insight

College of Veterinary Medicine and Biomedical Sciences Fall 2010 Vol. 36 No. 1

Stem Cell Research Offers Hope

Colorado State University

welcome

Dr. Lance Perryman

Dear Friends,

At the College of Veterinary Medicine and Biomedical Sciences, we strive to provide visionary leadership and excellence in veterinary education and biomedical discovery through innovative scholarship, cutting-edge research, essential outreach, and pioneering clinical activity. At the heart of all that we do, is the desire to serve society.

We work to deliver an excellent education by constantly challenging ourselves not to be complacent with what has worked, but to explore that which will help our students excel. In this edition of *Insight Magazine*, you'll see one example of this in the article on our veterinary student rotation at Harrison Memorial Animal Hospital.

In addition to our excellent Doctor of Veterinary Medicine degree program, our undergraduate ranks continue to impress. Word about the quality of education at Colorado State University is spreading, and this year we welcomed our largest freshman class in the University's history. The class also is the most diverse freshman class and one of the most academically qualified.

At the College of Veterinary Medicine and Biomedical Sciences, we seek to undertake research of international quality in focused areas of global significance for animal and human health. This year, for the third year in a row, Colorado State University had more than $300 million in research expenditures. You'll read about some of that research with our editorial focus on adult stem cell studies. CVMBS scientists are at the forefront of new therapies that may one day greatly impact diagnosis, treatment, and cures for devastating diseases such as cancer, kidney disease, asthma, and osteoarthritis.

We continue to recruit some of the most talented scientists in the nation to conduct research, educate our students, and provide service to our constituents. In addition, our faculty members are consistently recognized inside and outside of the University for their achievements. During the last year, faculty members honored with CSU, national, and international awards included Drs. Wayne McIlwraith, M.D. Salman, Gregory Amberg, Cynthia Smeraski, Stephen Withrow, Erica Suchman, Thomas Johnson, Sherry Stewart, Paul Lunn, Susan Lana, Narda Robinson, and so many more.

Our mission includes improving animal health and welfare in Colorado, nationally, and internationally. You'll read about Dr. M.D. Salman and his work around the world, particularly in developing countries that are facing great challenges in establishing stable food supplies in the face of drought, civil war, and disease. We are promoting public health and supporting society through an improved understanding of the relationships between people, animals, and the environment.

During a time of economic challenge, we are particularly aware of the need to fully engage with the stakeholders who will impact the continued growth and vitality of the College of Veterinary Medicine and Biomedical Sciences. Through new communications tools, we are connecting with our students, alumni, donors, private sector partners, governmental entities, and others who wish to join us in our efforts to serve society as we move into the future.

As a part of all these efforts, Colorado State University is engaged in a comprehensive campaign to raise $500 million by 2012. The College committed to raising $100 million of the University total. We have exceeded that goal, in large part due to the hard work of our faculty, staff, and Office of Development, led by Development Director Paul Maffey.

Thanks to each of you who continue to support the College of Veterinary Medicine and Biomedical Sciences. Through your contributions, we are able to provide scholarships to deserving students, fund research into promising areas of biomedical science, enhance educational programs, build facilities, outfit laboratories, and fund faculty positions that help us deliver on our promise – to serve society.

Best regards,

Dr. Lance E. Perryman
Dean, College of Veterinary
Medicine and Biomedical Sciences

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insight

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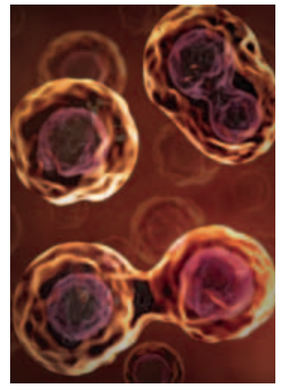

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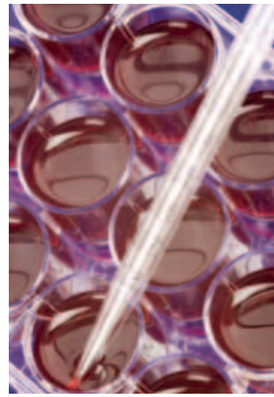
Stem Cell Science Growing Despite Controversy



Stem cell cloning

The phrase "stem cells" triggers a veritable avalanche of reactions: controversial, groundbreaking, hype, miracle cures, societal division, political football, biomedical advances, and, finally, hope for the incurably ill. For all that has been written and debated, one thing is certain. A lack of clarity around stem cells fuels a debate that often hides scientific advances being made in less controversial adult stem cells and induced pluripotent stem cells.

The use of stem cells as medical therapy has been around for more than five decades. Bone marrow transplants, which concentrate either a patient's own or donated bone marrow stem cells, are used most commonly to treat leukemia, Hodgkin's disease, multiple myeloma, and immunodeficiency disorders. At the College of Veterinary Medicine and Biomedical Sciences, researchers are pursuing investigations into the role of stem cells in early pregnancy and connections to preeclampsia; how bone marrow stem cells may enhance healing in horses with tendon and joint injuries; stem cells and kidney disease in cats; and much more.

"The term stem cell is quite broad and covers many different types of cells," said Dr. David Frisbie, Associate Professor in the Department of Clinical Sciences and a faculty member with the Orthopaedic Research Center. "But two common features of all stem cells are that they can self-replicate and, with correct signaling, can differentiate to any type of cell in the body."

Types of Stem Cells

Embryonic stem cells are primitive (undifferentiated) cells derived from a five-day preimplantation embryo that are capable of dividing without differentiating for a prolonged period in culture. From embryonic stem cells come all of the body's 212 cell types.

Somatic (adult) stem cells are undifferentiated cells found in smaller numbers in many organs and tissues with a limited capacity for both self-renewal (in the laboratory) and differentiation. Such cells vary in their differentiation capacity, but are usually limited to the cell types in the organ of origin, such as kidneys, liver, and pancreas. Some of these cells are prolific, like those found in bone marrow, while others rarely divide, like those found in the pancreas.

Induced pluripotent stem cells are somatic cells that have been manipulated to enter an

