Releasing anti-inflammatory power of turmeric
Partnerships, collaboration fuel problem-solving research

“Synergy is … the profound result when two or more respectful human beings determine to go beyond … preconceived ideas to meet a great challenge.”

This insight from American businessman and educator Stephen Covey illustrates a driving force behind research at South Dakota State University. Since being named vice president for research and economic development, I have emphasized the integral role partnerships play in helping researchers tackle the great challenges we face today and in the future. Creating knowledge, ideas and understanding to help solve complex problems and economically impact South Dakota communities and beyond are key facets of research at South Dakota State.

Our priorities focus on bold initiatives that encourage researchers to forge partnerships, not only with federal and state agencies, but also with industry partners to develop new technologies, improved processes and greater workforce expertise that has a positive impact on the global economy. Working with industry executives, we have provided opportunities to change the landscape of industries throughout the Midwest and collaborate on some of our greatest challenges.

This annual report features examples of SDSU researchers who have forged partnerships with companies, as well as federal and state agencies. These projects not only solve problems and spur economic growth while enhancing the quality of lives throughout South Dakota, but also provide a rich experience for graduate and undergraduate students to participate in the process of discovery and creation of knowledge.

For example Kodo Kids, a Colorado company that develops products for early childhood centers, preschools and day care centers, partners with faculty to help undergraduate students from five departments develop products that meet consumers’ needs. The partnership also provides a path to commercialization for their designs.

In addition, Associate Pharmaceutical Sciences Professor Hemachand Tummala has licensed his patented curcumin formulations to Academic Technology Ventures Inc. As a result, consumers can reap benefits of this anti-inflammatory compound through the nutraceutical products developed by startup company Turmeric Ultra Inc. Doctoral student Siddharth Kesharwani also received an award for his work on the formulations from the Evonik Corporation.

Furthermore, a unique partnership between food scientist Padu Krishnan and oat breeder Melanie Caffé is quantifying the nutritional components, particularly the cholesterol-lowering beta glucan, in oats and improving milling qualities of new oat varieties. To do this, the researchers received funding from and are collaborating with Grain Millers and General Mills, in addition to their U.S. Department of Agriculture grants. The General Mills oat breeder is also working with Caffé, Krishnan and other SDSU scientists to help increase American oat production.

These are just a few examples of how SDSU researchers are changing the world and making a positive impact on society. As Covey concluded, we need “people who can take the initiative and be the solution to problems.” We have those people at South Dakota State.
Curcumin formulation on its way to health product market

Flexibility key to forging research partnership with Kodo Kids

Researcher examines hope among children in Flint, Michigan

Plant pathologist battles stem canker

Removing ‘Typhoid Marys’ restores health of Custer bighorn sheep herd

Breeder, food scientist help improve quality of oats, increase local production

SDSU, community leaders explore new ways to drive research, partnerships

Collaboration with Sanford Health fuels statistical modeling

Engineering builds business connections through Research Park

Research expenditures increase by more than $4 million
Patented formulations that allow our bodies to access the anti-inflammatory power of curcumin will soon be available as a food additive or dietary supplement. Curcumin is the main component of turmeric, the spice that gives Indian curry its yellow color.

“People dealing with chronic inflammatory diseases, such as arthritis, Alzheimer’s disease and irritable bowel syndrome, are looking for natural products to help reduce symptoms,” explained Hemachand Tummala, an associate professor of pharmaceutical sciences. “This formulation will allow the development of nutraceutical products by increasing the bioavailability of curcumin.”

Scientists have been trying to figure out how to use curcumin for decades. Although animal studies looked promising, several human clinical trials failed, dampening enthusiasm among the scientific community. The main reason curcumin does not work in humans is because it is not soluble in water, Tummala explained. “If it does not dissolve, the body cannot absorb it.”

Tummala and his research team use Eudragit® polymers, a Food and Drug Administration-approved polymer suitable for oral consumption, to increase curcumin solubility. Their long-term goal is to treat diseases of the digestive tract, including stomach and colon cancer.

The research was funded by the South Dakota Board of Regents, SDSU Scholarly Excellence Funds, the College of Pharmacy and Allied Health Professions and Profile by Sanford.

**Making curcumin absorbable**

Using Eudragit® EPO polymers, Tummala and doctoral student Siddharth Kesharwani developed Ora-Curcumin® E that dissolves in the acidic pH of the stomach. “This formulation enhanced curcumin solubility up to 20,000 times,” Tummala said.

“Our technology not only removes the roadblocks in translating curcumin for human use but also provides a unique site-specific targeting ability that can reduce side effects in other places,” Kesharwani said. This unique formulation could be used to treat H. Pylori infection and stomach cancer. Their findings were published in the European Journal of Pharmaceutical Sciences.

