

ORTHOPAEDIC RESEARCH CENTER

2019-2021 Report



C. WAYNE MCILWRAITH
**TRANSLATIONAL
MEDICINE INSTITUTE**
COLORADO STATE UNIVERSITY



ORTHOPAEDIC RESEARCH CENTER



**COLORADO STATE
UNIVERSITY**



Preface

It is my pleasure to write a preface to the 2019-2021 report of the Orthopaedic Research Center. By my records, the first report (then called Equine Orthopaedic Research Laboratory Report) was 1993-1995, and the 1996-1997 was the first professionally bound report. Looking back, it has certainly been a “labor of love” to put together everything that our program has done, but I’m certainly very pleased to hand the reins over to Dr. Laurie Goodrich, director of the Orthopaedic Research Center and the new editor.

Our progress through the years has been steadily incremental, thanks to the principal investigators and all associated staff. Although I am officially “retired,” I still have an office and I am still going to continue to follow our research accomplishments and offer advice when asked. We are now housed in the fantastic Translational Medicine Institute and have added some key people to our program, as evidenced by what is contained in this report. Last but not least, critical to our success has been our many collaborators and, most importantly, our donors. Thank you, and best wishes,

Wayne McIlwraith

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From the New Director

It is with great enthusiasm and humility, as the new director of the Orthopaedic Research Center, to present this 2019-2021 report from the Orthopaedic Research Center program. I had the privilege of serving as interim director in the second half of 2019 and, within a few months, a raging pandemic began. This situation tested our abilities to carry on the important research that has led the field of equine orthopedics and translational orthopedics. In September 2020, I had the honor of becoming director of the Orthopaedic Research Center, at which time the pandemic seemed to be never-ending. Despite the challenge of becoming director in this tumultuous time, I had great support from our founding director, Dr. C. Wayne McIlwraith, and, of course, an incredible team of researchers, graduate students, and staff. We found our way through the difficult times to come out on the other side, still with excellent productivity and excitement for the future. This report spans three years (2019-2021), due to the challenges of the past three years. In the past, our reports have been over a one-year or two-year period. Following this report, we will make two major changes, and those will be 1) the report will now be online and in a PDF format, and 2) we will have an annual report that spans each year to keep our collaborators, donors, and funding partners updated on our progress.

As in the past, this report represents the ORC and our partners within the Musculoskeletal Research Program, which consists of researchers and clinician scientists within the Orthopaedic Bioengineering Laboratory, the Preclinical Surgical Research Laboratory, and the Orthopaedic Oncology Program at Colorado State University. As many of you know, the Orthopaedic Research Center program is now within our beautiful facility, the C. Wayne McIlwraith Translational Medicine Institute. The mission of the ORC continues to be to investigate the pathogenesis, diagnosis, treatment, and prevention of musculoskeletal disease and injury to the betterment of both animals and people. While our purpose is to find solutions to musculoskeletal problems, especially joint injuries and arthritis, we continue to expand and, more specifically, explore new therapies such as biologics and sports medicine and rehabilitation; new diagnostics such as advanced imaging and novel biomarker analysis; and new areas such as wearable technologies to detect early injuries. Further, understanding pain and pain pathways and manifestations of disease due to pain is integral to our mission as well. All of this folds in well to not only helping our equine athletes but also translating our advances in science to helping horses, humans, and companion animals as well. Thus, the move to the TMI underscores the progression of this mission and the talents of our researchers, staff members, and collaborators who are D.V.M.s, M.D.s, basic scientists, and industry partners.