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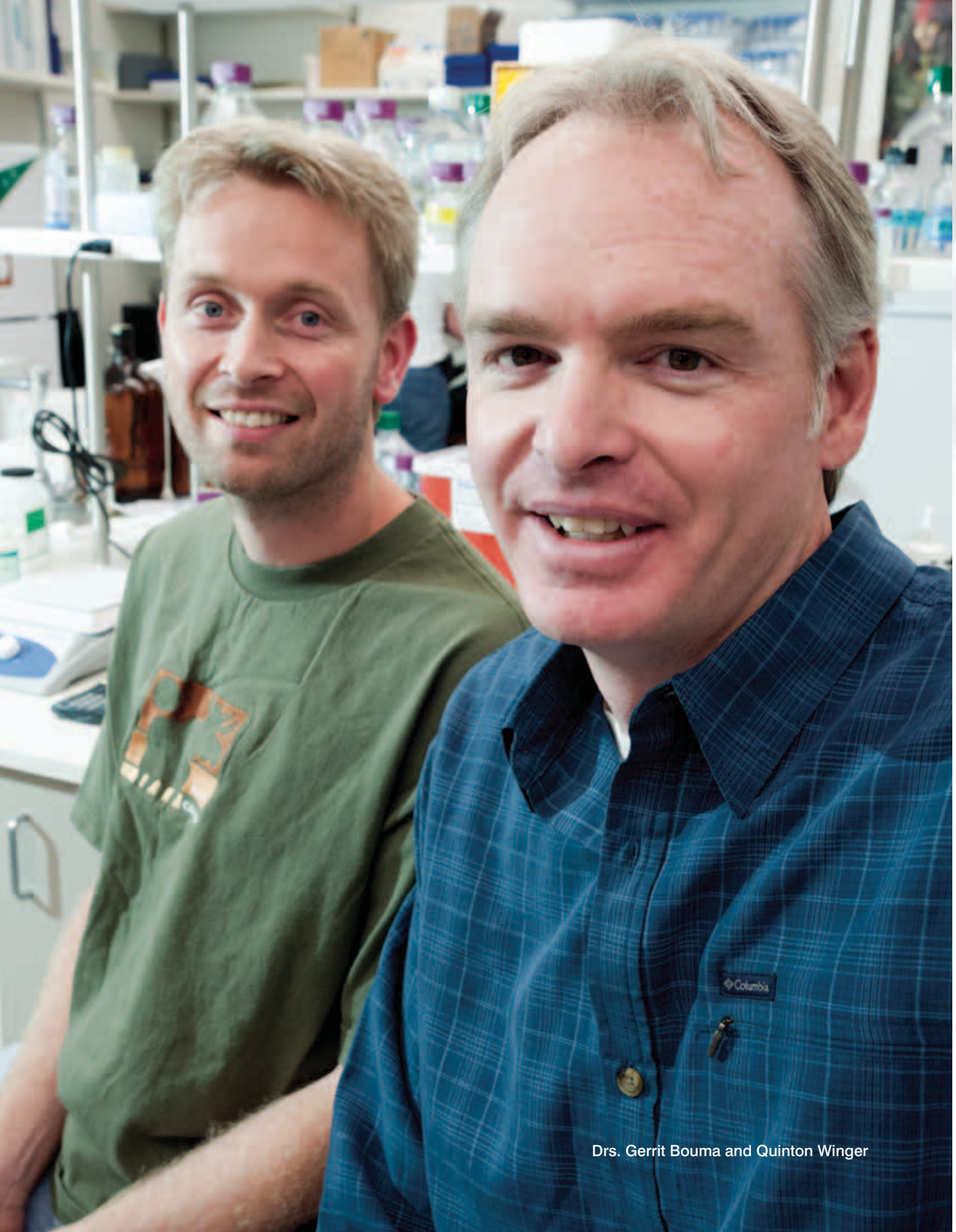


Drs. Gerrit Bouma and Quinton Winger

Studies Shed Light on Stem Cell Biology

In the public commons, most conversations about stem cells revolve around the curative possibilities of these "eternal life" building blocks, but researchers also are interested in what happens when stem cells fail to proliferate or differentiate according to plan. In the Department of Biomedical Sciences, Drs. Gerrit Bouma and Quinton Winger are investigating the role of a novel gene regulatory mechanism involving LIN28 to determine if disrupted regulation may play a role in the development of preeclampsia in pregnancy and reproductive cancers, and provide diagnostic markers for these conditions.

Preeclampsia

Globally, preeclampsia and other hypertensive disorders of pregnancy are a leading cause of maternal and infant illness and death. The condition can be life-threatening for the mother, as well as cause premature birth, intrauterine growth restriction, acidosis (when nutrients and oxygen through the placenta are restricted and lactic acid builds up), disability, and even death of the fetus. Conservative estimates suggest these disorders are responsible for 76,000 maternal deaths and 500,000 infant deaths each year (Preeclampsia Foundation). Researchers have long sought to find a diagnostic test for early detection of preeclampsia and other hypertensive disorders, as preventive care can help to avert some of the worst outcomes.

"Preeclampsia affects between 4 percent and 8 percent of all pregnancies worldwide and accounts for 20 percent of maternal mortality in the United States," said Dr. Winger, who is an Assistant Professor in the Department of Biomedical Sciences. "This research will improve our knowledge of trophoblast proliferation, differentiation, and invasion, by investigating LIN28, a novel gene regulatory pathway in trophoblast cells."

Trophoblast cells form the outer layer of a blastocyst which provide nutrients to the embryo and develop into a large part of the placenta. Trophoblasts are formed during the first stage of pregnancy and are the first cells to differentiate from the fertilized egg.

Proliferation and differentiation of trophoblast cells are necessary during early stages of pregnancy to produce a healthy placenta.

"To date there is no treatment or method of prevention for placenta insufficiency or preeclampsia except for premature delivery of the fetus," said Dr. Winger. "We want to find out what goes wrong in pregnancy that causes preeclampsia to develop, and we are tracking these problems all the way back to the early stages of implantation. We believe that when the invasion of the placenta into the mother's uterus is too shallow, it sets up a cascade of events that may eventually lead to preeclampsia."

Dr. Winger's research, using a mouse model, is testing the hypothesis that pluripotency factor LIN28 regulates molecular pathways controlling proliferation and invasion of human trophoblast cells. His research team wants to determine if LIN28 is necessary for the establishment and maintenance of the placenta. Long-term goals of his research are to identify critical genes involved in healthy and pathologic placental development and to identify markers that are useful for presymptomatic diagnosis of placental abnormalities.

Ovarian and Testicular Cancer

Cancer cells share in common at least one trait with stem cells – both proliferate – though with cancer cells the proliferation is cell growth gone haywire (cancer cells are often called immortal cells because they can divide an unlimited number of times, seemingly unaffected by the Hayflick limit which in humans is between 52 and 60 cell divisions). A third type of cell, whose very existence is still the subject of debate within medical research, is the cancer stem cell. This cell may generate tumors through self-replication and has the ability to differentiate into multiple cell types in a tumor. One reason cancers may recur is that therapies target cancer cells, while not being particularly effective against the cancer stem cell.

"Ovarian cancer is an especially insidious cancer, as its symptoms often are similar to other common conditions such as digestive and bladder disorders, and in most cases the cancer cells metastasize," said Dr. Bouma, an Assistant Professor in the Department of Biomedical Sciences. "It currently is the most lethal gynecological malignancy. Physicians can remove the ovaries, use chemotherapy, and have tumors come back five years later. The debate is whether cancer stem cells exist that give rise to recurrence and metastasis. If they do, can we develop new therapies and diagnostics that will target cancer stem cells and help to prevent metastatic disease?"

Dr. Bouma is investigating gonadal tissue markers for stem cells that show up in ovarian and testicular cancers. LIN28, which is high in stem cells, regulates a group of small non-coding microRNAs that in turn can regulate thousands of other downstream target genes. Because these markers are present in human ovarian cancer cell lines and in testicular germ cell tumors, Dr. Bouma's long-term goal is to see if LIN28 might provide a diagnostic marker for the earlier detection of ovarian and testicular cancers giving patients a better chance at treatment and cure.