When a 2017 American Cancer Society study showed an increase in colorectal cancer rates among American adults age 50 and younger, the National Institutes of Health made reducing colon inflammation a research priority.
Childhood experiences spark interest in curcumin research

When Hemachand Tummala was a child, his grandmother gave him hot milk laced with turmeric, the yellow spice that flavors Indian curry, and black pepper to treat a sore throat. “This remedy has been used for thousands of years because it works—and now we know why,” explained the India native, who is an associate professor of pharmaceutical sciences at South Dakota State University. The main component in turmeric is curcumin, an antioxidant that also reduces inflammation, but curcumin does not dissolve in water. “This is where anecdotal history becomes science,” Tummala said. “Curcumin is soluble in oil, so boiling the milk then partitions it into the oil droplets. When we drink the turmeric milk, the curcumin gets into our blood along with the milk fat.” Piperine, the active ingredient in black pepper, has been shown to increase the absorption of curcumin.

Tummala’s childhood experience fueled his interest in curcumin and the pharmaceutical scientist’s search for a means of accessing its anti-inflammatory power to treat inflammatory diseases and cancer.

As a result, Tummala and Kesharwani developed a second formulation using Eudragit® S100, which makes curcumin approximately 90 percent soluble at pHs above 6.7. This formulation releases in the intestinal tract to reduce colon inflammation and target ulcerative colitis and colon cancer.

“The formulation, known as Ora-Curcumin S, does not let any curcumin into the blood, but releases it in the lumen of the colon for local treatment of colon cancer,” Tummala said. “It is more like treating the colon inflammation locally after consuming the medicine by mouth rather than enduring painful procedures, such as an enema.”

For his work on the two formulations, Kesharwani received the 2016 Eudragit Award for North America from the Evonik Corporation, which makes Eudragit® polymers.

Treating colon inflammation, cancer
To advance Ora-Curcumin® S as a drug, Tummala collaborated with Dr. Amar Singh, a gastrointestinal biochemist and associate professor at the University of Nebraska Medical Center and a researcher at the Fred & Pamela Buffett Cancer Center in Omaha. A double-blind pilot study showed mice that began receiving the Ora-Curcumin® S formulation two days before being subjected to a chemical that causes colon ulcers and bleeding had less colon damage and inflammation. “We are so excited about this technology’s potential to improve people’s health and treat chronic diseases,” Tummala said. Their results were published in the November 2018 issue of the Journal of Controlled Release.

Last year, the Ora-Curcumin® technology was licensed to Academic Technology Ventures Inc., which will develop and market the formulations through startup company Turmeric Ultra Inc. The company will conduct human safety trials and obtain FDA Generally Recognized as Safe certification as a food additive or dietary supplement, according to Tummala, who also serves as a technical consultant to help ATV promote the technology to potential investors.

The formulation may potentially be integrated into beverages, including sports drinks and sparkling water; food products, including protein bars; and even pet food. In addition, it can be incorporated into a topical gel to improve joint health.

Furthermore, Tummala and Singh are partnering with ATV to develop the Ora-Curcumin® S formulation to treat inflammatory bowel disease and colon cancer. The development of health products containing Ora-Curcumin® will then help support drug discovery research.

Tummala’s father-in-law, G. Sivarama Krishnaiah, surveys his turmeric field in Pyaparru, India.
A shared interest in encouraging children's creativity has blossomed into a formal partnership between South Dakota State University and Kodo Kids, a Broomfield, Colorado, company that develops products for early childhood centers, preschools and day care centers.

Through a multiyear research agreement, SDSU researchers and students work with Kodo Kids designers to tailor undergraduate design projects to industry needs. The company provides supplies and donates in-kind through its designers’ time.

In return, the agreement gives Kodo Kids the first rights to an exclusive license on the designs, thus providing a pathway to commercialization.

“Kodo Kids is working with the researchers from the start—that is what we want. Learning what industry is looking for allows our researchers to use their skill sets,” said Will Aylor. The former assistant vice president for technology transfer and commercialization worked with Kodo Kids CEO Chris Hume to craft the research agreement that formalized the partnership.

Typically, university policies and procedures governing partnerships tend to be rigid, when what companies need is flexibility, explained Hume. However, his experiences with South Dakota State have been positive.

“It was refreshing—everyone is very open and interested in pushing the limits of what the norm is,” he said. “That flexibility opened us up as a company and gave us assurance that we could figure it out.”

How collaboration began
When professor Kay Cutler, director of the Fishback Center for Early Childhood Education, and Hume met at a conference nearly 10 years ago, they found a common interest in encouraging children’s creativity using a Reggio-inspired approach.

“We started talking about the role of the lab school and how it could be connected to business,” Cutler recalled. The following summer, Cutler’s materials and methods students began exploring the inquiry process with ramps and balls, a Kodo product, and interacting with Hume at the beginning and end of the experience.

The collaboration advanced to a new level when Assistant Interior Design Professor Angela McKillip approached Cutler looking for a realistic design experience for her students.

“We work with preschools all over the country, but giving college students experience in product development, that is amazing. I love to take people’s perspectives and stretch them a bit,” Hume said. The first group of interior design students developed chairs or stools for Kodo Kids in conjunction with mentor teachers from the Fishback Center for Early Childhood Education, SDSU’s lab school.
“It’s been an incredible process and a learning experience that has truly shaped their career trajectories,” McKillip said. The research agreement formalized the roles of the university, researchers and company, Cutler added. “That has given us a foundation to continue forward.”

