# Research in the College of Agriculture and Life Sciences Unfolds Novel Approaches to the Prevention, Detection, and Treatment of Human Diseases

Every day, researchers in the College of Agriculture and Life Sciences (CALS) are pushing back the frontiers of human medicine. Much of their work is not what people traditionally consider when they think of medical research, since it encompasses disciplines such as bioengineering, food science, plant science, and genomics. Within and across CALS departments, however, faculty and students are slowly unraveling the mysteries of the human body and its vulnerabilities and finding creative answers in some unusual places.

With a little help from some very advanced technology, CALS researchers are discovering new ways to defend the human body against disease. Carlo Montemagno, Biological and Environmental Engineering, works with nanomotors, tiny biosensors a few billionths of a meter in size, which potentially can be implanted in living cells. This ground-breaking technology has limitless possibilities for medical research, and may hold the secrets to treatments for paralysis, cancer, and a variety of other diseases. Once inside the cell, these tiny machines may have potential to do the work of damaged nerves in paralyzed bodies, or they could destroy microbes before they cause serious illness. "We may someday be able to produce a pharmacy in a cell, releasing drugs as needed, perhaps even treating illnesses before we even know we are ill," Montemagno explains.

Antje Baeumner, Biological and Environmental Engineering, develops electrochemical and optical biosensors to immediately reveal the presence of pathogens, as well as environmental pollutants, in food and drinking water. These biosensors may also have applications for clinical diagnosis of HIV, Dengue fever, and other diseases. Baeumner's research is particularly useful in third world countries that are ravaged by disease and desperately in need of simple, immediate, and accurate diagnosis methods.

Like Baeumner's biosensors, many biomedical research projects in CALS relate to pathogen and disease detection. In the Department of Food Science, researchers track food-borne illnesses such as listeriosis, which is caused by the bacteria *Listeria monocytogenes*. According to the Centers for Disease Control, approximately 2,500 Americans contract listeriosis each year, resulting in 500 deaths. Kathryn Boor and Martin Wiedmann study better ways to detect and track *L. monocytogenes*, using technological advancements such as DNA fingerprinting of different strains of the bacteria to trace the sources and transmission of listeriosis. "The key outcome of this work will be to improve our understanding of the environmental conditions that contribute to the persistence of dangerous bacteria in our food supply so that we can control and eliminate these hazards, hence improving our ability to protect human health," Boor says.

## From Food Safety to Nanomotors for Drug Delivery, Faculty in the College of Agriculture and Life Sciences Work to Protect Our Health

Frank DiMeo/CU

Antje Baeumner, Biological and Environmental Engineering, develops electrochemical and optical biosensors that will immediately detect the presence of pathogens in food and drinking water. These biosensors may also be relevant for clinical diagnosis of HIV, Dengue fever, and other diseases.

Frank DiMeo/CU

Robert Barker/CU

Kathryn Boor (l.), Food Science, and Martin Wiedmann (r.), Food Science, are studying ways to detect and track *Listeria monocytogenes,* a bacteria that causes the food-borne illness, listeriosis, using DNA fingerprinting of different strains of bacteria to trace sources and transmission of the disease.

"Research involving cancer diagnosis and treatment is a top priority in CALS biomedical projects."

Charles Harrington/CU

Rui Hai Liu, Food Science, studies the role of fruits and vegetables in the diet in reducing the risk of diseases such as cancer.

Charles Harrington/CU

Carl Batt, Food Science, explores the use of tumor antigens for cancer.

Nicola Kountoupes/CU

Eric Alani, Molecular Biology and Genetics, studies how inherited genetic traits such as mutations lead to colorectal and other forms of cancer, using baker's yeast as a model.

Dave Hinman

Stephen Winans, Microbiology, studies *Agrobacterium tumefaciens,* a bacterium that causes crown gall tumors in certain plants; his research has implications for cystic fibrosis patients.

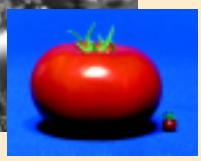
Other food scientists examine how healthy eating can help improve human health. Rui Hai Liu's research provides evidence that consumption of fruits and vegetables may play a significant role in reducing the risk of chronic diseases such as cancer, and it suggests that consumers should be getting antioxidants from fruits and vegetables in their diet rather than expensive nutritional supplements. In addition, Liu's group studied conjugated linoleic acid (CLA), a natural anticancer compound found only in dairy products, and found that it inhibited forestomach cancer in mice.

Research involving cancer diagnosis and treatment is a top priority in CALS biomedical projects. Carl Batt, Food Science, explores the use of tumor antigens for cancer treatment. As director of the Cornell University–Ludwig Institute for Cancer Research Partnership, he leads this joint effort to initiate and nurture numerous research and educational activities, including the establishment of the Bioprocess Research Laboratory and the Good Manufacturing Practices BioProduction Facility. Batt was recently named project leader for the Alliance for Nanomedical Technologies, a Cornell program that will use industrial funding to research and develop microscale optical detection devices that could have significant impact in biomedical research. Batt describes the alliance as "a gathering of scientists and engineers from academe and from the private sector who will look at nanobiotechnology with a specific focus on applications primarily for medical diagnostics, as well as for medical research devices."

