

2013

# Conquest

Johnson Cancer Research Center



K a n s a s   S t a t e   U n i v e r s i t y

The fight starts here! From nanoparticles and stem cells to antioxidants and drug discovery, Kansas State University faculty are conducting the basic and translational cancer research that leads to new treatments and cures, as well as training tomorrow's scientists and medical professionals.

To support the Johnson Cancer Research Center's vision to conquer cancer in our time, simply use the enclosed envelope to send your gift, or donate online at [found.ksu.edu/cancer](http://found.ksu.edu/cancer). With your help, we make a difference! To learn more about how you can support K-State cancer research and education, contact David Spafford at 800-432-1578 or [davids@found.ksu.edu](mailto:davids@found.ksu.edu).

**100%** of every gift goes directly to cancer research and education, not administration.

**\$500,000** a year is awarded to support cancer research and education.

**80** faculty researchers are fighting cancer in 16 departments of five colleges.

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1 Chalmers Hall, Kansas State University, Manhattan, KS 66506-3901  
785.532.6705 | cancerresearch@k-state.edu | cancer.k-state.edu  
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To view the annual report "Accepting a Challenge," visit our website's 'About Us' page.



Welcome to the 2013 *Conquest*, a magazine to update you on the outstanding cancer research performed at Kansas State University. This year finds us both reflecting on the past as K-State celebrates its sesquicentennial, and planning for the future via the K-State 2025 visionary plan to become a top 50 public research university. The Johnson Cancer Research Center has been, and will be, important to both.

Although the center has existed for only 32 of K-State's 150 years, it has contributed significantly to the university's current level of success. Our 80 affiliated faculty perform cutting-edge, internationally recognized research in 16 departments. Last year, they won more than \$11 million in national funding, a good deal of which was leveraged from seed grants from our center.

In this issue, we showcase George Wang, human nutrition, who studies cancer prevention through diet and exercise; the team of Deryl Troyer, anatomy and physiology, and Stefan Bossmann, chemistry, who are developing a tool to diagnose cancer in its earliest stages; and Annelise Nguyen, diagnostic medicine/pathobiology, whose research has led to a drug that eliminates breast cancer cells. We also feature K-State biochemistry alumni Mike and Elaine Jacobson, cancer researchers who currently head our advisory board.

K-State is known as one of the nation's best universities for student research opportunities. Over the years, we have invested more than \$1 million to train undergraduate students to do research. Many are inspired to pursue cancer research and health care professions. In this issue, we highlight chemistry major Angela Grommet, whose experience helped her, like many before her, earn major national recognition (a Goldwater Scholarship).

Cancer research has been designated a focus of K-State 2025. University leaders are confident we will bring increasing recognition to K-State, especially as our growing relationship with the University of Kansas Cancer Center helps expedite our research to clinical trials. Our supporters' investment in cancer research, equipment and future scientists will help K-State become a top 50 public research university. Memorials, major gifts and fundraiser events are just a few ways our mission is supported by generous people like the Klingler family and the Kaw Valley Rodeo Association, featured on page 7.

Many cancers are cured thanks to research. But there's much more work to do. We invite you to join K-State's fight against cancer, and sincerely thank those of you who already have.



Rob Denell

# Researcher works to improve cell communication, reduce toxicity of chemotherapies

By Trevor Davis

Opening the lines of communication is vital to help treat cancer.

Thu Annelise Nguyen, associate professor of diagnostic medicine and pathobiology, tries to understand how cancer cells communicate with each other and how to enhance their receptiveness to drug treatments. Nguyen's breast cancer research has led to the discovery, and a patent that is pending, of a drug that eliminates breast cancer cells. The Johnson Cancer Research Center helps fund Nguyen's research, along with student researchers working in her lab.

The goal with improving cell communication is to improve the passage of chemotherapeutic drugs from one cell to the next. This would decrease drug dosage levels and make patients less resistant to drugs.

"More and more patients are becoming resistant to chemotherapy drugs," Nguyen said. "They also have more side effects. Patients often die not because of cancer, but because of the side effects of anticancer drugs. The high doses are just too much and can kill healthy cells that should not be targeted."