After three iterations, the eight-week collaborative project blossomed into a design experience that now draws on the talents of faculty and undergraduates from five disciplines—interior design, advertising, early childhood education, entrepreneurial studies and mechanical engineering.

**Providing unique opportunity for undergrads**
The circumstances are unique because undergraduate researchers do not often have an opportunity to help develop university-industry intellectual property. “If their design is chosen, the university and the inventors, including the students, will receive royalty payments when a finalized product is marketed,” Aylor explained.

When Kodo identifies a project of interest, the SDSU technology transfer officer meets with the company to discuss protection, licensing and commercialization. If it is an entirely new concept, the university files for a normal patent. If it looks different, the university applies for a design patent. The prototype design then undergoes further scrutiny, including short-run production and testing at select early childhood centers. The next step is to redesign the piece and send it to national testing centers.

“What’s coming out of this is an industry-ready, licensable technology,” Aylor said. The Maker-Table has been patented and the licensing agreement has been completed.

Two products—the Discovery Hub and Flexnest—have been patented, but have not yet been licensed. If Kodo Kids decides not to license the product, the student designers can opt to start a company or the product can be licensed to another company.

**Interim Assistant Vice President for Technology Transfer and Commercialization Bill Gibbons hopes this success story will spark other conversations between researchers and industry. “Developing relationships with industry builds opportunities for research that people can use every day. As a land-grant institution, that is important for us—it’s part of our mission to improve society.”**
“The future like kind of scares me.”

“I have a hard time with school and … if I don’t get a good job… then I won’t be able to take care of them [my family].”

“…[I thought] I wasn’t gonna make it to the hopes I have.”

These statements from elementary-school children in Flint, Michigan, illustrate the challenges these youngsters face and the role that hope can play in their lives.

“Hope contributes to a person’s resiliency and well-being, buffering against adversity,” explained assistant professor Christin Carotta of the Department of Counseling and Human Development. Carotta came to SDSU in 2016 after doing postdoctoral research at Michigan State University. Her research focuses on children’s social and emotional development, mental health, hope and resilience. She is particularly interested in individual, family, and community factors that promote positive development and family outcomes for underserved populations.

More than 16 percent of South Dakota children live in families whose income levels are below the poverty line, according to 2017 statistics available at talkpoverty.org. Of the more than 100,000 South Dakotans who live in low-income households, 51 percent are Native Americans, nearly 25 percent are Asian Americans and about 18 percent are African American.

Nurturing hope is particularly important for children living in low-income communities. However, most of the studies examining hope in relation to adversity focus among adults, rather than children.

To address this knowledge gap, Carotta and colleagues at Michigan State, conducted a study to identify the hopes of elementary-school children in Flint, Michigan. Nearly 60 percent of Flint children live below the poverty line—nearly triple the national average.

The researchers interviewed 21 children, 9 to 12 years old, who attended a community center that serves youth. The interviews were completed in summer 2015, three months before problems with lead in the drinking water were nationally publicized.

Research questions focused on the specific hopes children have, the importance they ascribe to different hopes and the degree to which they are hopeful about attaining their desired outcomes. The team used an inductive, qualitative approach to identify common themes that emerged from the children’s narratives on hope. The study results were published in the September 2017 issue of The Qualitative Report.

“Children expressed a number of interrelated hopes, but they placed particular importance on their hopes of helping others, including providing for their families and aiding others in the community, particularly the poor and homeless,” Carotta explained.

The children in Flint also emphasized their hopes for academic achievement and career building as avenues through which they could gain the financial stability needed to help others. However, Carotta noted, they were uncertain that their hopes for academic success, rewarding careers and financial stability would actualize.

The children in Flint also emphasized their hopes for academic achievement and career building as avenues through which they could gain the financial stability needed to help others. However, Carotta noted, they were uncertain that their hopes for academic success, rewarding careers and financial stability would actualize.

School and community-based programs can be strengthened by attuning to the specific hopes children have, addressing feelings of hopelessness and providing strategies for cultivating more hopeful thinking about the future. This is particularly important for children and adolescents living in impoverished environments, as they often experience numerous adversities and chronic stress.

At SDSU, Carotta will continue to explore how hope develops throughout childhood to further delineate factors that are positively and negatively associated with hopeful thinking during periods of adversity. These findings will assist educators, parents and community service providers in developing more effective prevention and intervention strategies for youth in low-income South Dakota communities.

“We must concentrate on those areas in which children are most in need of hope-engendering strategies and help strengthen individual, family and community programs that facilitate hope,” she concluded.
Plant pathologist battles stem canker

The battle against Phomopsis stem canker in sunflowers must be waged on multiple fronts, according to field crops pathologist Febina Mathew, an assistant professor and South Dakota Agricultural Experiment Station researcher in the Department of Agronomy, Horticulture and Plant Science. Mathew and her team developed and are testing a disease-forecasting model to help sunflower farmers know when to spray fungicide to manage stem canker.