"Part of what we are doing is looking at cell lines in ovarian cancer patients," said Dr. Bouma. "We are investigating how LIN28 and Let-7 microRNA are involved in causing cells to transform into tumor cells. Recent experiments in my lab indicate that ovarian cancer cells secrete small vesicles (membrane-enclosed structures) that contain and transport biomaterials controlled by LIN28. These vesicles and their contents are markers of pregnancy, but we also believe they might serve as diagnostic markers for early-stage ovarian cancer or preeclampsia."

In their investigations, Drs. Bouma and Winger use a variety of different animal models, including pregnant sheep, transgenic mice, and human ovarian cancer cells. In addition, pluripotent trophoblast stem cells are used to find out how different factors such as LIN28 can regulate basic cell function including cell proliferation and differentiation.

For Drs. Bouma and Winger, stem cells offer the opportunity to investigate the biology of cells at the most basic level, examining how stem cell development impacts health. In addition, their work may help uncover new biomarkers that can provide early warning systems for preeclampsia and other prenatal hypertensive disorders, as well as for certain types of cancers, including ovarian and testicular cancers.

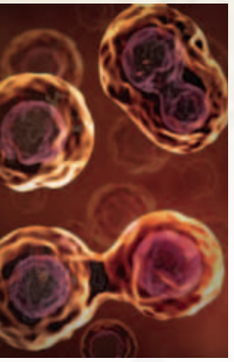
"Recent experiments indicate that ovarian cancer cells secrete small vesicles that contain and transport biomaterials controlled by LIN28. These vesicles and their contents are markers of pregnancy, but we also believe they might serve as diagnostic markers for early-stage ovarian cancer or preeclampsia."

Dr. Gerrit Bouma
Department of Biomedical Sciences

Treating Equine Musculoskeletal Injuries

Many great athletes as well as weekend warriors, human and horse alike, have been sidelined by injuries to the more susceptible tissues of the body, particularly the lateral and medial menisci, that are slow to heal and difficult to repair. For both veterinarians and physicians, and their animal and human patients, new hope may be coming in the form of mesenchymal stem cells derived from bone marrow.

MSCs are multipotent stem cells that can differentiate into a variety of cell types, including bone and cartilage. At Colorado State University's Orthopaedic Research Center, scientists are investigating the potential of these cells when they are harvested and expanded, and injected into injured tissues following arthroscopic surgery and after tendon and ligament tears. Results to date have been encouraging.



Mesenchymal stem cells

"In 2003, we started work with adult-derived stem cells in horses because of the promising work that had been done in other species," said Dr. David Frisbie, an Associate Professor in the Department of Clinical Sciences and member of the Orthopaedic Research Center. "Techniques had been developed to proliferate these cells without having them differentiate, but a central question remained. These cells are very powerful, so how do you control them?"

The ORC group had been approached to work with embryonic stem cells that, when tamed in a petri dish, are fairly easy to control. The outcomes once they are injected into a patient are less predictable. Dr. Frisbie notes that concerns over propagation, feeder cells, safety (particularly related to the risk of later development of cancerous tumors or the incorrect tissue), cost, and ethical issues remain concerns as the future of embryonic stem cell research is debated.

"We have continued to monitor this area, but have yet to see a clear benefit in clinical patients," said Dr. Frisbie. "With adult-derived stem cells, we are at the cutting edge of stem cell therapy using a method that is practical and affordable, and grounded in the reality of what is needed in a veterinary practice."

Working with the Massachusetts Institute of Technology and former MIT graduate student Dr. John Kisiday (who is now a faculty member of the Department of Clinical Sciences), the Orthopaedic Research Center began a series of investigations using bone marrow tissue as compared to adipose (fat) tissue to harvest and expand stem cells; benefits of MSC therapy in the treatment of arthritis; and the use of MSC therapy as an adjuvant to improve healing and recovery following arthroscopic procedures in stifle injuries, particularly the medial meniscus.

Dr. David Frisbie with Jen Suddreth, ORC barn manager

Dr. Frisbie, working in cooperation with Oakridge Equine Hospital in Oklahoma, Washington State University, and Texas A&M, has presented his results at the American Association of Equine Practitioners and the American College of Veterinary Surgeons annual conferences. His team has shown dramatically improved rates of "return-to-work" for horses treated with the adjuvant therapy. And, while results are promising, researchers are still exploring the basic biology of why improvements are seen with the addition of MSC therapy.

"We know there is improved healing and return-to-work, but we aren't sure exactly why," said Dr. Frisbie. "We do know from other work that stem cells considerably decrease scarring, but we are exploring this in more detail. We need to get a better idea on how the stem cells orchestrate their action. It's like the stem cells are policemen arriving at the scene of a crime and then setting into motion everything that needs to happen next."

While a popular misconception is that stem cells stay and multiply and build new tissue, Dr. Frisbie said that is not the case. Very few of the introduced stem cells stay within the injury location, but it seems to be enough to rally the body's reparative forces.

"With the success we've seen so far, we have expanded our studies to look at tendon and ligament tissues," he said. "Up until recently, there has been a dearth of people doing credible research in this area, but we are beginning to see a body of work develop that is leading to tangible results that will improve the health of horses, and may translate into new treatment approaches for people."

Drs. Jessica Quimby and Steven Dow

Promising Therapy for Asthma and Kidney Disease

To parents whose children suffer from asthma, life is a roller coaster. When symptoms are under control, they watch and wait and live in fear of the next severe attack. Trips to the emergency room are commonplace for many families with asthmatic children. A routine day can quickly devolve into a life-threatening respiratory event with their child struggling for each breath. To these families, stem cell therapy offers the promise of a treatment that may reduce their children's symptoms, improve their quality of life, prevent acute and severe illness, and even save their lives.

In the United States, asthma is a disease that is on the increase. Asthma ranks among the most common chronic conditions, affecting an estimated 14.9 million people and causing more than 1.5 million emergency department visits, about 500,000 hospitalizations, and more than 5,500 deaths annually. Statistics from the National Institutes of Health show that the burden of asthma in the U.S. population has been increasing during the past 20 years, especially among children. In Colorado State University's Department of Clinical Sciences, Drs. Steven Dow and Tracy Lehman Webb are hoping to change that trend.

"Looking at the immunological properties of stem cells – not to replace or regenerate new tissue – we see that stem cells can act as a very potent immune modulator that can reduce inflammation," said Dr. Dow. "In our work, we are trying to understand this ability from a level of basic science. We are asking what are the immunological properties of stem cells, what mediates those effects, and how can we capitalize on these properties to treat diseases, including asthma and chronic kidney disease."

Dr. Dow's team is partnering with National Jewish Health in Denver in an asthma project, using the mouse as a model for asthma disease in humans. In the studies, stem cells from adipose (fat) tissue are harvested and grown in culture, expanding out the stem cells. The stem cells are then introduced into the mouse model intravenously. Dr. Webb, a research associate in Dr. Dow's lab, labels the stem cells so that the team can track the cells' whereabouts once the cells are in the mouse model.

"What we have found is that not many of the cells end up in the lung, but the ones that are there exert a profound effect on lung function," said Dr. Dow. "There is a marked reduction of lung inflammation after stem cells are injected. For asthma patients and others with respiratory illness, the hope lies in clinical trials, but we are years away from that."