Nguyen and Duy Hua, university distinguished professor of chemistry, developed a compound that can regulate cell communication in cancer cells. Using fluorescent dyes, Nguyen found that the compound opens channels between breast cancer cells, increasing cell communication.

The researchers are working with a company that is interested in further studying the compound.

"This drug has the potential to treat cancer even better than other drugs currently in the marketplace," she said. "The compound could enhance a patient's outcome by acting as an anticancer drug and as a delivery system for other drugs."

Undergraduate students working in Nguyen's lab are directly involved with her research. Nguyen has embraced her role as a mentor, partly because of her own upbringing.

She moved with her parents from Vietnam to Texas when she was 10, but she was far behind her American peers in school. She did

not know how to read or write. Nguyen did not attend school in Vietnam because her family did not want her learning the communist ideology.

She caught up at school in Texas and later attended Texas A&M University. She took a biochemistry course her sophomore year and became interested in hormonal regulation. Nguyen joined Kansas State University in 2001 as a postdoctoral fellow after earning a doctorate in toxicology from Texas A&M.

"Students funded through the Johnson Cancer Research Center are a major contribution to my lab and are helping to make huge strides in cancer research," she said. "My lab serves as a place where students can explore the research field before going on to graduate school. I want to pass on my knowledge and experience to my students, because I've been in their position trying to find my way."



From left to right: Annelise Nguyen, Morgan Armbruster\*, Ying Ding\*, Luis Chavez\*, Julie Bernzweig, and Kristina Bigelow.\*

\*received Johnson Cancer Research Center support

# Researcher fights cancer through studies on nutrition, weight control

By Trevor Davis

Weiquan “George” Wang’s lunch may be a key factor in preventing cancer.

The human nutrition professor’s modest lunch consists of one banana, an apple and a bottle of water.

Wang, who swims twice a week at the campus pool, insists the small meal is all he needs to get through the afternoon — and to help avoid cancer.

Wang studies how nutrition and exercise can play a role in preventing cancer. He tries to decode the molecular mechanisms behind weight control and the chemical compounds in fruits and vegetables.

“Maintaining a healthy body weight with exercise and eating a healthy diet is an important strategy to reduce the risks of cancer and other chronic diseases,” he said.

The Johnson Cancer Research Center and the National Institutes of Health fund Wang’s research.

“The Johnson Cancer Research Center saw the potential in my research and initially supported my studies,” he said. “Now I have been awarded extramural funding from other sources, but that would have never been possible without the center’s initial support.”

## Super foods

Wang studies special plant chemical compounds, called phytochemicals, found only in plant-based foods. He investigates how and why fruits and vegetables help reduce the risk of cancer.

“If we can enhance our understanding of how to prevent the formation of cancerous cells through healthy eating behavior, we will provide novel approaches to preventing cancer,” he said.

Wang has investigated a purple sweet potato pie created at the university and found that it was filled with anthocyanin, a pigment associated with reduced risk of cancer.

He discovered that the purple sweet potatoes have significantly higher anthocyanin content and more anti-aging and antioxidant components than other sweet potatoes. He also found that two anthocyanin derivatives — cyanidin and peonidin — inhibit human colon cancer cell growth in the cultured human colorectal cancer cells.

## Weight management benefits

Weight control also can help in the fight against cancer, Wang said. Understanding the association between weight and cancer is vital as the U.S. population gets heavier.

More than one-third of American adults are obese, according to the Centers for Disease Control and Prevention.

“As people get heavier, there is strong evidence that they will increase their risk for chronic diseases like cancer,” he said. “We still don’t understand exactly why, but we know that as you get heavier, you have more risk.”

Using animal models, Wang has found that a liver-released hormone called insulin-like growth factor 1 and a fat-tissue-secreted hormone called leptin may mediate the underlying mechanisms. As body weight decreases, the release of both hormones also decreases.

Both IGF-1 and leptin hormones stimulate cancerous cell growth, increasing the risk of cancer, Wang said.

## Future findings

Wang said he hopes his research can help influence people’s behavior.

“We want people to live a healthy lifestyle with a healthy diet and exercise,” he said. “Furthermore, our research one day could help develop a pharmaceutical way to reduce cancer risk.”

Wang’s findings and the cancer research center’s support continue to drive his research.