Mathew, who came to SDSU in August 2014, has been at the forefront of the fight against stem canker since the fungal disease devastated sunflower crops in the Northern Great Plains in 2010. While completing her doctorate at North Dakota State University, she identified two fungal pathogens causing Phomopsis stem canker in sunflowers.

Last year, Mathew became the first SDSU researcher to receive the Early Career Award for the North Central Division of the American Phytopathological Society. Her research addresses stem canker in soybeans and sunflowers, soybean cyst nematode and root rot of soybean, nematodes and root rot of corn, bacterial and root diseases of pulse crops and emerging diseases on canola, carinata and other alternative oilseed crops.

The stem canker-forecasting model is supported by a three-year, $300,000 U.S. Department of Agriculture grant through the Critical Agricultural Research and Extension program. The project, which is in its third year, also involves Extension pathologists Sam Markell of North Dakota State University and Bob Harveson of the University of Nebraska-Lincoln.

“Any disease that attacks the sunflower stalk such as Phomopsis stem canker is a concern to producers—the underlying concern is standability,” said Tom Young, executive director of the South Dakota Oilseeds Council. The fungus overwinters in plant debris and the spores are spread by wind and rain splash.

Only one type of fungicide works but it must be applied in a very short window of time, about 10 to 14 days. However, Young noted, “As a producer, I am generally not scouting for stem canker in my sunflower fields at the proper time, before bloom.” This is where the disease-forecasting model helps.

Mathew said, “Because stem canker pathogens can live on crop residue, any time sunflowers go into the ground, farmers are likely to see disease under conducive weather conditions.” Once the forecasting model has been fully validated, the risk maps will be available on the National Sunflower Association website along with instructions to help farmers use the model.

Results from field trials in Nebraska, North Dakota and South Dakota show the model helps reduce disease, but Mathew said, “fungicides will not protect the crop until the end of the season.”

Some sunflower hybrids offer partial resistance, but with several pathogens capable of causing stem canker, Mathew said, “it is like taking the flu shot; it may not help with all strains of viruses circulating. That’s why we need to look at identifying sources of genetic resistance to stem canker.”

Mathew’s group identified sunflower accessions with resistance to two of the pathogens, but master’s student Renan Guidini has screened additional sunflower accessions for disease resistance at vegetative and adult-plant growth stages. He observed that few sunflower accessions that had resistance to one of the stem canker fungi at the vegetative stage maintained resistance at the adult-plant growth stage. In the coming months, he will work on identifying the region in the sunflower chromosome where resistant genes are likely to reside. “That is the information breeders need to know,” Mathew said.

To do this, they are working with Research Geneticist Brent Hulke, sunflower breeder at the USDA Agricultural Research Service in Fargo, North Dakota, and an SDSU alumnus. This project was made possible with funding from the South Dakota Oilseeds Council.

Although fungicide may be used for managing Phomopsis stem canker in sunflower fields, Mathew said, “breeding for genetic resistance in sunflower will be an economical, effective approach for the long-term management of this disease.”
Bighorn sheep in Custer State Park are healthy and thriving again, but only a few years ago, their future was uncertain.

An outbreak of bacterial pneumonia in 2004 decimated the herd—nearly 80 percent of the sheep died. More than a decade later, the herd was still struggling as most of its newborn lambs died from respiratory disease. The herd was destined for extinction, but Chad Lehman, South Dakota, Game, Fish and Parks senior wildlife biologist at Custer State Park, was not going to let that happen.

Meanwhile, Distinguished Professor Jonathan Jenks of the South Dakota State University Department of Natural Resource Management was part of a multi-institutional research team evaluating whether eliminating the “Typhoid Marys” that persistently shed a pathogen called Mycoplasma ovipneumoniae (Movi) could increase lamb survival.

The study was done in collaboration with wildlife biologist Frances Cassirer of the Idaho Department of Fish and Game, infectious disease specialist Tom Besser of Washington State University and quantitative ecologist Daniel Walsh of the U.S. Geological Survey National Wildlife Health Center in Wisconsin. It was funded by 11 state and federal agencies and wildlife groups.

Pneumonia is the No. 1 disease threatening bighorn sheep across the western United States and Canada, according to John Kanta, GFP terrestrial resource supervisor. Since 2010, Kanta has been working with Jenks to understand the disease mechanisms and develop management strategies to minimize its impact.

Typically, only a few animals in a herd are shedding the Movi pathogen, Jenks explained. Those testing positive for the pathogen three times at six-month intervals are shedders.

At the Department of Natural Resource Management’s research facility, Jenks and doctoral student Brandi Felts separated the shedders from the pregnant ewes and saw a drastic improvement in lamb survival. The information from the captive work was used to transition to the field.

Field-testing shedder removal theory
In 2014, Lehman and his interns began disease-testing the 25 remaining bighorn sheep at Custer State Park. “We darted and radio-collared them and did swab and nasal washes,” he explained. They identified two animals as shedders.

Lehman and Jenks, along with other team members, obtained a three-year grant from the Pittman Robertson Fund to field test the Typhoid Mary hypothesis, with the Custer State Park herd as the treatment population and the Rapid City herd, which SDSU doctoral student Joshua Smith documented as being positive for Movi, as the control. The study began in 2016.