In another study, working with Dr. Jessica Quimby, a clinician and doctoral student in the College of Veterinary Medicine and Biomedical Sciences, Dr. Dow is investigating the potential of stem cell therapy to treat chronic kidney disease in cats. In this study, adipose stem cells from donor cats are expanded and injected into patients. Dr. Quimby spearheaded the project when she approached Dr. Dow because she was frustrated by the lack of treatments available for treating chronic kidney disease and was interested in trying something new. Chronic kidney disease is one of the leading causes of death in older cats and, currently, veterinarians can manage the illness to improve symptoms and extend life, but not cure the disease.

"She (Dr. Quimby) said, 'Well, what about stem cells?' and I said, 'Well, what about them?' and she was off and running," said Dr. Dow. "We have a very robust program going now and are seeing some exciting results."

In an ongoing pilot study, cats with kidney disease receive a series of stem cell infusions and are monitored for biomarkers of inflammation and kidney function. Dr. Dow said they hope to target cats that have stable disease and are early in the disease process. The donor cats are healthy, young cats that are adopted out following donation. Dr. Dow hopes that the pilot study will eventually receive more funding to support an expanded clinical trial.

"The stem cells don't seem to need to home to the organ to exert effect," said Dr. Dow. "What the stem cells seem to do is suppress inflammation and stabilize the progression of the chronic kidney disease. Over time, we might see improvements in symptoms as well. This study is generating interest from around the country, and we hope to be able to expand our research relatively quickly."

Dr. Dow noted that with so much debate about embryonic stem cells and tissue regeneration, some of the most exciting work in stem cells is in the areas of adult stem cells and their unique properties – areas of research that are not as controversial.

"It is exciting to learn more about the other properties of stem cells and conduct research that may one day bring these properties into a therapeutic setting," said Dr. Dow. "We know stem cells can stimulate healing and reduce inflammation, and might be used as therapies for a whole range of diseases including asthma, arthritis, kidney disease, and joint disease. I think we really are on the cusp of some exciting breakthroughs."

"We know stem cells can stimulate healing and reduce inflammation, and might be used as therapies for a whole range of diseases including asthma, arthritis, kidney disease, and joint disease. I think we really are on the cusp of some exciting breakthroughs."

Dr. Steven Dow
Department of Clinical Sciences

Bone graft treated with fibrin only.

Companion Animals Benefit from Stem Cell Research

> "We all desperately want these therapies to offer new hope, not only to our animal patients, but new hope to cancer patients around the world."
>
> *Dr. Nicole Ehrhart*
> *Animal Cancer Center*

The Animal Cancer Center at Colorado State University is known for its development of cutting-edge therapies that have helped move the ball down the field of veterinary oncology. Some of those advances, including limb-sparing surgery, have crossed over to human medicine and continue to make an impact in the lives of those affected by cancer. Now, as ACC researchers seek to enhance the treatment value of limb preservation and other innovative cancer treatments, they are taking a closer look at the role stem cell therapy may play.

"In our lab, we are working primarily in two areas – the use of stem cells to enhance healing and long-term recovery after limb-sparing surgery, and the use of stem cells to strengthen targeted bone after radiation therapy," said Dr. Nicole Ehrhart, a Professor in the Department of Clinical Sciences and faculty affiliate with the Animal Cancer Center. "We are only at the beginning of our explorations, but I think that stem cell therapies look very promising for future developments in the treatment of cancer. At the same time, we need to look at the darker side of stem cells and the risks that they pose for creating other health problems, including the possible later development of new cancers."

Dr. Ehrhart said her interests lay mainly in how stem cells can help a bone to heal, or how to support bone in areas where the bone has been exposed to chemotherapy or radiation therapy, or where donor bone has been grafted in limb-sparing surgery. Specifically, her team would like to better understand if stem cells can work to enhance the recovery of damaged tissues and, if so, what are the mechanisms?

"The bone used in limb-sparing surgeries is cadaver bone and is not matched to the recipient, as compared to other transplant procedures like kidney or lung transplants," said Dr. Ehrhart. "When we do a limb-sparing surgery, what we see is that the bone heals slowly and not very well. The recipient's bone eventually grafts onto the ends of the donor, but the middle of the bone remains dead forever. This can lead to problems later in life when we see fractures or complete bone resorption triggered by the immune system."

In mouse studies, Dr. Ehrhart's team is showing that the injection of stem cells to the bone graft site creates a higher incidence of grafting, potentially building a stronger bridge between the donor and recipient bone. Whether the stem cells are recruiting other cells or are themselves populating the site is still unclear and one of many questions to be answered.

In a separate study with a rat model, researchers are investigating whether stem cells can help normal bone tissue recover from the collateral damage caused by exposure to radiation for cancer treatment. Normal bone is often weak following radiation treatment and can fracture more easily. Injections of stem cells may help grow new normal bone and strengthen the existing bone matrix. In her studies, Dr. Ehrhart uses both mesenchymal stem cells (MSC; multipotent stem cells that can differentiate into a variety of cell types including osteoblasts) and adipose-derived stem cells.

"With these studies, we want to begin to understand how multipotent stem cells help bone to heal or repair," said Dr. Ehrhart. "We want to understand how MSCs home to a site and, if they do end up there, what is the biologic effect? Are they there and gone or do they stick around? There are a lot of arms to this research, but I think what we are really most interested in is the question of recruitment versus direct interaction. Part of our research focuses on attaching fluorescing markers to stem cells that are injected so we can see where they disperse. "

For the "darker side" of stem cells, researchers are concerned that some adult stem cells used in autologous therapies may be genetically preprogrammed. These stem cells may be initially therapeutic but, over time, may eventually re-establish the cancer they are supposed to help cure. This aspect of the potential negative downside of stem cell research is just as important as finding cures, Dr. Ehrhart said, and something Colorado State University is uniquely equipped to do, especially as researchers look to move into clinical trials at the Veterinary Teaching Hospital.

"What Colorado State University has – unlike any place else in this country or world – is a strong translational aspect where we can go relatively quickly into clinical trials," said Dr. Ehrhart. "Here, we bring it all together and that is really unique. We can go from the petri dish to a mouse model and into a real-world pet animal model. We have that bridge right here. We all desperately want these therapies to offer new hope, not only to our animal patients, but new hope to cancer patients around the world."

Dr. Nicole Ehrhart

Bone graft treated with fibrin and stem cells.

Allison Ong neuters a dog during her rotation at Harrison Memorial.

Veterinary Students Test Their Wings

Cinnabuns, a too-cute Chihuahua with fruit bat ears and anime eyes, has returned to Harrison Memorial Animal Hospital for her last set of puppy shots. Turning on the charm, she works the room to ensure a never-ending supply of treats. She has the nervous but hopeful look of so many dogs at veterinary clinics, the one that says "I'll take your tasty treats, but I have a bad feeling there might be more to this."