“I believe that cancer is preventable,” he said. “I’m excited by this research because I can have a direct impact on families who are fighting cancer and want to contribute to improving lives.”

**\$1.7 million** has been invested in promising new cancer studies since 2003, but \$3 million was requested.



# When every minute counts

## Groundbreaking research makes cancer diagnosis in less than 60 minutes a reality

by Greg Tammen

An hour can now mean a greater chance at a longer life.

Stefan Bossmann, professor of chemistry, and Deryl Troyer, professor of anatomy and physiology, have developed a simple blood test that can accurately detect the early stages of breast cancer and non-small cell lung cancer — the most common type of lung cancer — before symptoms like coughing and weight loss start.

Detection happens in less than an hour.

A five-minute test also is being developed with funding from the National Science Foundation's Division of Chemical, Bioengineering, Environmental and Transport Systems.

"We see this as the first step into a new arena of investigation that could eventually lead to improved early detection of human cancers," Troyer said. "Right now the people who could benefit the most are those classified as at-risk for cancer, such as heavy smokers and people who have a family history of cancer. The idea is these at-risk groups could go to their physician's office quarterly or once a year, take an easy-to-do, noninvasive test, and be told early on whether cancer has possibly developed."

If cancer is confirmed, diagnostic imaging could begin that would otherwise not be pursued.

Additionally, for people already receiving chemotherapy, the test could tell doctors whether it is working.

The test combines iron nanoparticles, amino acids and a dye with a small sample of a patient's blood. The mixture looks for increased enzyme activity in the patient's body. Each type of cancer produces a specific enzyme pattern or "fingerprint."

Detection accuracy was tested on 32 participants in various stages of breast or lung cancer. Twelve people without cancer were also tested. All participants ranged in age from 26 to 81 years old, and blood samples from all participants were evaluated three times. The test had a 95 percent success rate of detecting cancer — including breast cancer in stages 0 and 1 and lung cancer in stages 1 and 2.

"The ultimate goal is to predict cancer before it spreads," Bossmann said. "Catching it in those very early stages is going to mean a much higher rate of survival than finding a tumor five or 10 years later when it has had time to grow and spread."

In October 2012, Troyer, Bossmann and colleagues at the University of Kansas Medical Center began testing for the genetic signatures of pancreatic cancer and triple-negative breast cancer, an aggressive type of breast cancer that is likely to recur and varies genetically, making it difficult to treat with anticancer drugs.

"The Johnson Cancer Research Center is very supportive of what we're trying to do," Troyer said. "It's a wonderful bridge connecting both Kansas State University and the University of Kansas on problems that require constant testing and refinement."

The researchers anticipate the test being available in doctors' offices in five years.



**\$55,000**

supported university laboratory equipment purchases in 2012, but hundreds of thousands of dollars are needed.

Research support has been leveraged by our faculty to as much in national funding.

# 25 times

## All cells on deck

Early detection is only part of the fight. Stefan Bossmann and Deryl Troyer are also working on turning the body's defensive cells into cruise missiles homed on tumors.

The researchers are altering a patient's blood sample with a nanoparticle formula and then reintroducing the blood into the patient. The sample's cells, now loaded with anticancer drugs, are attracted to a tumor. When they combine, the cells die and release the medication directly into the tumor, weakening or killing it.

"Cells do a much better job of detecting smaller metastases than current imaging technology," Bossmann said.

"With this method of making cells into cargo ships, we can basically combine both chemotherapy and immunotherapy into a single, concentrated burst."

The project is supported by the National Science Foundation's Integrated NSF Support Promoting Interdisciplinary Research and Education, or INSPIRE, award. It funds innovative, interdisciplinary projects that hold promise.

