**FACULTY RESEARCH INTERESTS**

# DEPARTMENT OF BIOLOGY

**SCHOOL OF SCIENCE**
**INDIANA UNIVERSITY-PURDUE UNIVERSITY**
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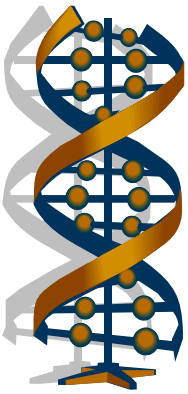

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## ANDERSON, GREGORY, Ph.D.

Microbiology

My laboratory studies the interactions between bacterial pathogens and the host epithelium. Specifically, we are interested in understanding how *Pseudomonas aeruginosa* exploits underlying lung dysfunction in individuals with cystic fibrosis (CF) to establish and maintain chronic lung infection. After CF lung colonization, *P. aeruginosa* undergoes genetic regulatory changes leading to the formation of antibiotic-resistant biofilms, which persist in the lung for the life of the patient despite aggressive antimicrobial therapy. We have developed a novel system for the development of *P. aeruginosa* biofilms on human CF-derived airway epithelial cells *in vitro*. Using this model, we are identifying factors that impact biofilm antibiotic resistance as well as bacterial virulence in the context of CF lung infection. The overall goal of this research is to better understand the nature of chronic infections so that new and better therapies can be developed.

## BARD, MARTIN, Ph.D.

Molecular Genetics

The yeast sterol pathway and its end-product, ergosterol, remain the major targets for antifungal therapy. Our goal is to understand how sterol synthesis is regulated and to assess which steps in the sterol biosynthetic pathway are absolutely necessary for yeast viability. We have cloned nine ergosterol biosynthetic genes and gene disruption studies surprisingly indicate that only four are essential for cell viability. Our present studies include determining the nature of protein-protein interactions among sterol biosynthetic enzymes and the possibility of a sterol biosynthetic channeled complex. Our long-term goals are to understand the nature of sterol trafficking in which sterols are transported from their site of synthesis to various intracellular membranes as well as to determine whether sterols have cellular functions other than as bulk membrane sterol components. Our investigations also have implications in medicine as a number of different genetic syndromes have been identified in which cholesterol synthesis is defective.

## BELECKY-ADAMS, TERI, Ph.D.

Developmental Biology

Development of a functional eye involves two basic processes. First, a homogeneous undifferentiated population of cells must be induced to acquire specific cell fates. Second, cells must also have a sense of where they lie within the retina (a process known as patterning) in order to form proper topographical connections with the rest of the brain. A loss of either one of these processes can lead to a loss of vision. My lab is focused on understanding the roles of a large family of proteins, known as the TGF-Beta family of growth factors, in the differentiation and patterning of the vertebrate eye. We are using tools such as microinjection of retroviruses carrying transgenes into the developing eye, as well as addition of factors in vitro to retinal cultures to perturb growth factor signaling to assay effects on differentiation as well as axonal and dendritic outgrowth. By understanding the mechanisms whereby cells differentiate and form connections, we will one day be able to understand and apply this knowledge to eradicate congenital defects and treat injured or degenerating neurons.

## BLAZER-YOST, BONNIE, Ph.D.

Physiology

The kidney plays a major role in maintaining salt and fluid homeostasis. The research interests of my laboratory are in the field of hormonal modulation of ion transport with a focus on renal epithelial Na+ transport. In the mammalian kidney, Na+ transport is precisely regulated by a variety of hormones. The present research is examining the effects of aldosterone (a classic natriferic corticosteroid hormone), insulin (a natriferic peptide) and insulin like growth factor 1 (IGF1) (a peptide growth factor). We are interested in points of convergence between the steroid and peptide responses, particularly whether both classes of hormones modulate renal epithelial Na+ transport at the level of the amiloride-sensitive Na+ channel. These studies utilize the disciplines of cellular physiology, electrophysiology, protein biochemistry proteomics, confocal imaging and molecular biology. Our studies have direct medical relevance to diseases such as essential hypertension, diabetic hypertension, polycystic kidney disease, congestive heart failure and cystic fibrosis.

## CHANG, HUA-CHEN, Ph.D.

Immunology

My research has been focused on understanding the role of transcription factors in the development of T helper cell subsets, which ultimately result in gene regulation and the subsequent immune responses. I have worked on the Signal Transducer and Activator of Transcription 4 (STAT4) protein, a transcription factor which is required in IL-12 mediated biological functions including Th1 lineage development and IFNγ production for anti-tumor immunity. On the other hand, Th1-mediated inflammation results in tissue damage, which is the culprit in many inflammatory diseases and autoimmune diseases. The ultimate goal is to understand the fundamental nature of immune physiology and to manipulate immunity effectors in various disease manifestations. Another project is to study Th2-mediated allergic inflammation which is responsible for respiratory disorders such as asthma and chronic obstructive pulmonary disease (COPD). The goal is to understand the interplay between the Th2 inflammatory environment and the onset of lung cancer, which could potentially lead to developing preventive strategies. In summary, my research is focused on the aspect of the interplay between the immune responses and human diseases.