Stethoscope in hand, Jessica McKenna is doting but not swayed by Cinnabuns and her attempts to be über-adorable. Cinnabuns will get her vaccinations and also have some blood drawn to check for heartworm. McKenna, who is a fourth-year Doctor of Veterinary Medicine student at Colorado State University, moves with confidence and surety as she does a brief physical exam on Cinnabuns and then takes her to the prep room. A few moments later, Cinnabuns has transformed from sweetness personified to evil incarnate as McKenna prepares to draw blood from her diminutive leg. A small muzzle protects McKenna and the technicians assisting her and, soon, a slightly ruffled and sullen Cinnabuns is back in the arms of her adoring owner.

McKenna and fellow student Allison Ong are nearing the end of their two-week rotation at Harrison Memorial Animal Hospital in Denver, a not-for-profit veterinary hospital that is a program of the Colorado Veterinary Medical Foundation. The hospital provides donor-subsidized veterinary services to economically disadvantaged pet owners in Denver, and also provides veterinary students from CSU the opportunity to practice medicine in a nonacademic, supervised, and supportive environment. The result is win-win-win – for students, for Harrison Memorial, and for Harrison Memorial's clients and their companion animals.

"Through school, we learn about diseases and steps to take, but the challenge at Harrison Memorial is to take that knowledge and figure out what your client can afford and make the best choices possible for your patient's well-being," said McKenna. "Sometimes, due to the client's financial position, we don't have the ability to perform all the tests we would like, so we have to rely more on our diagnostic skills and listen carefully to our clients. It's not so much about what we can't do, but more a focus on what we can do given limited resources."

The two-week rotation enriches students in a unique way, said Ralph Johnson, Executive Director of the Colorado Veterinary Medical Foundation. Harrison Memorial serves a special population that challenges the students' confidence and assertiveness, and it also calls their own personal beliefs into question when faced with clients who are economically disadvantaged and who often have been forced to defer their pet's healthcare until health conditions become so critical that sometimes little can be done.

"Students are faced with clients who have a very different educational level and cognitive ability," said Johnson. "Some may have disabilities that make a treatment plan difficult

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Where in the World is Mo Salman?

Dr. Mo Salman, far right, in Afghanistan

Bringing the science of veterinary epidemiology to intractable global challenges in animal and human health

Taking a page from reality television programming, Dr. Mo Salman has real potential for his own show – perhaps, *Keeping up with Mo Salman, Veterinary Epidemiologist,* a la *Keeping up with the Kardashians*. Whether it's bringing rival ethnic groups together in Bosnia and Herzegovina, donning a flak jacket in Afghanistan, or delicately dining on goat brain in Outer Kyrgyzstan, Dr. Salman's international ventures seek to bring the science of veterinary epidemiology to intractable global challenges in animal and human health.

As Director of the Animal Population Health Institute at Colorado State University, Dr. Salman is particularly concerned with addressing the endemic and emerging problems of developing countries, specifically those countries that face complex on-the-ground logistical concerns due to poverty, political unrest, cultural upheaval, war, climate change, or natural disasters. Most recently, Dr. Salman's group was awarded a $15 million grant from the United States Agency for International Development to address the impact of climate change on global livestock systems.

Dr. Salman was born in Baghdad, Iraq, where he completed his veterinary degree at the University of Baghdad (in a joint program with the University of Edinburgh, Scotland) and mandatory military service. He moved to the United Arab Emirates in 1974, and he was the second veterinarian to practice in that federation. He moved to the United States in 1978 where he was in private practice for a short time before embarking on graduate studies at the University of California, Davis.

"Because of my own experiences and interests, my goal was to eventually work in developing countries where the needs are great and resources limited," said Dr. Salman, who also is a Professor in the Department of Clinical Sciences. "At UC Davis, I was able to work in the mastitis laboratory and pursue my master's degree and PhD, and then contract independently with a dairy farmer in Mexico who was interested in tuberculosis and brucellosis."

Looking for an academic home from which to build his program in international veterinary epidemiology, in 1984 Dr. Salman applied for a position at Colorado State University as an analytical veterinary epidemiologist. In 2002, he helped establish the Animal Population Health Institute at Colorado State. The institute is devoted to addressing animal health around the globe on the principle that protecting animal health can help countries maintain or obtain economic stability, protect an important resource, and help to protect the health and stability of citizens within those countries.

His work has taken him to embattled countries such as Bosnia and Herzegovina, where the existing veterinary infrastructure was decimated by ethnic cleansing and ensuing warfare. There, working with the U.S. Army, he had to be a veterinary epidemiologist, neutral diplomat, and demanding taskmaster.

"After the armed conflict ended, I was in Sarajevo and could see firsthand the devastation of this beautiful city," said Dr. Salman. "My role was to bring together those who would rebuild the veterinary system in the country, and help them develop a plan to do so. For some of those individuals, it was the first time they had to sit down at a table together and the wounds and anger were still fresh. I had to ask them to set aside what had happened and focus on the task at hand. After the first meeting, I remember leaving the conference room and there was the media outside asking how we got these people to sit together. I just said that they were professionals and we had a job to do."

Since then, Dr. Salman has worked throughout Eastern Europe (particularly after the collapse of the Soviet Union), Africa, and the Far East, and Middle East, trying to make life better for animals and humans, regardless of religion, ethnicity, or nationality. His work often focuses on helping countries identify and combat zoonotic diseases, or diseases that can spread from animals to humans, such as avian influenza. He also has played a significant role as a representative on international panels focused on world health, as well as helping the United States government address animal health at home and abroad.

Much of Dr. Salman's success has to do with how he works with local communities. Rather than imposing Western practices that may not be pertinent in developing countries, he has found that most of the individuals he works with are open to new ideas and are ready to move into a different paradigm. But novel proposals have to make sense given a country's distinctive cultures and often limited resources.

"Each country has its own unique set of challenges. Much of what we have to consider is the role of the production animal in the community and to the family, and the cost/benefit of a husbandry program," said Dr. Salman. "In the United States, at a large dairy farm, it may not make sense economically to vaccinate for a particular disease. But in another country, where subsistence farming is the norm, vaccines may have a greater value in keeping a single animal or small herd healthy."

Especially rewarding for Dr. Salman are successful programs in countries that have seen too much conflict and want to move toward peace, prosperity, and self-reliance. In Afghanistan and Iraq, Dr. Salman noted, the majority of citizens don't want war. "What they want," he said "are fewer arms and more technical and professional assistance so they can move forward. They want to learn how to take care of their country."

Dr. Salman has received numerous recognitions for his work, including a Fulbright Scholarship in 1991; the American Humane Association's Waco F. Childers Award in 1998; the U.S. Department of Agriculture's Animal and Plant Health Inspection Service Administrative Award for Animal Health in 2007; the American Veterinary Medical Association's 12th International Veterinary Congress Award in 2007; and the 2009 Alumni Researcher of the Year Award from the University of California, Davis. In 2006, he was selected to serve on a panel of scientific advisers on animal health and welfare to the European Food Safety Authority, the only North American among 191 scientists serving on the panel.

Left: Dr. Salman investigates avian influenza in a Turkish village in 2008.

Dr. Salman lectures during the first scientific conference for the animal health program in Baghdad, Iraq, in 2007.

Dr. Salman visits a new animal health hospital and artificial insemination center in Afghanistan in 2006.