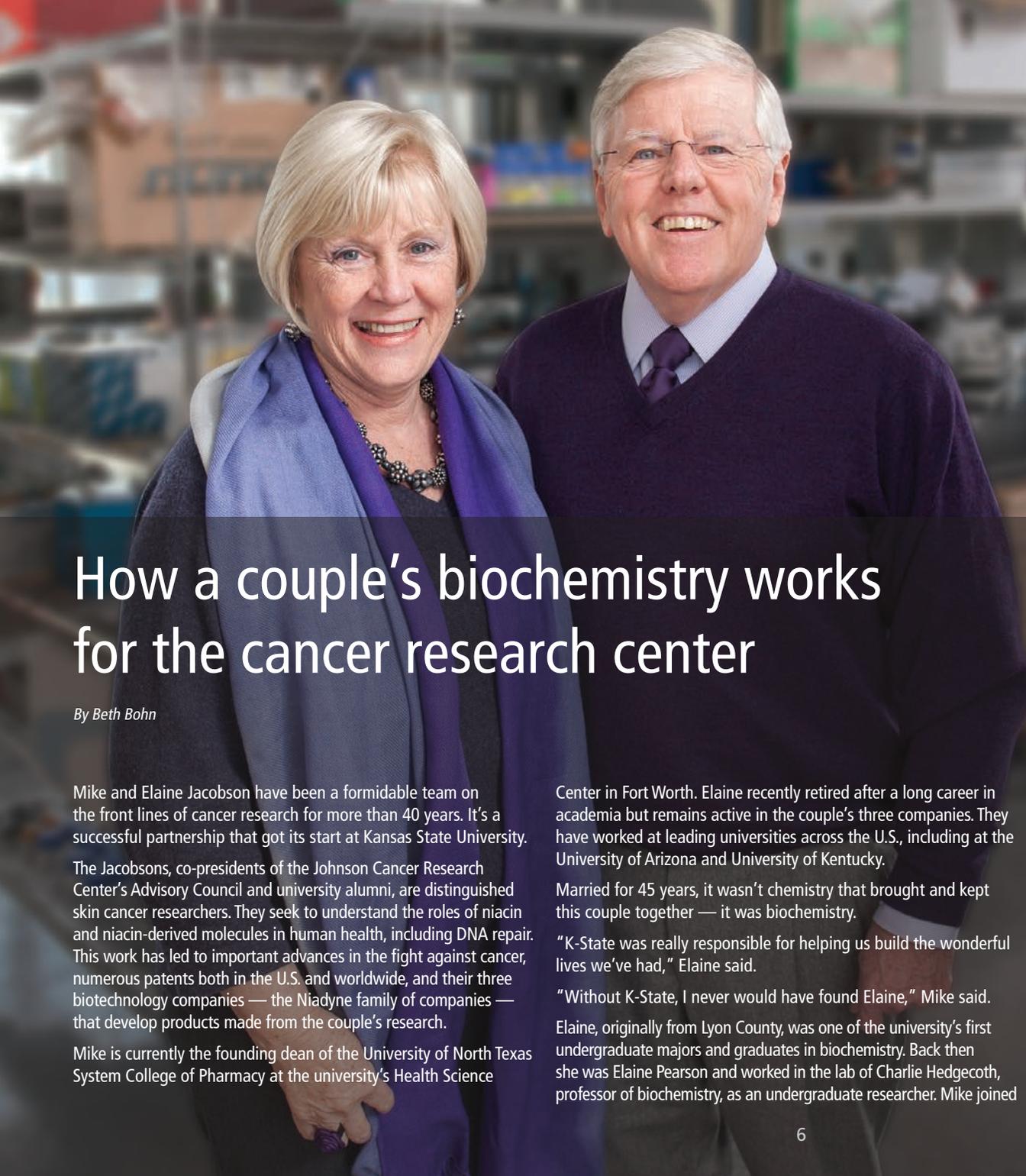
## Bossmann and Troyer's multidisciplinary team includes:

- Matt Basel, postdoctoral fellow, anatomy and physiology
- Tej Shrestha,\* postdoctoral fellow, anatomy and physiology
- Siva Balivada,\* doctoral candidate, physiology
- Hamad Alshetaiwi, master's student, biomedical science
- Marla Pyle, research technician, anatomy and physiology
- Hongwang Wang, postdoctoral fellow, chemistry
- Dinusha Udukala,\* doctoral candidate, chemistry
- Thilani Samarakoon, postdoctoral fellow, chemistry
- Ayomi Perera, postdoctoral fellow, chemistry
- Sebastian Wendel, doctoral candidate, chemical engineering
- Aruni Malalasekera, doctoral candidate, chemistry
- Asanka Yapa, doctoral candidate, chemistry
- Gayani Abayaweera,\* doctoral candidate, chemistry
- Harshi Manawadu,\* doctoral candidate, chemistry
- Pamela Maynez,\* senior, chemistry
- Jenny Barriga, junior, chemistry

\* received Johnson Cancer Research Center support



From left to right: Sebastian Wendel, Deryl Troyer, Ayomi Perera and Stefan Bossmann.



