 2006

The plant hormone auxin plays important roles in most aspects of plant growth and development and is currently a focus of study in many converging areas of plant research. Since Charles Darwin and his son started studying plant tropisms, which are mediated by auxin, in the late 1800's an in-depth understanding of how auxin functions has developed. Multiple lines of inquiry have recently been integrated by a mechanistic explanation for auxin transport and signal transduction. In the last two decades the specific ways in which auxin affects plant development have been described and auxin transporters, receptors and genes involved in auxin responses have been identified, cloned and characterized. Even with this detailed knowledge of auxin biology many important (and seemingly simple) questions such as how much biologically active auxin is in each cell in a plant remain unanswered.

This seminar will attempt to provide an overview of the field of auxin biology through discussions of recent primary literature with a focus on trying to integrate organismal phenomena and molecular mechanisms. Each week two students will each present one or two research papers and sometimes appropriate reviews which will be discussed by all seminar participants. The papers will be chosen the previous week by Nick and the presenter and will be posted on Blackboard. Each presentation is expected to consist of an introduction to the topic, a careful and critical analysis of the paper to be discussed, and an attempt to sum up the conclusions of the papers for the week. Everyone will take part in the discussion and it is expected that you will read and think about the papers ahead of class.

In addition to the journal club component of the course there will be a research component consisting of independent projects related to the research in Nick's lab which is in turn focused on understanding how auxin signaling generates medial-lateral patterning during embryogenesis. The lab component of this course is a whole unit of academic credit, so while we will all meet for one afternoon each week in lab you are also expected to work on your project outside of this time period. At the end of the semester you will write up a complete but concise lab report explaining the question that you were working on, what experiments you performed and your conclusions from these experiments, and what experiments you think should be performed next. This write up will be accompanied by a poster which will be displayed in Martin at the end of the semester.

Biology 115 Fall 2006 – Auxin and Development reading list

Week 1

Geldner N, Anders N, Wolters H, Keicher J, Kornberger W, Muller P, Delbarre A, Ueda T, Nakano A, Jurgens G. The Arabidopsis GNOM ARF-GEF mediates endosomal recycling, auxin transport, and auxin-dependent plant growth. Cell. 2003 Jan 24;112(2):219-30.

Taiz and Zeiger Chapter 19, Auxin.

Week 2

Furutani M, Vernoux T, Traas J, Kato T, Tasaka M, Aida M., PIN-FORMED1 and PINOID regulate boundary formation and cotyledon development in Arabidopsis embryogenesis. Development. 2004 Oct;131(20):5021-30.

Jenik PD, Barton MK., Surge and destroy: the role of auxin in plant embryogenesis. Development. 2005 Aug;132(16):3577-85.

Aida M, Beis D, Heidstra R, Willemsen V, Blilou I, Galinha C, Nussaume L, Noh YS, Amasino R, Scheres B., The PLETHORA genes mediate patterning of the Arabidopsis root stem cell niche. Cell. 2004 Oct 1;119(1):109-20.

Week 3

Dharmasiri N, Dharmasiri S, Estelle M., The F-box protein TIR1 is an auxin receptor. Nature. 2005 May 26;435(7041):441-5.

Ruegger M, Dewey E, Gray WM, Hobbie L, Turner J, Estelle M., The TIR1 protein of Arabidopsis functions in auxin response and is related to human SKP2 and yeast grr1p. Genes Dev. 1998 Jan 15;12(2):198-207.

Dharmasiri N, Dharmasiri S, Weijers D, Lechner E, Yamada M, Hobbie L, Ehrismann JS, Jurgens G, Estelle M., Plant development is regulated by a family of auxin receptor F box proteins. Dev Cell. 2005 Jul;9(1):109-19.

Yang X, Lee S, So JH, Dharmasiri S, Dharmasiri N, Ge L, Jensen C, Hangarter R, Hobbie L, Estelle M., The IAA1 protein is encoded by AXR5 and is a substrate of SCF(TIR1). Plant J. 2004 Dec;40(5):772-82.

Week 4

Benjamins R, Quint A, Weijers D, Hooykaas P, Offringa R., The PINOID protein kinase regulates organ development in Arabidopsis by enhancing polar auxin transport. Development. 2001 Oct;128(20):4057-67.

Christensen SK, Dagenais N, Chory J, Weigel D., Regulation of auxin response by the protein kinase PINOID. Cell. 2000 Feb 18;100(4):469-78.

Friml J, Yang X, Michniewicz M, Weijers D, Quint A, Tietz O, Benjamins R, Ouwerkerk PB, Ljung K, Sandberg G, Hooykaas PJ, Palme K, Offringa R., A PINOID-dependent binary switch in apical-basal PIN polar targeting directs auxin efflux. Science. 2004 Oct 29;306(5697):862-5.

Treml BS, Winderl S, Radykewicz R, Herz M, Schweizer G, Hutzler P, Glawischnig E, Ruiz RA., The gene ENHANCER OF PINOID controls cotyledon development in the Arabidopsis embryo. Development. 2005 Sep;132(18):4063-74.

Week 5

Reinhardt D, Pesce ER, Stieger P, Mandel T, Baltensperger K, Bennett M, Traas J, Friml J, Kuhlemeier C., Regulation of phyllotaxis by polar auxin transport. Nature. 2003 Nov 20;426(6964):255-60.

Reinhardt D, Mandel T, Kuhlemeier C., Auxin regulates the initiation and radial position of plant lateral organs. Plant Cell. 2000 Apr;12(4):507-18.