As brief background, I want to introduce myself, as many of you know me but some may not. I have been part of CSU since 2005, beginning as an assistant professor of equine surgery and lameness. After being on faculty at Cornell as an equine surgeon for four years and then completing my Ph.D. from Cornell in 2005, my dream was to come to CSU as a surgeon and as an orthopedic researcher. Interestingly, my mentor in both surgery and research at Cornell's College of Veterinary Medicine was none other than one of Dr. McIlwraith's first surgical residents at CSU, Dr. Alan Nixon. As I was nearing the end of my Ph.D. at Cornell, I knew the equine surgery program and, specifically the Orthopaedic Research Center here at CSU was world-renowned, and I wanted nothing more

than to become part of this team. I was granted that opportunity and have been able to be part of the incredible success of this program since then. Through the years, I have seen the results of hard work and progress of this center, and I have witnessed the clinical benefits to our equine patients as well as the translational efforts to people and other animal species. I have personally experienced what mentorship and support can do to foster future scientists who then want to "pass it on" to younger, impressionable "effectors of change." So, it is only logical that I had the desire to then help lead this program. The shoes (of Dr. McIlwraith) to fill are big and ultimately not "fillable," but I am excited to take the reins and feel that the honor and privilege of this opportunity will drive me to carry on the legacy of Dr. McIlwraith's original intent. We are lucky to have an ever-expanding team with great talents, and we have beautiful facilities and the support of our CSU leadership to make it happen. The ORC team will be one of the six teams within the TMI, and the new director of TMI, Dr. Frank Barry, and I will continue to build new collaborations within the TMI and inside and outside CSU to carry on the impacts of musculoskeletal research. I am very fortunate to have Dr. McIlwraith's continuing friendship and advice at my fingertips and, for that, I am very grateful. I had the great honor of being awarded the Barbara Cox Anthony University Chair in Orthopaedics at the end of 2021, and I hope to live up to what it stands for and exemplify what Barbara Cox Anthony contributed to our philanthropic support to help the program and, specifically, the horse.

In this report, we describe the updated (2018) focuses that are integral to our mission. We have three main focuses that are described in this report, and the list of publications is extensive and represents the productivity of our clinicians, clinician scientists, basic researchers, staff, and collaborators. The PDFs of highlighted articles can be found in our online report. The manuscripts are "broken down" into each focus, but often the focuses overlap. We are also going to bring you an updated ORC website in the next couple of months. This website has been a long time coming, and we wanted to launch it following the release of our three-year report that has been delayed because of COVID-19. The link for this updated website will be sent to you in the next couple of months.

As we move forward, our efforts to be awarded large and small grants from institutions such as the National Institutes of Health and the Department of Defense and foundations such as the Grayson-Jockey Club Research Foundation, the Hong Kong Jockey Club Research Foundation, and the Morris Animal Foundation, will continue. We will also continue to collaborate with our industry partners and those collaborations will be crucial to our success. We will also continue our philanthropic efforts, as it is this incredible support that has built the buildings, created positions with endowed chairs, and sustained our research program through the years of sometimes uncertain funding. Following our lifetime/career celebration for Dr. McIlwraith in September 2021, we began an ORC research excellence operations endowment fund (advancing.colostate.edu/ORCE) that will be a major focus of our philanthropic efforts, as this fund will allow us to support new positions, graduate students, and operations that will allow our research program to grow and thrive. The past success of the ORC would not have been possible without the incredible talent that has been the individuals of the ORC and the gracious support of our donors.

Thank you for reading this report. I hope you find it compelling and informative. I look forward to updating you annually but, as I tell our team, "my door is always open to constructive criticism, advice, and suggestions," so please let me know if you have input and thoughts on how to be better!