In September, Dr. Salman received the 2010 Penn Vet World Leadership in Animal Health Award, a prize that comes with $100,000 in unrestricted funding. The award, underwritten by the Vernon and Shirley Hill Foundation, is presented annually to a veterinarian who has dramatically changed the practice and image of the profession and substantially influenced the lives and careers of others. Dr. Salman is the third veterinarian to be honored with the award, which was presented on Sept. 28 at the University of Pennsylvania.

Impact of Climate Change on Global Livestock Systems

Colorado State University received a $15 million grant this summer from the United States Agency for International Development to look at the impact of climate change on livestock around the globe, particularly in developing countries.

Colorado State will manage the grant and, during the next five years, develop partnerships for multiple research projects in areas such as sub-Saharan Africa and central Asia. The grant was awarded to CSU's Animal Population Health Institute and the University's Institute for Livestock and the Environment.

The grant funds CSU's oversight of the project and research in developing countries. The research focuses on ways to help developing countries manage livestock under changing climate conditions. In these developing countries, a large portion of the population depends upon livestock for a significant part of their income. Ultimately, the goal is not just to study these processes but to help livestock producers adapt to climate change and improve their livelihoods.

"The risks to livestock and developing livestock industries in these countries as a result of climate change encompass a broad range of issues and challenges," said Dr. Mo Salman, Principal Investigator and Professor in the Department of Clinical Sciences, College of Veterinary Medicine and Biomedical Sciences. "As just one example, we know that climate change may drive changes in precipitation and temperature in many regions that are already arid or semi-arid. That leads to reduced crop yields and pasture productivity for livestock, which makes it difficult for farmers and herders to support their livelihood. Because they can no longer survive off the land, those farmers and herders may migrate to urban areas. This changes the social fabric of communities, alters a people's cultural identity, and potentially increases political instability."

Because climate change impacts different regions of the globe in different ways, the grant helps scientists from multiple disciplines start to identify the scope, location, and nature of these impacts so that planning for potential adaptations can begin. The grant focuses on learning more about the risks and opportunities of climate change on livelihoods in the areas under study, the social and environmental impacts, how infrastructure can be strengthened to better support food safety and animal health, and how livestock herders can manage their businesses to optimize production while protecting the environment and health of animals.

The program is led by a CSU management team of Dr. Salman; Dr. Shana Gillette, Co-Principal Investigator; Jessica Davis, Program Director; and Dana Hoag, Associate Director. In addition to the management team from the College of Veterinary Medicine and Biomedical Sciences and the College of Agricultural Sciences, other CSU collaborators include the Natural Resource Ecology Laboratory and the Warner College of Natural Resources.

Dr. Mo Salman

Dr. Gerald Callahan

Combining Passion for Science with Love of Writing

For the last 25 years, Dr. Gerald Callahan has woven together words and science to bring the more esoteric heights of scientific discovery to the straightforward plane of the printed page. While his books serve as a vehicle for his own creative release, they serve even more importantly the greater public good by taking complex scientific concepts and putting them into a language and context accessible to a nonscientific audience.

His latest work tackles not only science, but also the court of public opinion and societal debates couched in terms of right and wrong, good and bad, and choice versus biologic destiny. *Between XX and XY: Intersexuality and the Myth of Two Sexes* explores the biology of sexual determination and examines the lives of the 65,000 individuals born worldwide each year who are of indeterminate sex. The book was a finalist for a Colorado Book of the Year Award in 2010.

Dr. Callahan, who has a joint appointment in the Department of English and the Department of Microbiology, Immunology and Pathology, began to discover science early in life, but his love of words didn't develop until later.

"My father was a petroleum engineer so I was exposed to science at a very early age," said Dr. Callahan, who grew up in Utah. "I got started with chemistry – I think it was a Gilbert Chemistry Set – and one of my favorite pastimes was mixing together different chemicals to see what would happen. It was a little different in those days.

"My best experience, though, was in biology. I had a great teacher who set me on that path. My biology teacher was a nun who was very creative on a low budget and pushed us to be creative too. She used to pull part of her habit over her head to show what an amoeba looked like. We explored the world of box elder bugs, puddles of water, microscopic life – she just really made science come alive."

Dr. Callahan attended the University of Utah where he graduated with a bachelor's degree in biological sciences, then entered graduate school to study biology as a master's student before transferring to a doctoral program in experimental pathology. After graduating in 1974, he moved to La Jolla, Calif., where he was in a postdoctoral program at the Scripps Clinic and Research Foundation. He conducted research and advanced his knowledge and skill set there for 10 years before joining the faculty at Colorado State University.

His research at CSU initially focused on trying to manipulate the immune system to treat cancer, looking at a particular group of molecules on the cell surface. But, as federal funding priorities changed, research dollars began to dry up and he began to write. His wife signed him up for a poetry course, and the ink began to flow.

"I had been messing around with poetry for years, and was always telling my wife I wanted to learn more, and to do more," said Dr. Callahan. "I think she just got tired of my one-day-I'll-get-around-to-it delaying tactic and just called my bluff."

Dr. Callahan began to write and was published in smaller milieus, first poetry and then essays. He began to write in earnest, learning firsthand the cruelties of editors and publishers offhandedly rejecting the blood, sweat, and tears of new writers. (Most memorable was a rejection note from the *Denver Quarterly* that consisted of a corner ripped off of a steno pad with just one word printed on it – "*Sorry.*") His first collection of essays, *River Odyssey: A Story of the Colorado Plateau*, was published in 1998, followed in 2002 by his first venture into creative nonfiction science writing, *Faith, Madness, and Spontaneous Human Combustion: What Immunology Can Teach Us About Self-Perception*.

"I felt that in my writing I had more freedom and more creativity, but I felt a little guilty so I limited myself to writing in my spare time," Dr. Callahan said. "Eventually, I came to focus on a scientific style that allowed me to bring creative expression to science, leading to a joint appointment in the Department of English. It's a natural pairing. Poets and scientists do basically the same thing – we try to uncover answers to things we are struggling to understand, and then strive to share that knowledge."

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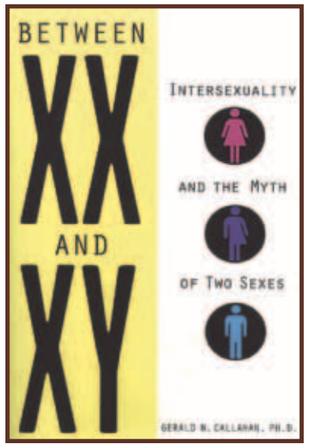
>
> *Dr. Gerald Callahan*
> *Department of Microbiology, Immunology and Pathology, and Department of English*

Dr. Callahan's work has been featured on National Geographic Television, the ABC Evening News, the *Los Angeles Times*, National Public Radio, and *Salon.com*, as well as many international news outlets. In addition to English, his books have been published in Portuguese, Chinese, Japanese, and Korean. Today, Dr. Callahan continues to teach in the College of Veterinary Medicine and Biomedical Sciences and the College of Liberal Arts. He is a faculty affiliate with the graduate program in creative nonfiction writing, and still finds great fulfillment in exploring the world of science under the laboratory microscope as well as through the written word.