SDSU graduate student Tyler Garwood, who completed his master’s degree in May 2018, worked with Jenks, Lehman and other team members. “We had good disease histories in Custer and good information on the Rapid City herd from the Game, Fish and Parks people there,” explained Garwood.

“We did exactly the same work with both herds, but removed the shedders in Custer,” Lehman explained. All animals were tested and vaginal implants placed in the ewes, so the researchers could collar lambs within six to 48 hours after they were born to monitor lamb survival.

Increasing lamb survival
“What we found was pretty striking—not a single respiratory disease death in Custer,” Garwood said. In the first year, nine of 10 lambs survived; the second year, only four of 10 survived because a mountain lion developed a taste for lamb, but there was no respiratory disease.

Though the researchers were continuously disease-testing the ewes and rams they captured, they never confirmed another positive Movi test or any pneumonia among the adults in the Custer herd.

That was not the case in the Rapid City herd. “The first year, three lambs survived from the 18 we collared; the second year, we got nine lambs and none survived,” Garwood reported. “The most common source of death was respiratory disease.”

Lehman said, “This is the first time we have been able to demonstrate that this [removing shedders] works because we have a unique situation in South Dakota where we have access to all our sheep.”

This approach can be applied to other herds, but Jenks cautioned that the pathogen strain and herd characteristics are important factors to consider. “This approach works with smaller populations in which you can get full coverage so you don’t miss
a chronic shedder,” he said. Lehman and Jenks recently received funding to remove the shedders from the Rapid City herd.

“This is cutting-edge stuff that is leading research in the West. It’s a really nice collaboration,” Lehman said. The future of bighorn sheep in South Dakota is brighter, thanks to this new management technique.

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National Park Service monitors health of Badlands bighorn sheep

The Badlands bighorn sheep herd is healthy and thriving, and National Park Service Wildlife Biologist Eddie Childers wants to keep it that way.

“It’s one of the largest and the healthiest populations in the state of South Dakota,” said Childers, who has been managing the Badlands bighorn sheep herd in the north unit since 1999. The herd numbers about 180 animals.

Through a three-year National Park Service-funded study, Childers is working with Distinguished Professor of Natural Resource Management Jonathan Jenks and graduate student Austin Wieseler to examine survival and mortality in the Badlands herd.

“We are looking at a broad spectrum of diseases that can potentially hurt these populations,” Childers said. The research, which began in February 2017, involves monitoring adult and yearling sheep, as well as lambs.

Although the herd has previously been exposed to pneumonia-causing pathogens, none are Mycoplasma ovipneumoniae shedders, according to Wieseler. In summer 2017, he collared 23 lambs and recorded a 74 percent survival rate through 6 months of age. By the end of May 2018, Wieseler had collared 30 lambs. “The goal is to get them to a year old,” Wieseler said.

In addition, the National Park Service monitors wild sheep, particularly young rams, that stray into neighboring domestic flocks. Due to the disease risk, these animals cannot be allowed back into the Badlands herd, Childers explained.

The researchers hope to work with private landowners whose sheep and goats graze within 8 miles of the park to help reduce the risk from pneumonia-causing pathogens. Meanwhile, researchers are working on potential treatments, including a Mycoplasma ovipneumoniae vaccine.
Breeder, food scientist help improve quality of oats, increase local production

“SDSU has a great reputation in agriculture and particularly as the leader in oat breeding and research.”

Tom Rabaey, General Mills research agronomist
Collaboration between a plant breeder and a food scientist is addressing the needs of producers and the food industry to help increase the quantity and quality of South Dakota oats.

Oat breeder Melanie Caffé and food scientist Padu Krishnan have been working together for nearly five years to improve the nutritional and milling qualities of new oat varieties. Their work also seeks to develop cultivars that are higher in beta glucan, the soluble fiber that helps decrease blood cholesterol levels.

The research is supported by the U.S. Department of Agriculture as well as General Mills and Grain Millers Inc., processors of oat cereals. Caffé and Krishnan are researchers in the South Dakota Agricultural Experiment Station.

“Oats requires fewer inputs than other crops and when integrated into a corn-soybean rotation, oats can improve soil health and break pest cycles,” explained Caffé, an assistant professor in the Department of Agronomy, Horticulture and Plant Science. In 2016, South Dakota was the No. 1 oat-producing state, according to USDA National Agricultural Statistics Service.

“With 50 percent soluble and 50 percent insoluble fiber, oats has all of the weapons to lower cholesterol and help manage diabetes,” said Krishnan, a professor in the Department of Dairy and Food Science.

“SDSU has a great reputation in agriculture and particularly as the leader in oat breeding and research,” said General Mills Research Agronomist Tom Rabaey. In 2016, General Mills relocated its oat breeding program to Brookings, in part, to facilitate collaboration with Krishnan, Caffé and other SDSU scientists.