Very respectfully,

Laurie Goodrich

Faculty Awards

Dr. Laurie Goodrich –
Barbara Cox Anthony
University Chair in
Orthopaedics, 2021

Dr. Brad Nelson – CSU
President's Council on
Culture Group Award
(Honorable Mention), 2021

Dr. Fiona Hollinshead –
CSU Institutional Animal
Care and Use Committee
KUDOS Award, 2020

Dr. Melissa King – Clinical
Sciences Research Award,
CSU College of Veterinary
Medicine and Biomedical
Sciences, 2020

Dr. Kelly Santangelo –
Zoetis Award for Veterinary
Research Excellence,
2020; CSU College of
Veterinary Medicine and
Biomedical Sciences
"Living Our Values" Award
Recipient, 2019

Dr. C. Wayne McIlwraith –
CSU Spirit of Philanthropy
Award, 2020; American
Veterinary Medical
Association Lifetime
Excellence in Research
Award, 2019; American
College of Veterinary
Surgeons Foundation
Legends Award, 2019

Our Impact as a Preeminent Equine and Translational Orthopaedic Research Program

Both nationally and internationally, the ORC provides critical new findings of significant clinical impact and has been able to attract talented students who wish to pursue careers in orthopedic research. Students choose this program because of its excellent reputation and because of the opportunities they have to be involved in research during their undergraduate and pre-veterinary programs and veterinary or post-veterinary careers (either while in residencies or post residencies). Many pre-veterinary students have served as volunteers in equine orthopedic research over the past 10 years; this allows students to develop a high level of research expertise during this undergraduate experience. This involvement encourages students to pursue advanced degrees and ultimately research careers, rather than traditionally private veterinary practice. Our program also impacts undergraduate and pre-veterinary education by applying findings from research studies to clinical veterinary medicine.

The breadth of dissemination of information from the ORC is extensive, with information distributed to graduate and undergraduate students in eight departments within five colleges at Colorado State University. Many faculty members from these five colleges who are participants in the Orthopaedic Research Program are internationally recognized; they are therefore able to share research findings worldwide to the academic community, the equine industry, the scientific community, and private biomedical industry. The ORC's extensive collaboration with M.D.s doing research on similar areas of the musculoskeletal system, such as those at CU School of Medicine, Rush Medical Center, Stanford Medical Center, and Steadman Philippon Research Institute, as well as biotechnology companies, with collaboration in multiple NIH and Department of Defense research grants, has significantly impacted the treatment of humans with orthopedic injuries and osteoarthritis. Human medicine, as well as veterinary medicine, has been positively affected by the dissemination of the ORC's findings over the last several decades.

Impact of the Orthopaedic Research Center within the Translational Medicine Institute

Faculty and Staff: Over the last 25 years, funding for our orthopedic research and specialized personnel availability has increased dramatically. Until 1994, orthopedic research was being performed by faculty members within the Department of Clinical Sciences. The ORC research team now encompasses 29 full-time faculty members (including three bioengineering faculty) in our program. To support the work of faculty researchers, we now have 11 research associates/ research trial coordinators/administrative assistants. We have 19 graduate students in the program as of 2022. To view the full list of ORC members, affiliates, graduate students, and postdoctoral candidates, please visit our website for their bios and publications. Our current funding is approximately \$2 million to \$4 million annually.

Facilities: In 2002, thanks to generous private donors, most notably Gail Holmes and Herbert Allen, the construction of the Gail Holmes Equine Orthopaedic Research Center and the remodeling of the Orthopaedic Research Laboratories were completed with joint funding from the ORC, School of Biomedical Engineering, and vice president of research at the time, Dr Tony Frank. At the same time, we built a state-of-the-art equine MRI facility (the first equine-dedicated MRI in the U.S.), funded by Ken and Virginia Atkinson together with a College Chair to fund personnel (that also involved a significant contribution from Jon and Abby Winkelried). In 2018, with the completion of the C. Wayne McIlwraith Translational Medicine Institute, the Orthopaedic Research Center program moved into the TMI building along with the imaging efforts that were initiated in the Gail Holmes building. This allowed access to new surgical facilities, a new gait laboratory, high-speed treadmill, and equine barns for our preclinical investigations to be performed. The gait laboratory and equine barn are part of the ORC program and the building, which houses both the gait lab and the new barn, is called the Equine Performance Analysis Facility. The Gail Holmes building that once housed the ORC program is now dedicated to the Equine Sports Medicine and Rehabilitation Program, and the Orthopaedic Research Laboratories have received further renovation and are largely occupied by the OBRL. This space is shared, to some extent, with the ORC. These facility updates have greatly contributed to the larger vision of the ORC mission of impacting not only horses but also people through translational research.