## CHERNOFF, ELLEN A., Ph.D.

Developmental Biology

Our laboratory studies factors underlying tissue organization in embryonic development, wound healing, and regeneration. Our primary research projects examine the mechanisms that permit urodele amphibians to regenerate their spinal cords and limbs throughout their lives. We are currently interested in the role of resident stem cells in these processes and the mechanism through which the spinal cord prevents formation of a meningeal/fibrotic scar. We use tissue culture models systems, biochemical and molecular biological techniques to analyze the contributions of the cells, extracellular matrix remodeling and stem cell-related gene expression to amphibian regeneration.

## DAI, GUOLI, Ph.D.

Regenerative Biology

My laboratory investigates the molecular mechanisms regulating hepatocyte proliferation and liver growth in both physiological and pathological conditions. The maternal liver adapts to pregnancy by marked growth manifested by hepatocyte proliferation and liver size increase. We are particularly interested in revealing the role of placental hormones in mediating the hepatic growth response to pregnancy. In response to acute or chronic liver injuries, the liver regenerates, repairing damaged tissue and restoring original structures and functions. The hepatic regenerative response is a phenomenon of compensatory growth of injured liver. Timely and/or enhanced hepatocyte proliferation leads to recovery from liver injury and survival, whereas delayed and/or inhibited hepatocyte proliferation in pathological conditions results in liver failure and death. We are investigating the functions of transcription factors that can be activated by a pharmacological approach in modulating hepatocyte proliferation during liver regeneration. Our goal is to develop a clinical strategy to rescue injured livers by targeting hepatocyte proliferation and thereby liver repair.

## LEES, N. DOUGLAS, Ph.D.

Microbiology/Molecular Biology

The yeast sterol biosynthetic pathway and its end product sterol, ergosterol, present two major targets for antifungal drugs. Accelerated research in the area of antifungal drug development is required due to increased fungal infections brought about by advanced medical procedures, such as cancer chemotherapy and transplantation technology, and human diseases such as AIDS, all of which result in impaired immune system function. Our research seeks to identify reactions essential to sterol synthesis and metabolism in order to identify new targets for antifungal chemotherapy.

## LI, JILIANG, Ph.D.

Cell Biology/Bioengineering

My research interests are in bone cell biology and bone regeneration. For several years I have studied the mechanisms by which exercise builds bone with the goal of identifying novel drug targets linked to increased bone strength. My research activities include the study of the biological and mechanical aspects of bone using animal models and cell cultures, as well as the study of molecular and cellular mechanisms of mechanotransduction, the process of conversion of mechanical signals into biological signals in bone cells. I am also involved in studying pharmaceutical treatments for osteoporosis and bone fracture. These research projects have direct medical relevance to a variety of diseases such as osteoporosis, bone fracture, paraplegia and bone loss in space flight due to weightlessness.

## MALKOVA, ANNA, Ph.D.

Yeast Genetics

My research is focused on mechanisms of DNA repair and recombination. Specifically I am studying pathways that are employed by living cells to repair double-strand DNA breaks threatening genomic integrity. In my research I am using yeast *Saccharomyces cerevisiae* proved to be convenient and fruitful model organism to study different eukaryotic processes. Currently I am focusing on one pathway to repair DNA lesions called Break-Induced Replication (BIR). This pathway is useful for the cell as it allows repairing chromosomal breaks, but it is also dangerous because it can lead to genetic changes and chromosomal rearrangements known to cause cancer in humans. It was suggested that some tumor cells use BIR to stabilize their chromosomal ends, which leads to immortalization. Also BIR is responsible for creating chromosomal rearrangements that change regulation of genes involved in cell cycle regulation, which also leads to cancer. Goals of my current project include identification of genes responsible for suppression of BIR and studying of mechanisms leading to gross chromosomal rearrangements similar to those leading to cancer. My other research projects deal with different aspects of meiotic recombination, including meiosis-specific crossover control and competition between different DNA repair pathways in yeast meiosis.

## MARRS, JAMES A., Ph.D.

Cell and Developmental Biology

My research laboratory investigates cell-cell junctional complexes (adherens junctions and tight junctions) and their function in the establishment and maintenance of cell polarity. Cell polarity mechanisms act during embryonic development, during stem cell activation, during normal adult polarized cell functions (e. g., transepithelial cell transport) and are disrupted in certain disease states, like metastatic cancer.