Exploring Biologic and Social Definitions and Ideas of Gender

During an honors course in creative writing, Dr. Gerald Callahan was challenging his students to explore how they develop ideas about themselves: of how they see and define self. Almost all his students started their self-definition with gender, establishing themselves first as man or woman. And that set Dr. Callahan to wondering. He did a Google search on gender and was quickly overwhelmed by the number of results categorized by "indeterminate sex."



That initial foray into the world of intersexuality led in 2009 to the publication of his most recent book, *Between XX and XY: Intersexuality and the Myth of Two Sexes*. The book tackles the presupposition of two sexes, seeing that presupposition as more of a social idea rather than a biological construct. The chromosomal structure, states Dr. Callahan – at its most basic level, XX for females and XY for males – is not fully predictive of a person's sexual identity. A full spectrum of genetic disorders, environmental influences, hormonal factors, and continuum of genital development complicate the simple picture of boy and girl, of man and woman.

"Each year, more than 65,000 individuals are born worldwide who are of indeterminate sex," said Dr. Callahan, who is a Professor in the Department of Microbiology, Immunology and Pathology, with a joint appointment in the Department of English. "There are hundreds of different conditions that affect sexuality and humans often don't fit neatly into the boxes that we've constructed as a society. The things that we take for granted are not so fixed."

In his book, Dr. Callahan explores the biology and physiology of intersexual individuals, as well as explores the lives of a few who have struggled to define their own sexuality. Born during a time when doctors believed the right thing to do was quick surgical "fixes" on infants with indeterminate genitalia, these individuals often grew into adults with bodies, hormones, and minds that weren't in sync with each other.

"This book represents the story of those intersexual people who struggle day by day to fit into a world that often doesn't have a place for them," said Dr. Callahan. "Perhaps by developing a better understanding of intersex individuals, we can accept them for who they are and not view them as someone who has to be fixed. Perhaps, too, if we lose some of our preconceptions about sex, all of us can enrich our own lives and ways of thinking about ourselves."

Since publication of his book last year, Dr. Callahan has heard from numerous readers, including a woman who wrote that his book helped her and her husband accept their gay son. He's also heard from intersex individuals who found in his writings some answers to the questions they had regarding their own struggles around sexuality and their desire to find the right fit in a world dominated by two check-off boxes – male or female.

Books by Dr. Gerald Callahan

Between XX and XY: Intersexuality and the Myth of Two Sexes (2009)
Infection: The Uninvited Universe (2006)
Faith, Madness, and Spontaneous Human Combustion: What Immunology Can Teach Us About Self-Perception (2002)
River Odyssey: A Story of the Colorado Plateau (1998)

Essays

Blindsight (2008)

Dr. Callahan's books are available at the Colorado State University Bookstore, Amazon.com, and Barnes & Noble online.

"There are hundreds of different conditions that affect sexuality and humans often don't fit neatly into the boxes that we've constructed as a society. The things that we take for granted are not so fixed."

Dr. Gerald Callahan
Department of Microbiology, Immunology and Pathology, and Department of English

Cappy

Fund Established for Equine Dermatology

For 2 ½ years, Mary Lou Lane worked tirelessly to save her horse Cappy's life – not after a life-threatening bout of colic, or a traumatic injury, or even an infectious disease such as encephalitis – Cappy had a minor scrape on his front fetlock that, despite the best care, eventually cost him his life.

To honor Cappy and his fight, Lane has established Cappy's Equine Dermatology Research Fund at the Colorado State University Veterinary Diagnostic Laboratory to help support research related to diagnosing equine dermatology problems.

"The special bond we shared with Cappy is one that is understood by all those who love their horses," wrote Lane in a tribute to Cappy. "We never want them to know pain and suffering. Yet, despite their great physical strength, they remain fragile in many ways. With all the enormous advances in veterinary medicine, there are still so many conditions science is unable to conquer."

Lane first met Cappy in 1986 and adopted him when he was 9 years old. In 2007, Cappy got a seemingly minor scrap on his front fetlock. Despite prompt and constant care, he developed alopecia and lesions that extended from the fetlock down around the coronary band. Eventually, his foot was compromised and he developed laminitis. His heel, frog (part of a horse's hoof), and hoof slowly stopped growing and the coffin bone began to drop. Despite all the best efforts of Lane, her veterinarians, and farrier, Cappy eventually reached the point where he had to be euthanized.

His lower leg and foot were sent to the Veterinary Diagnostic Laboratory in hopes the veterinary pathologists there would be able to determine what organisms caused the dermatitis that led to the infection, and why all treatment was resisted. Pathologists are still trying to determine the underlying cause of the infection, and why it proved so difficult to treat.

"Despite all her efforts, Mary Lou was unable to save Cappy, but wanted to do something to help other horses and their owners," said Dr. Patricia Schultheiss, an Associate Professor in the Department of Microbiology, Immunology and Pathology, and a veterinary pathologist at the VDL. "What we hope to be able to do through this fund is to improve our equine dermatology diagnostics so that we can determine what a problem is, in order to help veterinarians develop better treatment plans."

Cappy's Fund will help researchers further develop the field of equine dermatology by working to improve diagnostic tools and treatment planning. To make a donation to Cappy's Fund, visit www.cvmbs.colostate.edu/ns/donors/ or call the CVMBS Office of Development at (970) 491-0663.

Leaping into the Future

CVMBS using social media to connect with alumni, family, and friends.

The College of Veterinary Medicine and Biomedical Sciences launched its new communications portal this summer, looking to connect with its constituents through student blogs and social networking sites including Twitter, Facebook, LinkedIn, and through the new CVMBS website.

The College's new website and communication tools are designed to engage everyone interested in biomedical and veterinary sciences and in Colorado higher education, reaching out to alumni, donors and friends, future students, current students, faculty and staff members, and all of those close to these constituents. Updated daily, the College's website and social media outlets keep readers current on what's new and what's coming up at the College of Veterinary Medicine and Biomedical Sciences.

This summer, visitors to the CVMBS website were able to travel the world with student bloggers who shared their internship and research experiences, from the wilds of Alaska to the high-tech world of cyclotrons in Japan. The blogs, with new students featured this fall, give CVMBS students the opportunity to enrich their personal learning experiences while educating and informing others.

Visitors can keep up to date on the latest research and teaching news, as well as keep abreast of what is happening at the College and University through the CVMBS calendar. Potential undergraduate, graduate, and Doctor of Veterinary Medicine students can find programs of study, application processes, and videos from current students on what campus life is really like. Current students can find information on course and seminar schedules, scholarships, and international opportunities. Alumni can connect or reconnect with the College through the Alumni link.

Get connected by visiting www.cvmbs.colostate.edu.

Find out how you can make a gift through the Donor link to support something you are passionate about, whether that is improving cancer treatment for humans and their companion animals, helping to eradicate tuberculosis, or providing scholarship support to our students.

We invite you to become an active part of the College of Veterinary Medicine and Biomedical Sciences community and engage in a broader scientific dialogue through our new web portal. Take a few minutes a day to be encouraged by the brilliance of young minds, to be inspired by the passion of our scientists, and to be moved by the compassion of our veterinarians.

Stem Cell Science Growing Despite Controversy

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embryonic stem cell-like state by being forced to express factors important for maintaining the "stemness" of embryonic stem cells. Mouse iPSCs were first reported in 2006 and human iPSCs were first reported in late 2007. Researchers are actively comparing iPSCs and embryonic stem cells to identify important similarities and differences.