Endowed Chairs: The ORC has three, \$3 million University Endowed Chairs; the Barbara Cox Anthony University Chair in Orthopaedics (held by Dr. Laurie Goodrich); Iron Rose Ranch Chair (held by Dr. Chris Kawcak); and the Abigail K. Kawānanakoa Chair in Alternative Medicine

(supporting Dr. Kevin Haussler). We also have a \$1.5 million Chair in Musculoskeletal Imaging from the estate of Kenneth and Virginia Atkinson and, most recently, a \$6 million Presidential Endowed Chair from John and Leslie Malone named the Leslie Malone Presidential Chair in Equine Sports Medicine (now supporting Dr. Melinda Story who just recently completed her Ph.D. and has become an assistant professor in equine sports medicine and rehabilitation). The funding also supports one of our equine sports medicine residencies. We continue to pursue endowed funding to make all our positions permanent.

Equine Ambulatory Sports Medicine and Rehabilitation Service: A new veterinary specialty, the American College of Veterinary Sports Medicine and Rehabilitation, was accredited by the American Veterinary Medical Association May 2009. There were 27 charter diplomates established by a nomination and Delphi election system. Four of our faculty, Drs. C. Wayne McIlwraith, Kevin Haussler, Chris Kawcak, and David Frisbie, were made charter diplomates of the new college. An equine ambulatory sports medicine service was initiated in 2010 from within the ORC, and has now grown to the following members; Drs. Kawcak, Frisbie, Haussler, Melissa King, Mindy Story, Erin Contino, and Katie Seabaugh. There are now four clinical technicians/administrative assistants: Michelle Alexander, Becca Cedar, Meredith Park, and Shelby Roberts assisting in this service offering state-of-the-art expertise in equine ambulatory musculoskeletal problems in athletic horses. Britt Mactavish is the equine operations manager of the program. The service has three sports medicine residents (one in each year) and has graduated 12 residents from the three-year program in equine sports medicine and rehabilitation.

Unrestricted Funding from Donors and Foundations: The period 2019-2021 has been one of continuing to function, albeit at a reduced tempo. We have continued with good support and have been further able to increase faculty and staff positions, despite the COVID-19 pandemic that caused significant shutdowns, delays, and reorganization efforts. Donor support is critical to our continued operation and growth. Our team has come through this dark time with resolve and looks forward to carrying on our mission through much expanded and translational efforts of our team. In celebration of Dr. McIlwraith's brilliant career, we held a commemoration of his lifetime efforts and put together a video (available to view on our website) of different aspects of the industry he has influenced. Also, with this effort, we established an ORC operations endowment that will be imperative to support ORC operations moving forward (advancing.colostate.edu/ORCE). We have begun fundraising for this official endowment and this will be a primary focus of philanthropic efforts in the next few years. Our goal is to raise \$10 million to support salaries, graduate students, and research efforts that are integral to our program.

MISSION – To investigate the pathogenesis, diagnosis, treatment, and prevention of musculoskeletal disease and injury for the betterment of both animals and humans.

PHILOSOPHY – To offer the best treatment of clinical cases possible, with continued and critical assessment of our results; to use these results to change our treatments; to point our research toward prevention of problems we cannot treat effectively or that cause permanent clinical damage.

PURPOSE – To find solutions to musculoskeletal problems, especially joint injuries and arthritis.

GOALS – To find new methods to heal joints already damaged; to use state-of-the-art research techniques to find ways to prevent the occurrence of joint diseases and musculoskeletal injuries; to find methods of early treatment to prevent permanent damage when joint disease does occur.