Cadherins are transmembrane proteins that mediate cell-to-cell adhesion within the adherens junctions. Cadherins regulate cell polarity development and maintenance. We examine the functions of individual zebrafish cadherins during specific morphogenesis and differentiation events during embryogenesis.

My laboratory also uses the zebrafish to model fetal alcohol syndrome (FAS; the consequences of prenatal ethanol exposure). Our experiments and those from other laboratories show that zebrafish is a useful model for mechanistic experiments, which should lead to a better understanding of this devastating human clinical condition.

## MARRS, KATHLEEN, Ph.D.

Biology Education

My research is in the area Biology Education, and serves to advance the Department of Biology's commitment to excellence in teaching and learning. My research goals are to develop ways to reinforce the content students are exposed to in lecture, to help students develop the intellectual skills needed to understand science and the scientific process, and to continually establish connections concerning the relationship of biology and science to society. I teach Biology K101, the first course for Biology Majors in the School of Science. I am currently the Director of UCASE: The Urban Center for the Advancement of Science, Technology, Engineering, and Mathematics (STEM) Education. I currently have a number of funded programs to help increase the number of STEM teachers in Indiana who teach in high-need school districts, grades 6-12, and also have a campus-wide GK-12 program for graduate students to advance scientific knowledge through partnerships with K-12 schools. My active projects and grants include:

(1) The GK-12 Urban Educators Program at IUPUI (2008-2012)
(2) Advance Urban Learning: Teach Science (2007-2011)
(3) The Woodrow Wilson Indiana Teaching Fellowship (2008-2010)
(4) Urban Educators: Robert Noyce Scholarship for Mathematics and Science Teachers (2005-2009)

## RANDALL, STEPHEN K., Ph.D.

Cellular Biochemistry

My laboratory uses biochemistry and molecular genetics to characterize molecular mechanisms by which plants respond and adapt to environmental stresses such as cold and drought conditions. Thus we are conducting proteomic and genetic analysis to identify cellular components important for these processes. We focus on Arabidopsis, cultivated strawberry, and soybean. Some plants are able to develop stress tolerance (to cold, drought, salt, etc.) but many, including most crop plants are unable to adapt. Dehydrins are proteins whose expression is associated with embryonic and vegetative developmental pathways that involve osmotic, water, and salt stress. Indeed, when they are overexpressed in plants, they confer increased stress tolerance. They are found in all higher plants, being expressed in a variety of cell and tissue types. Much of my work focuses on study of the roles and functions of the dehydrin family, particularly in response to cold and drought stress. Our experimental goal is to understand the biochemical and physiological mechanisms that underlie the role of these proteins, in particular, the impact of regulation of calcium-binding activity of these proteins by phosphorylation. To understand the functional domains of these proteins, we are presently examining site-directed mutants in one of these proteins and are testing for function by introducing them into Arabidopsis plants that are mutated or "knocked out" in that gene.

## ROPER, RANDALL J., Ph.D.
Genetics

Trisomy 21 occurs in about 1/750 live births and causes a constellation of phenotypes known as Down syndrome. Our goal is to understand the mechanisms by which genes in three copies on human chromosome 21 cause developmental abnormalities leading to specific Down syndrome traits. A number of tissues affected in Down syndrome, including facial, nervous system, heart, and digestive tract, are partially derived from a transient developmental precursor, the neural crest. Using mouse models of Down syndrome, our work provided the first experimental evidence that trisomy adversely affects neural crest cells. Our laboratory uses genetics, cell and molecular biology, developmental biology, and unbiased stereology to examine how trisomy affects development and the generation, migration, proliferation and survival of the neural crest in trisomic animals. The mechanisms by which trisomy alters normal neural crest development may suggest a common basis for other tissues affected by trisomy. Our long term goal is to apply the knowledge of how and when trisomic genes affect developmental processes to ameliorate or prevent Down syndrome phenotypes.

## STILLWELL, WILLIAM H., Ph.D.
Membrane Biochemistry/Biophysics

My laboratory studies the effect of various important biochemicals on membrane structure and function. We are particularly interested in the anti-cancer properties of omega-3 fatty acids (a major component of fish oils) and the mode of action of the lipid-soluble vitamins A and E. We also investigate the interaction of plant hormones with membranes and the effect of oxidative phosphorylation uncouplers on membrane bioenergetics All projects are based on unraveling the mysteries of how membrane structure affects living processes.