# How a couple's biochemistry works for the cancer research center

By Beth Bohn

Mike and Elaine Jacobson have been a formidable team on the front lines of cancer research for more than 40 years. It's a successful partnership that got its start at Kansas State University.

The Jacobsons, co-presidents of the Johnson Cancer Research Center's Advisory Council and university alumni, are distinguished skin cancer researchers. They seek to understand the roles of niacin and niacin-derived molecules in human health, including DNA repair. This work has led to important advances in the fight against cancer, numerous patents both in the U.S. and worldwide, and their three biotechnology companies — the Niadyne family of companies — that develop products made from the couple's research.

Mike is currently the founding dean of the University of North Texas System College of Pharmacy at the university's Health Science

Center in Fort Worth. Elaine recently retired after a long career in academia but remains active in the couple's three companies. They have worked at leading universities across the U.S., including at the University of Arizona and University of Kentucky.

Married for 45 years, it wasn't chemistry that brought and kept this couple together — it was biochemistry.

"K-State was really responsible for helping us build the wonderful lives we've had," Elaine said.

"Without K-State, I never would have found Elaine," Mike said.

Elaine, originally from Lyon County, was one of the university's first undergraduate majors and graduates in biochemistry. Back then she was Elaine Pearson and worked in the lab of Charlie Hedgecoth, professor of biochemistry, as an undergraduate researcher. Mike joined

the lab as a doctoral student after earning his master's in biochemistry from the University of Wisconsin, Platteville. Both earned doctorates in biochemistry from K-State.

The Jacobsons' experiences in the lab as students are why they wanted to get involved with the cancer research center both as supporters and advisers.

"We understand the importance of giving students opportunities to get involved in cancer research early," Elaine said. "This cancer research center is an investment in developing future cancer researchers."

The Jacobsons got involved with the center after serving as alumni fellows for the College of Arts and Sciences in 2007. During a visit to campus, they were asked by Rob Denell, university distinguished professor of biology and director of the cancer research center, to serve on the center's advisory council.

"We know the work done here does a lot of good. As co-presidents of the advisory council, we're trying to stimulate the center's growth and future funding," Elaine said.

While progress is being made against cancer, Mike said treatment options often are as bad as the disease itself because of their toxicity.

"We're on the verge of a new paradigm for treatment of cancer — developing therapies that are not generally toxic. Our research has laid the cornerstones for this," he said.

Researchers have found that specific types of cancers have what Mike calls an Achilles heel — or vulnerability. Once a cancer's Achilles heel is identified, he said, researchers will be able to make cancer diagnoses earlier and perhaps delay the onset of cancer.

It's what the Jacobsons have been working on in their research on nonmelanomas. These tumors are so prevalent that Mike said cancer registries have given up keeping track of them. A common nonmelanoma is Actinic keratosis — a rough, scaly red patch that usually appears on the face or scalp. This premalignant skin condition is caused by sun exposure and typically affects those age 45 and older. In rare cases, it can develop into squamous cell cancer and spread.

The Jacobsons have developed agents to reverse Actinic keratosis that can be applied topically so they are less toxic and fewer doses are needed. These agents are part of skin care products produced by one of the couple's companies.

Their success is a major reason the Jacobsons wanted to be part of the cancer research center at their alma mater.

"We're longtime cancer researchers. We started our foundation in cancer research at K-State and we wanted to give back," Elaine said.

# Klingler family uses love of rodeo to fight cancer

By Stephanie Jacques

A sea of pink filled the stands of Manhattan's Wells Arena in late July 2012. Excited fans donned pink shirts, pink boots and pink cowboy hats, as little hands released balloons that became pink polka dots in the blue sky. Even the toughest cowboys proudly wore pink. All the pink was in honor of those who have been lost and those who have survived breast cancer.