The Orthopaedic Research Center began as a multidisciplinary equine program dedicated to finding methods to treat and prevent equine musculoskeletal disease and injury. Prior to 1984, the program's research was primarily clinical. During this time, many of the techniques for arthroscopic surgery were developed and optimized at CSU, and these techniques were used to treat joint problems more effectively and, further, enable continued athletic function of equine athletes. We also identified and defined a number of new clinical conditions and documented some of the best methods for diagnosis and treatment for musculoskeletal conditions.

The goals of our program are summarized in our research focuses. As we developed arthroscopic surgical techniques to treat these clinical conditions, we identified limitations in terms of secondary osteoarthritis and articular cartilage loss, and this led into phase two of our program of finding solutions through scientific research. A major goal of the program has always been to find solutions to musculoskeletal problems, especially joint injuries and arthritis. As clinicians, clinician scientists, and/or basic science researchers, we strive to offer the best possible treatment of clinical cases with continual and critical assessment of the results, which are then used to modify treatments and direct the research toward disease prevention. The program's goals are to use state-of-the-art research techniques to find new methods to rehabilitate musculoskeletal injuries, specifically damaged joints, tendons, and bones, to prevent or decrease the occurrence of joint disease and musculoskeletal injuries. We strive to improve methods of early detection, develop better treatments to prevent permanent damage to injured joints, and validate manual therapies and rehabilitation techniques.

The ORC collaborates closely with the Orthopaedic Bioengineering Research Laboratory, and we often function as a single unit. The ORC and OBRL, together with the Preclinical Surgical Research Laboratory and Orthopaedic Oncology, make up the Musculoskeletal Research Program, which is a Program of Research and Scholarly Excellence at Colorado State University. This designation of PRSE

to us was originally granted in 2004 and has been renewed in 2008, 2012, and 2016. The significant collaborations with the College of Engineering and School of Biomedical Engineering, as well as the Department of Health and Exercise Science, has added considerably to our research strengths. In recent years, considerable human-based funding – Orthopaedic Foundation, National Institutes of Health, Department of Defense, and corporate grants – has added to our support.

Another significant addition to the ORC has been the development of the equine ambulatory sports medicine service and an Equine Sports Medicine and Rehabilitation Residency Program. This followed the accreditation of the new American College of Veterinary Sports Medicine and Rehabilitation specialty and four of our faculty being made charter diplomates. We quickly developed an equine ACVSMR residency program and have added four diplomates (board-certified in American College of Veterinary Sports Medicine and Rehabilitation, equine specialty) to make us the largest Equine Sports Medicine and Rehabilitation Program in the U.S. This has led to considerable clinical and research advancements in the rapidly emerging field.

In 2016, we achieved funding of \$70 million to build the C. Wayne McIlwraith Translational Medicine Institute. This building came to fruition in 2018, and the Orthopaedic Research Center program moved into the TMI building at that time. The Gail Holmes building has now transitioned to be the Equine Sports Medicine and Rehabilitation Center led by Dr. Melissa King. The TMI is going to take us to a new level of orthopedic research in translational musculoskeletal research (as well as allied areas of biologic therapies and stem cell research), doing what we have always done for horses but greatly expanding our efforts in human musculoskeletal disease. This is made possible by a lead gift of \$40.5 million from John and Leslie Malone for the building (an additional \$10 million in operating funds), \$10 million from CSU, and a \$20 million matching gift from Princess Abigail K. Kawānanakoa of Hawaii.