In addition to ongoing support from the South Dakota Crop Improvement Association, the SDSU oat breeding program recently received a three-year, $175,000 grant from Grain Millers. Bruce Roskens, director of crop sciences at Grain Millers Inc., said, “SDSU has always had one of the best U.S. oat breeding programs—for both farmers and millers—for many decades. We are proud to be able to help support this effort and help develop even better new varieties that add value to the oat industry.”

Producing a high-value crop

When it comes to oat production, disease resistance and yield are important. Saddle, an oat variety released in 2017, has resistance to crown rust, Caffé reported. Yields of 150 bushels per acre are attainable with newer varieties and test weights range from 38 to 42 pounds per bushel with the use of fungicide or a resistant variety.

However, when it comes to food-grade oats, the milling yield—the proportion of groat, or dehulled oats, compared to the full kernel—is also a priority. “We want as much groat as possible in the weight and the hull must be easily removed during the milling process,” Caffé said.

Caffé led a team of researchers that developed models to predict oat milling and nutritional qualities based on genetic markers. The two-year project, begun in 2016, was supported by a $150,000 National Institute of Food and Agriculture grant.

The researchers genotyped and tested 450 lines of oats at four locations—Volga, Winner, South Shore and Beresford. The resulting model predicts the phenotype, the traits expressed in the plant, for untested breeding lines based on their genotype, or DNA makeup. One graduate student and several undergraduates worked on the project.

“Removing the lines that are least likely to perform well at an earlier stage allows us to focus more on evaluating those that have the highest chance of performing well,” Caffé said. The goal is to make the selection process more efficient.
Developing calibration to measure beta glucan
Milling companies must make sure their oat products contain at least 0.75 gram of beta-glucan per serving to meet Food and Drug Administration requirements for using the “heart healthy” label. Krishnan and his team used near-infrared spectrometry to develop a faster, more accurate means of measuring beta glucan that will save money for companies and consumers. The research was supported by a $140,000 grant from General Mills and Grain Millers Inc.

“Without this instrument and technique, companies will need to spend thousands of dollars doing chemical analyses,” Krishnan said. Master’s student Devendra Paudel analyzed nearly 500 reference samples to develop the NIRS calibration and determine how close the NIRS-predicted values are to the true values from traditional chemical methods.

“Those calibrations become decision-making tools to determine which samples to use in food processing and what health claims can be made on the food labels,” Krishnan explained. Using one instrument, the researchers can determine moisture, protein, fat, carbohydrate and beta glucan content.

In addition to oat samples from South Dakota breeding lines, the researchers analyzed varieties from Iowa, North Dakota, Minnesota, Illinois and Washington, thanks to Rabaey and Roskens, who are both SDSU alumni. The researchers also scanned samples from multiple years because the growing conditions also affect the characteristics of the grain.

“We have a very robust calibration,” Krishnan said. “It takes less than a minute to scan a sample and we can do the analysis using dehulled oats that can then be planted to get the next generation—this is a powerful tool for the plant breeder and the food technologist.”

Refining calibration, developing new products
The success of the NIRS calibration helped Krishnan and Caffé secure a three-year, nearly $450,000 NIFA grant in 2018. The grant will allow them to continue improving oat cultivars and to develop new oat products.

Krishnan and his team will evaluate more samples of North American oats to increase the robustness of the NIRS calibration. “We can build predictive calibrations, new parental lines and research tools that can be used to develop oat varieties specific to our region,” Krishnan said. By increasing the number of samples from other states, the researchers can also build a national calibration.

“This new grant will provide additional tools for developing new oat cultivars with characteristics that meet processors’ needs and provide increased health benefits for consumers,” Caffé said.

In Krishnan’s lab, graduate student Beatrice Manu is developing an oat beverage and graduate student Kara Konst is incorporating oat flour into Asian noodles. The researchers will also examine variables that affect the milling and flaking qualities of oats and try to improve product shelf life and stability.

“We are talking about a whole host of new oat products that are high in beta glucan,” Krishnan said. “Our goal is to take oats beyond the breakfast aisle.”
Tying faculty expertise into industry needs can help South Dakota State University leverage university research to promote economic growth in the state and region, according to Vice President for Research and Economic Development Daniel Scholl. The Brookings Economic Development Corporation and the Research Park at South Dakota State University are key entities helping faculty researchers link up with private sector partners.

“To move the technologies researchers develop into the marketplace, we must listen carefully to understand industry problems and provide solutions to those problems,” Scholl explained.

Identifying opportunities
A substantial portion of university funding comes from federal sources, which may or may not be aligned with more immediate private sector needs,” explained BEDC Director Al Heuton. “Much of this research can be many years away from a viable market application.”

To find out what the marketplace needs now, the BEDC commissioned a study that identified 30 broad industry types with both high growth rates and competitive wages that might fit the Brookings community. When Heuton conferred with Scholl and SDSU President Barry Dunn, they decided to focus first on precision agriculture, which encompasses everything from dairy science to satellite imagery to crop production and service companies.

“Our goal is to better align university research and talent production with private-sector needs,” said Heuton, who brought in Lisa Prassack, a consultant involved in business development and emerging agricultural technologies. She met with key researchers in May 2018. Then about 30 university researchers and administrators attended a June workshop, hosted by BEDC and the Research Park, in which Prassack encouraged the formation of interdisciplinary teams to address some of the challenges in precision agriculture.