It was Tough Enough to Wear Pink night at the Kaw Valley Rodeo. What started as a breast cancer survivor's challenge to rodeo cowboys to help spread awareness of the disease has grown into a national trend. Sponsored by Wrangler Jeans, winners of participating rodeos are awarded an extra \$50 if they are wearing pink, and the local rodeo association promoting the event donates \$1 from each ticket sold to an organization of its choice.

The Kaw Valley Rodeo Association chose the Johnson Cancer Research Center and has raised more than \$48,000 since the first pink night in 2007.

Each year, the association has added more support, including corporate sponsorships, a spaghetti dinner, silent auction and various pink merchandise sales.

"The 2012 campaign raised almost \$10,000 for K-State cancer research faculty and students," said Jan Galitzer, assistant to the director of the center. "It is the dedication of many people working together that makes the event a success."

Among those are the Klinglers: Gene, Sue and their daughter, Becky. Having been involved with the rodeo association for a number of years, Gene Klingler was asked to chair the pink committee when it first began and has helped since. All three family members can be spotted during the event wearing their pink as they help sell tickets, cook food or raise money.

Although rodeo has been a favorite family pastime, supporting cancer research is one of the family's highest priorities.

As a surgeon and medical director for the Manhattan Surgical Center, Gene has seen numerous cancer patients. But the strongest impact he's experienced was in 1965 when the Klinglers lost their 4-year-old son, Eugene "Bert" Klingler, to an ependymoma, a cancer usually starting at the base of the brain.

"He was a typical 4-year-old," Gene said. "He was very bright, inquisitive and loved the outdoors. There's not a day that goes by that I don't think about the little guy."

After their loss, the family relied on their faith and support from family, friends and hospital staff to help them through the grieving process. Upon the establishment of the cancer research center, the Klinglers created an endowed fund in Bert's memory because they saw the possibilities their support created.

"The center is working across several departments to investigate the cause of cancer," Gene said. "I like the direction the investigation is taking because it involves undergraduates and class-act scientists. I would not be surprised if within the next 10 years we see a Nobel Prize coming out of K-State just because of its quality of people."

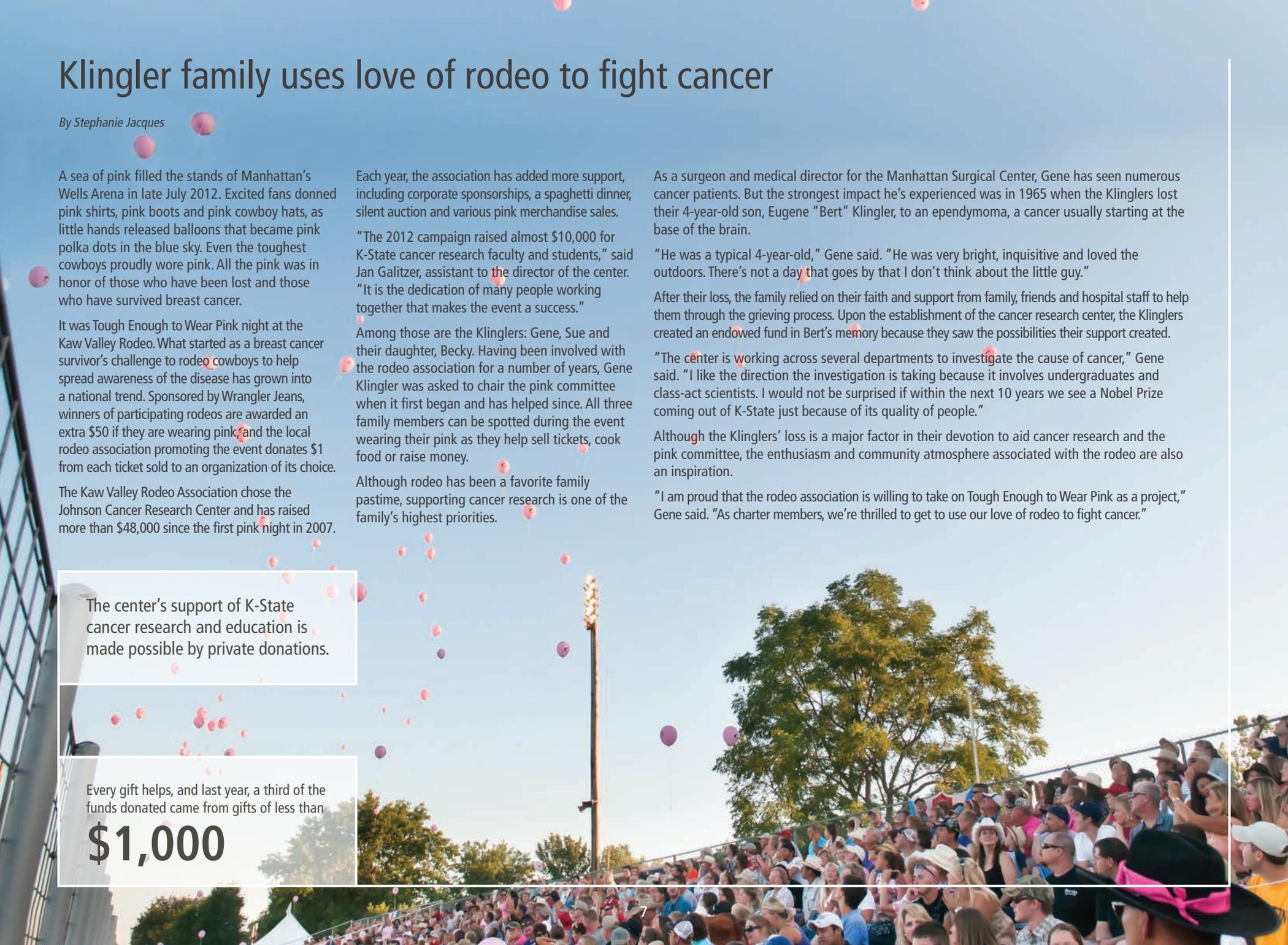
Although the Klinglers' loss is a major factor in their devotion to aid cancer research and the pink committee, the enthusiasm and community atmosphere associated with the rodeo are also an inspiration.