Faculty/Principal Investigators

Laurie Goodrich – Director of ORC, Barbara Cox Anthony University Chair, Professor of Equine Surgery and Lameness

C. Wayne McIlwraith – University Distinguished Professor, Founding Director of ORC, Barbara Cox Anthony University Chair Emeritus

Myra Barrett – Associate Professor, Veterinary Diagnostic Imaging

Luke Bass – Assistant Professor, Equine Field Service

Erin Contino – Assistant Professor, Equine Sports Medicine and Rehabilitation

Felix Duerr – Associate Professor, Small Animal Sports Medicine and Rehabilitation

David Frisbie – Professor, Equine Sports Medicine and Rehabilitation

Kevin Haussler – Associate Professor, Equine Sports Medicine and Rehabilitation

Fiona Hollinshead – Associate Professor, Small Animal Reproduction

Christopher Kawcak – Director of Equine Clinical Services, Professor of Equine Surgery and Lameness

Melissa King – Associate Professor, Equine Sports Medicine and Rehabilitation

John Kisiday – Associate Professor, ORC

Brad Nelson – Assistant Professor, Equine Surgery and Lameness

Lynn Pezzanite – Assistant Professor, Equine Surgery and Emergency Critical Care

Kelly Santangelo – Associate Professor, Microbiology, Immunology, and Pathology

Katie Seabaugh – Assistant Professor, Equine Sports Medicine and Rehabilitation

Kurt Selberg – Associate Professor, Veterinary Diagnostic Imaging

Katie Sikes – Research Scientist, Preclinical Surgical Research Laboratory

Mindy Story – Equine Sports Medicine and Rehabilitation Veterinarian and Postdoc Fellow

Kelly Zersen – Imaging/Anesthesia Coordinator

Postdoctoral and/or Graduate Students

Sandro Colla – Postdoc Fellow

Angie Esselman – Postdoc Fellow

Sherry Johnson – Postdoc Fellow

Zabi Khan – Postdoc Fellow

Ah Young Kim – Postdoc Fellow

Bethany Liebig – Ph.D. Candidate

Tom O'Brien – Postdoc Fellow

Mana Okudaira – Veterinary Intern, Equine Field Services

Frances Peat – Postdoc Fellow

Lauren Smanik – Postdoc Fellow

Gabby Solum – Postdoc Fellow

KT Steward – Postdoc Fellow

Holly Stewart – Postdoc Fellow

Hayley Sullivan – Postdoc Fellow

Riley Thompson – Postdoc Researcher

Alicia Yocum – Postdoc Fellow

Research Scientists and Staff

Michelle Alexander – Administrative Assistant, Equine Sports Medicine and Rehabilitation

Taryn Boxleitner – Laboratory Support

Becca Cedar – Veterinary Technician, Equine Sports Medicine and Rehabilitation

Jennifer Daniels – Research Trials Coordinator

Skyla Hall – Administrative Assistant, ORC

Natalie Lombard – ORC/TMI Surgical Technician

Melinda Meyer – Equine Reproductive Laboratory Assistant

Meredith Park – Veterinary Technician, Equine Sports Medicine and Rehabilitation

Nikki Phillips – Research Associate

Shelby Roberts – Veterinary Technician, Equine Sports Medicine and Rehabilitation

Ryan Shelton – Lead Technician

Parvathy Thampi – Research Scientist

Orthopaedic Bioengineering Research Laboratory Principal Investigators, Research Staff, and Postdoctoral/Graduate Students

Susan James – Vice Provost of Faculty Affairs

Christian Puttlitz – Department Head and Professor, Mechanical Engineering

Soham Ghosh – Assistant Professor, Mechanical Engineering

Kirk McGilvray – Assistant Professor, Mechanical Engineering

Ben Gadomski – OBRL Manager

Cecily Broomfield – Research Associate

Jimmy Johnson – Postdoc Fellow

Samantha Kaonis – Ph.D. Candidate

Jason Kuiper – Ph.D. Candidate

Kevin Labus – Research Scientist/Scholar

Peter Linde – Ph.D. Candidate

With grateful acknowledgment to those who are so critical to the continued success of our program.