## STOCUM, DAVID L., Ph.D.
Regenerative Biology and Medicine

My research is on the cellular and molecular processes that regulate the regeneration of amphibian limbs. Current specific projects in my laboratory are (1) identifying the contributions of reserve stem cells and stem cells derived by dedifferentiation to the regeneration blastema; (2) elucidation of the cellular and molecular mechanisms by which morphological patterning is specified in the proximodistal axis of the regenerating limb; (3) genomic and proteomic analyses of the molecular differences between regeneration-competent limbs of urodele amphibians and regeneration-deficient anuran amphibians; and (4) the use of natural regenerative signals to improve the regeneration of regeneration-deficient anuran limbs. The ultimate goal of this research is to translate our findings into pharmaceutical regenerative medicine therapies that restore structure and function to damaged human tissues and organs that are regeneration-deficient or are incapable of regeneration.

## WANG, XIANZHONG, Ph.D.
Ecology

My research centers on the effects of global environmental change on plant physiology and productivity at the cell, organismal and ecosystem levels. My specific interests are: (1). Effects of elevated atmospheric carbon dioxide (CO2) on plant respiration; (2). The interaction of other environmental factors, e.g. soil nutrients, with elevated CO2 in affecting carbon sequestration at the individual and ecosystem levels; (3). Physiological adaptation of plants to their changing environments; (4). How will global change affect male and female individuals of dioecious species; (5). Statistical synthesis of published results using meta-analysis. My research is interdisciplinary in nature and aims at understanding the responses of plants to the abiotic factors.

**WATSON, JOHN C., Ph.D.**
Molecular and Cellular Biology

We study a set protein kinases and their genes from the garden pea, soybean, *Arabidopsis* in order to understand their role in seedling development. To identify protein kinases that might transduce light signals, we identified kinase genes whose expression is regulated by light. These pea genes, called *PsPK1* through *PsPK5*, are differentially expressed during de-etiolation in peas. We now have considerable insight into the function of 4 of the 5 members of the original *PsPK* series:
(1) *PsPK4* and *PsPK5* are members of the phototropin 1 family. The phototropins are blue light photoreceptors for phototropism in plants. We showed that PsPK4 encodes a functional blue light photoreceptor for phototropism by transgenic expression in an Arabidopsis *phot1* mutant.
(2) *PsPK2* encodes the pea homolog of PINOID, which regulates polar auxin transport.
(3) PsPK3 is a close relative of an auxin-inducible kinase from cucumber called CsPK3. PsPK3 polypeptide levels are regulated by light in a pattern distinct from the changes in mRNA levels.
We also study *WAG1* and *WAG2*, the two *Arabidopsis* homologs of *PsPK3*, which like *PsPK3* are photoregulated at the mRNA level. The distinctive phenotype in *wag1/wag2* knockout mutants is constitutive root waving. Our data suggest that *wag* phenotype may result from a defect in auxin transport. We are also genetically dissecting the WAG signaling pathway to understand the role of graviperception, auxin transport, and circumnuation in root waving. Work on the soybean homolog of PsPK3 is just beginning.

## ADJUNCT FACULTY

**CHARLES BARMAN, Ph.D.** (School of Education, IUPUI)
Biology Education

**SUBBA CHINTALACHARUVU, Ph.D.** (Eli Lilly and Company)
Immunology

**KEITH DUNKER, Ph.D.** (Indiana University School of Medicine)
Computational Biology & Bioinformatics

**MARK HEIMAN, Ph.D.** (Eli Lilly and Company)
Neuroendocrinology/Physiology

**GARY KRISHNAN, Ph.D.** (Eli Lilly and Company)
Bone Development/Hormone Action

**JOHN MCINTYRE, Ph.D.** (Clarian Health Care Partners)
Histocompatibility

**JOSEPH PETOLINO, Ph.D.** (Dow AgroSciences)
Plant Cell Biology

**SIMON RHODES, Ph.D.** (Indiana University School of Medicine)
Molecular Development/ Endocrinology

**JOHN SCHILD, Ph.D.** (Biomedical Engineering, IUPUI)
Sensory Neuron Electrophysiology/Computational Neuroscience

**RAFAT SIDDIQUI, Ph.D.** (Clarian Health Care Partners)
Signal Transduction

**KYLE SLOOP, Ph.D.** (Eli Lilly and Company)
Endocrinology

**FENGYU SONG, MS, DDS, Ph.D.** (IU Dental School)
Oral Biology

**ROSAMUND SMITH, Ph.D.** (Eli Lilly and Company)
Developmental Biology

**EDWARD SROUR, Ph.D.** (Micro/Immunology, Indiana University School of Medicine)
Stem Cell Biology

**CHRIS VLAHOS, Ph.D.** (Eli Lilly and Company)
Signal Transduction

**FRANK WITZMANN, Ph.D.** (Physiology, Indiana University School of Medicine)
Proteomics

**STEVE ZUCKERMAN, Ph.D.** (Eli Lilly and Company)
Macrophage Biology