"I am proud that the rodeo association is willing to take on Tough Enough to Wear Pink as a project," Gene said. "As charter members, we're thrilled to get to use our love of rodeo to fight cancer."

The center's support of K-State cancer research and education is made possible by private donations.

Every gift helps, and last year, a third of the funds donated came from gifts of less than

**\$1,000**



# Immortal issues

## Connected with university common book, Bascom lecture offers insight into HeLa cells, biomedical research

by Jennifer Tidball

Students, faculty, staff and community members who gathered for the Johnson Cancer Research Center's George S. Bascom lecture in October learned about the good, bad and ugly aspects of HeLa cells and biomedical research.

Yvonne Reid, manager and scientist in the cell biology program at American Type Culture Collection, presented the 14th lecture in the George S. Bascom Memorial Lecture Series on Current Issues in Clinical Medicine.

The lecture series offered the center an opportunity to sponsor an event associated with K-State's 2012 common book, "The Immortal Life of Henrietta Lacks" by Rebecca Skloot. The university community was invited to join freshmen in reading, discussing and exploring the book and its themes.



Yvonne Reid

Presentations, tours, materials, educational events and information are provided to raise awareness of cancer, risk reduction and research.

The book is based on the true story of Henrietta Lacks, a poor black tobacco farmer whose cells — known as HeLa to the many scientists who use them — were taken without her knowledge and used to help develop some of the most important advances in medicine, including the polio vaccine, cloning, gene mapping, in vitro fertilization and more.

Reid works with HeLa cells at the American Type Culture Collection — a private, nonprofit biological resource center. Her lecture, titled "HeLa cells and biomedical research: the good, the bad and the ugly," enhanced the campus discussion on research, bioethics and race in connection with the book.

"The 'good' has to do with the contribution HeLa cells have made to modern medicine and to basic and applied research," Reid said. "The 'bad' has to do with the whole issue of misidentification and contamination that started with HeLa in the early days and has persisted. The 'ugly' has to do with the role of government policies in protecting private information."

Reid said that misidentification of cell lines in research is a continuing problem that can cause false data and losses of time and money.

"There are simple procedures that we can use to identify cell lines," Reid said. "Scientists, funding agencies, journal editors and other stakeholders all have a role to educate the public and make it known that there are best practices in tissue culture that can be used to alleviate the problem."