\$35,000,000 and Above

Dr. John C. Malone and
Leslie A. Malone

**\$20,000,000 to
\$34,999,999**

Abigail K. Kawānanakoa

\$1,000,000 to \$4,999,999

Herbert A. Allen

Barbara Cox Anthony

Kenneth and Virginia
Atkinson Estate

Iron Rose Ranch – Thomas Bailey

Louis L. Borick Foundation –
Robert Borick

Steadman Philippon
Research Institute

Alice Walton

\$100,000 to \$999,999

Fahd Al-Sobayil, D.V.M.

Duncan Alexander

American Quarter Horse
Association

Ashford Stud

Attache International
Marketing Inc.

Boettcher Foundation

Peter A. and Cathy L. Dea

Mark P. Dedomenico, M.D.

Walter C. and Jaynn M. Emery

Equine Sports Medicine LLC

Keeneland Association

Keith Goett Family

Yaron and Tiffany Goldman

Gail Holmes

Marijane and Buck Hutchinson III

IDEXX Laboratories Inc.

Robert B. and Beverly J. Lewis

Dan Lufkin

Luitpold Pharmaceuticals Inc.

John and Susan Magnier Family

Tommy Manion

Wayne Mcllwraith, D.V.M.,
Ph.D. and Nancy Goodman-
Mcllwraith, D.V.M.

Prince Sultan bin Muhammed

Stavros S. Niarchos Foundation

Pfizer Inc.

George R. Pidgeon Sr.

The Peter Jay Sharp Foundation

Marilyn M. Simpson Trust

Iris Smith

John M. Sparks Family

Trailsend Foundation –
Jim Kennedy

Frederick and Melissa
Westerman

John and Abby Winkelried Family

\$25,000 to \$99,999

John Andreini

Bayer Corporation

Boettcher Foundation

Burnett Ranches LTD

George Dewell, D.V.M.

Josh Donnell, D.V.M.

EE Ranches Inc.

EquuSys Inc.

Equus Foundation Inc.

Fasig-Tipton Company Inc.

Gooding Family Foundation

Stephen Grove

Elaine Hall Endowment Fund

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Raymond James Charitable

Keeneland Corporation

Ann Marion

Jeffrey and Sherri Matthews

Mendota Equine Sports Medicine

Dellora A. and Lester J.
Norris Foundation

Oak Tree Charitable Foundation

Oak Tree Ranch – Volodar
and Zory Kuzyk

Pavillard Scholarship

Platinum Performance Inc.

Progenteq Limited

Rosenthal Family Trust

Southern California Equine
Foundation Inc.

Thoroughbred Charities
of America Inc.

Thoroughbred Corporation –
Prince Ahmed Salman

TBR Ranch – Stephen
and Paula Reynolds

Jack E. Waggoner

Martin J. and Pamela S.
Wygod – Rose Foundation

\$10,000 to \$24,999

Susan Allen

John and Jerry Amerman

Arthroscopy Dynamic
Technologies Inc.

Vincent A. Baker, D.V.M.

Sandy Bonelli

Britt Land & Cattle Company Inc.

Buffalo Ranch

Lindy Burch

California Authority of
Racing Fairs

Calmark Corporation

Circle C Ranch Company

Community Foundation
of Greater Memphis

Vaughn and Jill Cook, D.V.M.

Heather S. Dedomenico Estate

Del Mar Thoroughbred Charities

Nancy Dickerson

Doolin Family Foundation

Glenn Drake Family

Dual Peppy Partners

Esperanza Ranch

Flaxman Holdings Limited

Winston Hansma Family

George R. Hearst Jr. Family

HMT High Medical
Technologies USA Inc.

Hollywood PK Racetrack
Charities

Holmes Cutting Horses

KMN Racing LLC

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Benny Martinez Family

Matthews Cutting Horses LLC

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Sally Ranney

Rocky Mountain LAE Inc.

Rood and Riddle Foundation Inc.

S&S Farms

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SDP Buffalo Ranch

Mace Siegel

Barry W. Simon, D.V.M.

Slate River Ranch LLC

Smart Little Lena Syndicate

Spectravet Inc.