Fields of Study

Many scientists study embryonic stem cells to better understand how normal human development takes place, as well as to understand the normal and abnormal functioning of stem cells. At Colorado State University, Drs. Gerrit Bouma and Quinton Winger, both Assistant Professors in the Department of Biomedical Sciences, are investigating the role of sheep stem cells in embryonic placental implantation, and correlations between abnormal implantation and the later development of preeclampsia in the mother. Stem cells are not only studied to understand normal biology but also to understand the biology of disease.

The use of autologous (self) stem cell transplantation, using somatic stem cells, is an active area of research looking particularly at how this technique can be used as adjuvant therapy to enhance healing and recovery from treatments such as limb-sparing surgeries in cancer patients, bone grafts, skin grafts, and tendon and ligament injuries as well as to augment injuries treated with arthroscopy. Dr. Frisbie's team has shown increasing rates of return-to-work for horses treated with bone marrow stem cells following arthroscopy as compared to those horses with similar injury that did not receive the additional therapy. Kidney disease in cats is also an active area of investigation for researchers at CSU, looking at the potential of somatic stem cell transplants to slow the rate of disease progression in patients.

Drug discovery is another important area of research. Once diseases are carefully modeled, researchers can study disease processes in controlled environments where drug therapies can be designed, tailored, and studied for effectiveness on the exact cells they are designed to treat.

Most controversial is research into the potential use of embryonic stem cells for treatment of a multitude of diseases, including Parkinson's disease, heart disease, Alzheimer's, multiple sclerosis, and others. This is known as regenerative medicine, using stem cells to regenerate or replace damaged tissues and organs. Research under way today uses existing cell lines. Uncertainty surrounds embryonic stem cell research programs in the United States due to court challenges and changing governmental regulations, particularly regarding federal funding of these research endeavors. Other concerns include the efficacy of embryonic stem cells because of possible health risks, ethical issues, and costs.

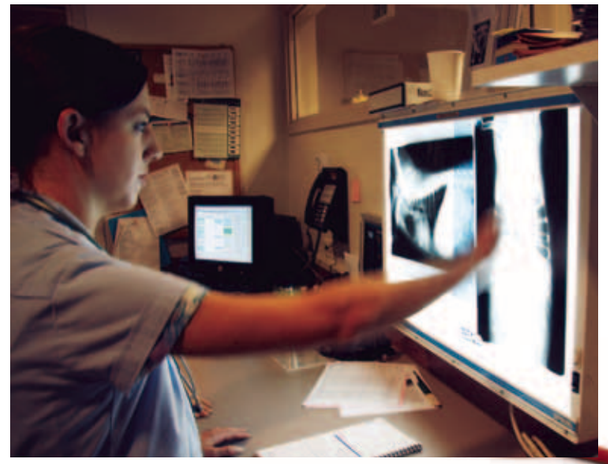
"Even if science can move forward with these studies, there are some pretty big challenges to the use of embryonic stem cells in medical practice," said Dr. Frisbie. "For our research, we are focused on adult stem cells, particularly those found in the bone marrow."

The science and medicine of stem cells is further complicated in the public's mind by health clinics that proffer dubious claims of cure and longevity without rigorous scientific analysis of their treatment protocols. Vulnerable Americans looking for cures to devastating illnesses are often lured by promises of health and wellness. Stem cell tourism is an exploitation of the promise of stem cells offered outside of the United States because rigorous standards would not allow such treatments here, notes Dr. Jeanne Loring, Director for Regenerative Medicine at Scripps Research Institute.

"When looking at stem cell therapy what we are interested in is what works best," said Dr. Frisbee. "With 200-plus different cells types, we want stem cells that can turn into anything. Because rejection is a concern, we want stem cells that are genetically identical to the patient. Because of ethical concerns, we want stem cells that are widely acceptable to the public for use. Adult somatic stem cells and the recent discovery of induced pluripotent stem cells address many of these considerations.

"There are a lot of hurdles to developing stem cell therapies, but when you look at the progress that has occurred in the short time since the first human stem cell was isolated in 1998, I have no doubt that we will move forward."

Jessica McKenna and Cinnabuns



Checking a patient's radiographs

Veterinary Students Test Their Wings

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to follow, and treatment plans are often based in economic terms. The students learn that people still love their animals, they just may not have the means to care for them as well as others can – especially when you have to make a choice between food for the family and veterinary care for the pet."

For the students, in addition to client communications, many have their first experiences in being directly responsible for the care, treatment, and follow-up of their patients. While McKenna had some previous surgical experience, Ong got to do her first solo neuter and spay.

"You can practice and practice and practice, but until you take full responsibility for your first case, from selecting anesthesia, making the first incision, performing the procedure, and tying the final suture, it's hard to fully grasp your role as veterinarian and how you have this animal's life in your hands," said Ong.

Dr. Ingrid Pyka, Harrison Memorial Animal Hospital Director and a 1992 graduate of the DVM program at Colorado State University, said watching the students transform over a period of two weeks is personally very rewarding.

"At the beginning of their rotation they are much more tentative and ask a lot of questions," said Dr. Pyka. "They know most of the answers, but need to build trust in themselves and their abilities. By the end of their rotation, they have completely transformed. They are confident and assured, and very comfortable in their client interactions."

Students stay at an apartment leased by the College of Veterinary Medicine and Biomedical Sciences during their two-week rotation at the hospital, allowing them to fully immerse in the hospital environment. The Harrison Memorial rotation is a joint project between Colorado State University and the Colorado Veterinary Medical Foundation with both organizations providing funding to help support the program. In addition, the Animal Assistance Foundation in Colorado has generously supported the program for the last two years, providing invaluable assistance that has allowed the rotation to continue to give DVM students a rich learning experience while helping to provide outstanding veterinary care to the animals, and their owners, who need their help.

Colorado State University

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2010-2011 Calendar Highlights

Dec. 7	Alumni Reception at the American Association of Equine Practitioners Annual Meeting
Dec. 8	Front Range Neuroscience Group Annual Meeting
Dec. 9	Class III Laser THOR Seminar*
Dec. 17-18	Fall Commencement 2011
Jan. 8-9	72nd Annual Conference for Veterinarians
Jan. 9-10	Foaling and Care of the Newborn Foal*
Jan. 12-15	Equine Reproductive Management and Artificial Insemination*
Jan. 16	Techniques for Handling and Utilizing Transported Cooled Equine Spermatozoa*
Jan. 17	Techniques for Handling and Utilizing Frozen Equine Spermatozoa*
Apr. 25	Multipurpose Rigid Endoscopy*
Apr. 26-27	Introduction to Small Animal Laparoscopy*
Apr. 28-29	Advanced Surgical Laparoscopy and Thoracoscopy*
Apr. 28	Laparoscopic Ovariectomy*
May 18	Advanced Techniques in Regional Analgesia*
May 13-14	Spring Commencement

To view other calendar details for the College of Veterinary Medicine and Biomedical Sciences, visit www.cvmbs.colostate.edu.

* Continuing Education Course

calendar