Reid incorporated the university common book and the example of the Lacks family throughout her lecture. She said she hoped her lecture showed the human aspect of obtaining people's tissues for research.

"We need to be a little more sympathetic and understanding and reach out when we can," Reid said. "In the process of asking people to participate in research projects, it is on us as investigators to explain what we are going to do with the cells and recognize the sensitivity of the situation."

The lecture series honors Bascom, a Manhattan, Kan., physician, poet and leader in the formation of the Johnson Cancer Research Center. Bascom wanted to inform faculty, students, medical care providers and the general public about challenges faced in clinical medicine and research. He died of cancer in 1993, and in 1996 a group of donors established a fund for the lecture series in his honor.

"I think my brother would have been pleased with the lecture," said Charles Bascom, who is George Bascom's brother and attended the lecture. "I was especially interested in the discussion of the issues of property and privacy."

Past speakers for the lecture series have included oncologists, researchers and medical doctors. The lectures have covered topics such as AIDs, drug development and the future of cancer research.

# Uncovering goals, discovering success

Student uses her passion for research to propel her education and fight for cures

by Megan Saunders

Once upon a time, Angela Grommet sat with thousands of other new K-State students at freshman orientation. That day may have shaped her college career.

Grommet, a senior in chemistry, said that was the day she discovered research was an option for her. Since then, her passion for discovery has led to winning a prestigious Goldwater Scholarship and two consecutive Cancer Research Awards from the Johnson Cancer Research Center.

She heard about the Goldwater during a scholarship workshop at orientation. The national scholarship offers funding to students who pursue careers in math, science or engineering.

"I was interested, but I wasn't sure about the research component," she said. "I knew I was book smart but research is entirely different. I decided if I went for the Goldwater, even if I didn't get it, I would work harder than if I hadn't."

Initially, Grommet worked with Christer Aakeroy, university distinguished professor of chemistry, on a project that focused on creating a single drug that could treat both pain and cancer using diclofenac, a painkiller. The project helped Grommet receive her first Cancer Research Award, which provides \$1,000 and mentored research opportunities to 50 undergraduate students a year, as well as an additional \$1,000 to their faculty mentors for research expenses.

This led to the project that Grommet believes helped her win the Goldwater Scholarship and her second Cancer Research Award. Grommet has been assisting Aakeroy in researching the hydrogen bond between the chemical compound 2-aminopyrimidines and another group of compounds, carboxylic acid, which could create more effective and less taxing cancer treatments.

"My job is to create a set of rules that will predict how these chemical structures — called co-crystals — will bind," Grommet said. "We have a 90 percent success rate — we like predicting the future."

Grommet attributes much of her success in the classroom and lab to her awards. In addition to lightening her financial burden, they have allowed her to focus on her research and education.

"It's a relief to know I don't have to struggle to make ends meet, which increases my productivity in the lab," Grommet said. "I want to continue to develop answers to the questions I'm currently working on, so these awards are going to have a lasting effect."

Grommet said she believes she was a scholarship and award recipient because of her clearly defined goals, which include attending graduate school to study supramolecular chemistry and eventually teaching at a research university. Her career goal is to create a supramolecular reaction library, which she hopes could be used to battle diseases like cancer.

"Medications aren't just one person's job," Grommet said. "It's exciting to think that my research might be the first step in eventually helping someone."

While she may have initially become involved in undergraduate research as a way to increase her chances of receiving a prestigious scholarship, today Grommet's love of research motivates her to find continued success.

"Research is tough and not always fun," she said. "But I love problems that no one else deals with and finding an answer. It's not always about raw smarts. I would tell myself as a freshman that through hard work and many hours, you can do pretty much anything."



50 undergraduates a year receive research training with our annual investment of

**\$100,000**

## Cancer Research Departments

### College of Arts & Sciences

Biochemistry and Molecular Biophysics

Biology

Chemistry

Geography

Physics

### College of Agriculture

Grain Science & Industry

Horticulture

Plant Pathology

### College of Engineering

Chemical Engineering

Electrical & Computer Engineering

Engineering Extension

### College of Human Ecology

Human Nutrition

Kinesiology

### College of Veterinary Medicine

Anatomy & Physiology

Clinical Sciences

Diagnostic Medicine/Pathobiology

### School of Leadership Studies

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