“The key is listening well and thinking across disciplines to determine how to combine our expertise to creatively solve real problems that exist in the digital agriculture world,” Scholl said. Teams were formed to develop partnerships in three areas: remote sensing applications to agriculture, animal nutrition and soil health documentation through the value chain.

Partnering with businesses
“The main purpose of the Research Park is to assist SDSU in building the research enterprise,” said Research Park CEO and Executive Director Dwaine Chapel. Leasing office space at the Research Park gives companies proximity to students and researchers.

The Research Park, which was built through private, city and state funding, “enables private entities to take advantage of the intellectual environment of the university,” Scholl explained. For instance, SDSU’s partnership with Raven Industries through its presence at the Research Park focuses on research and development in precision agriculture, as well as workforce development. This partnership engages researchers and students from multiple areas, including plant and soil sciences, computer science, statistics and engineering.

In addition, General Mills moved its oat breeding program to Brookings, opening an office in the Research Park and entering a public-private facility use agreement at SDSU’s Young Brothers Seed Technology Laboratory, located within the Research Park. This allows the company’s oat breeder, Paul Richter, to work with SDSU oat breeder Melanie Caffé and professor Padu Krishnan, a cereal chemist, to produce oats with the agronomic and milling traits General Mills needs (see story page 10).

Working together, Scholl, Heuton and Chapel hope to encourage more collaborative partnerships that connect faculty research expertise with industry needs and thereby fuel economic growth.
Making use of the wealth of health-care data being collected means figuring out which variables are the most meaningful predictors of client-patient outcomes.

Emily Griese, director of the Sanford Data Collaborative, said, “We have tons of data on patient interactions within the health-care delivery system, but we cannot look at all of it ourselves.” Conversations with academic institutions and partners revealed their need for real-life data. That was the impetus behind forming the Sanford Data Collaborative nearly two years ago.

This builds on the university’s partnership with Sanford Health, a five-year agreement that has been supporting projects involving SDSU and Sanford researchers since 2015.

“Individuals from different disciplines look at data with a different lens. Different ways of looking at the world push you to do things differently—that’s the value of collaboration,” Griese said.

Analysis of client data helps improve weight-loss program

Harnessing the power of big data can help increase the effectiveness of the Profile by Sanford weight-loss program by identifying when clients may be at risk of dropping out.

“We know the program works. Using big data to identify trends gives us another way to individualize the program, to personalize what we do to make sure that person is successful,” said Stephen Herrmann, director of program development and training for Profile by Sanford. That will then allow coaches to test different approaches to retain those clients.

“We are finding patterns that will help clients and the weight-management team and coaches,” said Xijin Ge, an associate professor of mathematics and statistics whose specialty is bioinformatics and data mining. Ge works with statisticians, associate professor Gemechis Djira and assistant professor Gary Hatfield, and Sanford Research Senior Scientist Paul Thompson, as well as mathematics and statistics department head and professor Kurt Cogswell.

The project received $155,014 through the Sanford Health and South Dakota State University partnership and additional support through the South Dakota Board of Regents Research and Development Innovation Program.

A 2008 study estimated that a $10 per person investment in community-based programs proven to improve diet, exercise and lifestyles could save the nation more than $16 billion annually within five years.
Model categorizes patient engagement using existing data

Following doctor’s orders may seem like a no-brainer, but a surprising number of patients do not. About half of the time, patients do not take their medications as prescribed, according to the Centers for Disease Control and Prevention.

Health care is transitioning from a fee-for-service to a value-based care industry, according to Emily Griese, director of the Sanford Data Collaborative. “We are held responsible, not just for doing the surgery, for example, but for the outcomes that go along with that. Understanding how engaged our patients are with health-care delivery is crucial to predicting outcomes for patients.”

Assistant professor Semhar Michael and associate professors Xijin Ge and Gemechis Djira of the Department of Mathematics and Statistics worked with former associate professor of pharmacy practice Surachat Ngorsuraches to develop a statistical model to evaluate how engaged patients are in their health-care regimen. Public health and health outcomes data analyst Patricia Da Rosa and professor Howard Wey, now retired, from the College of Nursing, were also involved in the 2017 Sanford Data Collaborative research project.

The Patient Activation Measure is a lengthy patient survey that quantifies patient engagement, but Sanford Health wants to build a similar score using data that is already being collected, Michael explained. In addition, she said, “Because patients assess themselves, there is a lot of subjectivity. We wanted to make it more objective, to look at what they do rather than taking their word for it.”

Michael and her colleagues used finite mixture models and three variables—appointments attended, prescriptions refilled and immunizations recorded—to build a score, which was associated with high, medium or low patient engagement.

The scores from the new model were associated with more outcome measurements than those from 1,442 patients given the Patient Activation Measure, Michael reported. “It was a more accurate indicator of patient engagement.”

Michael worked with graduate student Mosa Alsabhi to refine the model. The research was part of Alsabhi’s master’s thesis, which was completed in July 2018.