Reinhardt D., Phyllotaxis--a new chapter in an old tale about beauty and magic numbers. Curr Opin Plant Biol. 2005 Oct;8(5):487-93

Skim: Smith RS, Guyomarch S, Mandel T, Reinhardt D, Kuhlemeier C, Prusinkiewicz P., A plausible model of phyllotaxis. Proc Natl Acad Sci U S A. 2006 Jan 31;103(5):1301-6.

Skim: Jonsson H, Heisler MG, Shapiro BE, Meyerowitz EM, Mjolsness E., An auxin-driven polarized transport model for phyllotaxis. Proc Natl Acad Sci U S A. 2006 Jan 31;103(5):1633-8.

Week 6

Paciorek T, Zazimalova E, Ruthardt N, Petrasek J, Stierhof YD, Kleine-Vehn J, Morris DA, Emans N, Jurgens G, Geldner N, Friml J., Auxin inhibits endocytosis and promotes its own efflux from cells. Nature. 2005 Jun 30;435(7046):1251-6.

Sachs, T, Cell polarity and tissue patterning in plants. Development Supplement 1;83-93 (1991).

Week 7

Weijers D, Benkova E, Jager KE, Schlereth A, Hamann T, Kientz M, Wilmoth JC, Reed JW, Jurgens G., Developmental specificity of auxin response by pairs of ARF and Aux/IAA transcriptional regulators. EMBO J. 2005 May 18;24(10):1874-85.

Hardtke CS, Ckurshumova W, Vidaurre DP, Singh SA, Stamatiou G, Tiwari SB, Hagen

G, Guilfoyle TJ, Berleth T., Overlapping and non-redundant functions of the Arabidopsis auxin response factors MONOPTEROS and NONPHOTOTROPIC HYPOCOTYL 4., Development. 2004 Mar;131(5):1089-100.

Knox K, Grierson CS, Leyser O., AXR3 and SHY2 interact to regulate root hair development. Development. 2003 Dec;130(23):5769-77.

Ellis CM, Nagpal P, Young JC, Hagen G, Guilfoyle TJ, Reed JW., AUXIN RESPONSE FACTOR1 and AUXIN RESPONSE FACTOR2 regulate senescence and floral organ abscission in Arabidopsis thaliana., Development. 2005 Oct;132(20):4563-74.

Week 8

Deyholos MK, Cavaness GF, Hall B, King E, Punwani J, Van Norman J, Sieburth LE., VARICOSE, a WD-domain protein, is required for leaf blade development., Development. 2003 Dec;130(26):6577-88.

Cnops G, Neyt P, Raes J, Petrarulo M, Nelissen H, Malenica N, Luschnig C, Tietz O, Ditengou F, Palme K, Azmi A, Prinsen E, Van Lijsebettens M., The TORNADO1 and TORNADO2 genes function in several patterning processes during early leaf development in Arabidopsis thaliana., Plant Cell. 2006 Apr;18(4):852-66.

Week 9

Abas L, Benjamins R, Malenica N, Paciorek T, Wisniewska J, Moulinier-Anzola JC, Sieberer T, Friml J, Luschnig C., Intracellular trafficking and proteolysis of the Arabidopsis auxin-efflux facilitator PIN2 are involved in root gravitropism., Nature Cell Biology 2006 Mar;8(3):249-56.

Luschnig C, Gaxiola RA, Grisafi P, Fink GR., EIR1, a root-specific protein involved in auxin transport, is required for gravitropism in Arabidopsis thaliana., Genes and Development 1998 Jul 15;12(14):2175-87.

Week 10 - Guest lecture and discussion with Dr. Paula McSteen, Penn State University

Paula McSteen and Sarah Hake, *barren inflorescence2* regulates axillary meristem development in the maize inflorescence, Development 128, 2881-2891 (2001).

Andrea Gallavotti, Qiong Zhao, Junko Kyozuka, Robert B. Meeley, Matthew K. Ritter, John F. Doebley,M. Enrico Pe, Robert J. Schmidt, The role of *barren stalk1* in the architecture of maize, Nature 432:630-635 (2004).

Nicola Carraro, Cristian Forestan, Sabrina Canova, Jan Traas, and Serena Varotto, *ZmPIN1a* and *ZmPIN1b* Encode Two Novel Putative Candidates for Polar Auxin Transport and Plant Architecture Determination of Maize, Plant Physiology, 142:254–264 (2006).

Week 11

Frigerio M, Alabadi D, Perez-Gomez J, Garcia-Carcel L, Phillips AL, Hedden P, Blazquez MA., Transcriptional regulation of gibberellin metabolism genes by auxin signaling in Arabidopsis., Plant Physiol. 2006 Oct;142(2):553-63.

Nemhauser JL, Mockler TC, Chory J., Interdependency of brassinosteroid and auxin signaling in Arabidopsis., PLoS Biology 2004 Sep;2(9):E258.

Week 12

Hay A, Barkoulas M, Tsiantis M., ASYMMETRIC LEAVES1 and auxin activities converge to repress BREVIPEDICELLUS expression and promote leaf development in Arabidopsis., Development. 2006 Oct;133(20):3955-61.

Fischer U, Ikeda Y, Ljung K, Serralbo O, Singh M, Heidstra R, Palme K, Scheres B, Grebe M., Vectorial information for Arabidopsis planar polarity is mediated by combined AUX1, EIN2, and GNOM activity., Current Biology 2006 Nov 7;16(21):2143-9.