Cancer is just one of the many important medical issues addressed in the Department of Molecular Biology and Genetics (MBG), which receives the most funding from the National Institutes of Health of any department at Cornell. Eric Alani studies how inherited genetic traits such as mutations lead to colorectal and other forms of cancer, using baker's yeast as a model. "About eight years ago, scientists at Harvard Medical School and Johns Hopkins found that mutations in 'spellchecker' genes conferred a predisposition to nonpolyposis colorectal cancer," Alani explains. "The spellchecker gene products, which remove errors that occur when DNA is being copied, are highly conserved and are found in the simplest (bacteria) and most complex (humans) organisms. My laboratory is studying the mechanism by which the spellchecker gene products identify the replication errors and remove them." Other MBG professors are researching drug addiction, HIV, and prevention and treatment of specific and general cancers.

"CALS researchers specializing in plant-based research also make discoveries relevant to human medicine."

Peter Morenus/CU



Kent Loeffler/CU

Steven Tanksley, Plant Breeding, and Plant Biology, discovered a direct genetic link between the processes involved in plant growth and those involved in the growth of cancerous tumors in humans and other mammals.

CALS researchers specializing in plant-based research also make discoveries relevant to human medicine. In the Department of Microbiology, Stephen Winans studies *Agrobacterium tumefaciens*, a bacterium that causes crown gall tumors in certain plants. These bacteria only carry out certain functions when their numbers are high enough, which researchers detect by measuring the concentration of a chemical the bacteria secrete, a phenomenon called quorum sensing. "It has turned out that this phenomenon is important in several pathogens, including *Pseudomonas* in cystic fibrosis patients, and it is therefore a target for designing antibacterial drugs," according to Stephen Zinder, department chair.

Another example of plant research paving the way for human medical breakthroughs comes out of CALS efforts in genomics, one of the most significant areas of scholarship in which the college is currently engaged. While studying the evolutionary changes that caused fruits and vegetables to evolve over time from tiny, wild species to the large and bountiful specimens associated with modern agriculture, Steven Tanksley, Plant Breeding, and Plant Biology, discovered a direct genetic connection between the processes involved in plant growth and the processes involved in the growth of cancerous tumors in humans and other mammals. With the help of the Parallel Processing Resource for Biomedical Scientists at the Cornell Theory Center (CTC), Tanksley's group used a computational biology program, developed at the CTC, to create a three-dimensional structure from the protein sequence in domesticated fruits and vegetables. As a result, the research team found the connection between the way in which plants make edible fruit and the way in which humans become more susceptible to cancer. This may have significant implications for future cancer treatments, among other areas of research. "In this era of genomics, many people are looking at divergent organisms, and we're starting to realize connections we never imagined," Tanksley says.

This is just a small sampling of CALS research projects currently underway that stand to impact understanding of human health and the prevention, detection, and treatment of human diseases. In addition to projects within specific departments, CALS biomedical research often crosses departments and colleges, and it is partnered with extension staff, other universities, and government programs.

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**For more information:**
http://www.cals.cornell.edu

# From Human Development to Policy Analysis and Management, the College of Human Ecology Breaks New Ground in Medical and Medical-Related Research

The College of Human Ecology responds to human needs by improving nutrition and health, advancing design and technology, promoting development throughout the life course, and securing economic and social well-being for individuals, families, and communities. The college's multidisciplinary academic departments and programs conduct research that addresses complex societal issues including the cross-cutting theme of human health. Some faculty conduct medical or medical-related research.

## Human Development

Steven Robertson studies fetal and infant development. With Peter Nathanielsz, formerly at Cornell's College of Veterinary Medicine, and William Smotherman at the University of Massachusetts, he has demonstrated in fetal sheep that contractions of the uterus, long before the onset of labor, influence an important source of behavioral complexity also present in humans. Assessments of fetal behavior can indicate the clinical status of the fetus and predict neonatal outcome. His research with infants has revealed a tight link between general motor activation and visual attention. This link is likely to be mediated by the same subcortical brain structures that have been implicated in the pathophysiology of attention deficit hyperactivity disorder (AD/HD).

Elise Temple's work has implications for dyslexic children. Temple and her collaborators at Stanford University have used functional magnetic resonance imaging of the brain to analyze disrupted neural responses to phonological and orthographic processing in dyslexic children. During letter matching, normal-reading children showed activity throughout the extrastriate cortex, especially in occipito-parietal regions, whereas dyslexic children had little activity in the extrastriate cortex during this task. Thus, dyslexia may be characterized early in childhood by disruptions in the neural bases of both phonological and orthographic processes.

Richard Depue conducts research on the neurobiology and neurochemistry of personality, emotion, and cognition. He studies dopamine, serotonin, norepinephrine, and opioid function in relation to the traits of extraversion, emotional stability, fear-anxiety, and affiliation, as well as cognitive functioning. These personality traits define major dimensions of temperament in children. The work has direct implications for personality disorders and disorders of affect, as well as to the etiology and maintenance of substance abuse. Further, Depue studies the manner in which these systems come to be controlled by environmental context.

Jeffrey Haugaard investigates the mental health and development of female adolescents, who have exhibited high levels of physical violence and verbal aggression, in juvenile corrections facilities. He analyzes the effect of this aggression and the staff members' counter-aggression that