“Sanford really liked this scoring, and we are investigating adding more variables and trying to internally use this score to identify patients that need more provider involvement,” Michael explained.

“The score [generated by this predictive algorithm] will calibrate the way we provide services to individuals who have a low engagement potential,” Griese said. Additional support, such as a case manager and online tools, can help improve outcomes for these patients.
Engineering builds business connections through Research Park

Approaching research with a more entrepreneurial flair can help engineering researchers connect with companies that can benefit from their expertise. Building those connections is what Dennis Helder, who recently retired as the associate dean of engineering research, and Dwaine Chapel, CEO and executive director of the Research Park at South Dakota State University, have been doing.

In May 2017, they began developing a strategic plan to recruit businesses that would find value in working with researchers in the Jerome J. Lohr College of Engineering.

First, Helder pointed out, “We had to learn each other’s language. We had to get to know the other person’s world.”

The question for Helder was “how do we as a college leverage the resources that the Research Park offers and do it in an optimal way? I did not understand the mechanisms or direction we could go to be successful,” he said.

Chapel agreed: “My background is in economic development, so I understand what companies want.” However, in working with industries, Chapel found companies with specific needs did not know where to start to find faculty who could help.

To meld their two worlds, Helder and Chapel got direction from two respected financial consultants, Charlie D’Agostino, head of Louisiana State University’s Innovation Park and the Louisiana Business and Technology Center, and J. Trent William, CEO of Regional Technology Strategies Inc. of North Carolina. They learned about specific approaches that work to make a research park successful.

“Companies want to be near a university to hire students, so we need to identify companies from that perspective,” Helder said. “But we also need to take that to the next level, to get companies connected to faculty.” The university’s partnership with Raven Industries is an excellent example.

Helder and Chapel settled on a two-pronged approach, which they shared with faculty in April 2018.

“First, we want to make sure faculty are aware of the resources available at the Research Park and then find out who is interested in partnering with companies,” Helder said.

At the same time, they identified key industry sectors and companies that want to connect with SDSU. Specifically, Chapel said, “we are trying to figure out the low-hanging fruit within a 100-mile radius of Brookings.” Initially, they focused on three key areas—big data analysis, actuarial skills and precision agriculture.

Chapel and Helder also compiled information on faculty interests and expertise. “We have opportunities to build teams and then market that to industry once we understand who needs what, but we have to develop a value proposition for the company,” Chapel explained. This is work that the Office of Engineering Research will continue, according to associate professor Stephen Gent, who began serving in June as the interim associate dean for engineering research.

“As we develop partnerships with the companies, we want to bring them closer to SDSU through the Research Park,” Chapel said. “At the end of the day, it’s about building relationships—and what we do for engineering, we can replicate with the other colleges.”
Research expenditures increase by more than $4 million

Research expenditures this year increased by more than $4 million. Expenditures rose 6.5% from $63.5 million in fiscal year 2018 to $67.6 million in fiscal year 2019.

Funding Sources FY2019
- University: $107,734
- Other: $19,385,855
- For Profit: $1,954,867
- State: $15,663,144
- Federal: $30,479,110

Colleges and Research Centers FY2019
- Others: $990,586
- Nursing: $577,018
- Pharmacy and Allied Health Professions: $978,762
- Arts, Humanities and Social Sciences: $1,300,184
- E. A. Martin Program in Human Nutrition: $848,269
- Natural Sciences: $8,542,265
- Education and Human Sciences: $1,034,307
- Sun Grant: $5,713,770
- EPSCoR: $4,704,326
- Jerome J. Lohr College of Engineering: $3,890,803
- Agriculture, Food and Environmental Sciences: $39,010,420

Developing SDSU technologies through the Research Park
New sensor monitors blood glucose through a breath

A simple puff into a handheld device may one day be all it takes for diabetics to monitor their blood glucose levels using a new technology being developed through startup company, Nano Tek LLC, in the Research Park at South Dakota State University.

The sensor device will work like a breathalyzer, but rather than measuring alcohol, the sensor measures acetone to determine an individual's blood glucose level, according to Harold C. Hohbach Endowed Professor in Electrical Engineering Qi Qiao. He and doctoral student Khalid Emshadi co-founded Nano Tek LLC.

“Acetone is a biomarker for blood glucose level,” explained doctoral student Md Tawabur Rahman, lead researcher for the technology. The sensor is highly sensitive and selective with a fast response, he noted.

The device will not only be painless, but reusable—no finger pricks or expensive test strips, explained Emshadi, who is the business development and marketing director.

Emshadi envisions putting the breath sensor into a smartphone along with an app that enables users to effectively monitor and manage their blood glucose levels. “This new technology promises to be revolutionary.”

LEFT: This flexible sensor could hold the key to diabetics one day monitoring their blood sugar with a simple puff into a handheld device. The technology is being developed by South Dakota State University researchers through startup company Nano Tek LLC.

RIGHT: Doctoral student Md Tawabur Rahman, left and Professor Qi Qiao prepare to use direct current sputtering to deposit a thin layer of gold onto the flexible plastic substrate.

Dennis Helder