Peter D. Stent Family

Strawn Valley Ranch

Melanie Taylor Family

THORN BioScience LLC

Thoroughbred Owners
of California

Three Chimneys Farm

Verdad Foundation

Victor Cattle Company

\$1,000 to \$9,999

Abrakadabracre Partnership

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Therapies

Alamo Pintado Equine Hospital

American Association of
Equine Practitioners

American Livestock
Insurance Company

Animal Health Options

Arcese Quarter Horses

Arizona Community

Jorg A. Auer

Aurora Pharmaceutical LLC

Bañuelos Ranches Association

Bart Baker, D.V.M. and Ann Baker

Barbara Banke

Marty Baxter

Chip Beckett, D.V.M.

Bemak, N.V. Ltd. Co.

Charles A. Bess Family

Bet Hesa Cat Syndicate

Bet On Me 498 Syndicate

J. Mark Beverly, D.V.M.

Edward and Darci Biach

Bigtime Favorite Partners

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BioVision Veterinary Endoscopy

BiTerra Quarter Horse LLC

Buckeye Blake Family

Blessed Twice LTD Partnership

Blue Grass Community
Foundation – on behalf
of Taylor Made Sales

Breeze Easy

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Brightstone Ranch

Maynard B. Brittan

Brokaw Family Foundation

California Thoroughbred
Breeders Association

Farall Canning Family

Capps Radio Ranch

Captain Courage Partners

CARE Research Inc. Cattle Co.

Ryan Carpenter, D.V.M., M.S.

Celavie Biosciences LLC

Center Ranch

Victoria Chapman

Andrew H. Chavers Family

Cherry Creek Equine

Robert N. Clay

Coalson Acres Ranch

Michelle Cowan

Ron Crockett

A. Lindsay Croom, D.V.M.

David C. Davis, D.V.M., Family

Denali Stud

C. George Dewey, D.V.M., Family

Don Alberto Corporation

Michael Drevalas

Dual H Horses

Joseph S. and Maureen E. Eddy

Kim Ellis

Billy Emerson
Equine Trust Foundation
Essar Charitable Foundation
Fairlea Ranch Family
Marylynn A. Fischer Family
Fossil Creek Veterinary
Hospital Foundation Inc.
Margaret Lee Foster
Foxwood Stables
David D. Frisbie, D.V.M., Ph.D.
Gaiesway Farm
Gaines Way Management
Corporation
Gary West, D.V.M.
Gayle and Judith Trotter
GCH Land and Cattle
Company LLC
George S. Martin, D.V.M.
Nicole Gibson
Glenwood Veterinary Clinic LLC
Laurie Goodrich, D.V.M.,
M.S., Ph.D.
Henry and Lorie Gordon
Graystone Ranch
Candace Gregory
Jimmy W. Guest Family
Tom and Lisa Guinn
Hacienda Colima Quarter Horse
Shannon Hall
Paul L. Hansma
Sandy Haskins Family
Dorothy Russel Havenmeyer
Hidden Paint Ranch
Ken Hill
Mike Hollibaugh Family
Jim Holmes Cutting Horses
Home Place Horse & Cattle

Joni Hyrick
Brad R. Jackman, D.V.M.
J Five Horse Ranch
Management LLC
Jenkins Veterinary Services P.C.
Juddmonte Farms
Christopher E. Kawcak,
D.V.M., Ph.D.
William J. Keller
T.D. Kelsey Family
Kentucky Consignors and
Breeders Association
Kentucky Thoroughbred
Association
Kentucky Thoroughbreds
Owners & Breeders Inc.
Kirk Horse Insurance LLC
Kobie Wood Family
Bill Lacy Family
Land O'Lakes Farmland Feed
James M. Latham Jr., D.V.M.
Lectric Company LTD
Midge Leitch, V.M.D.
Don Lester Family
Little Rush Syndicate LLC
LNJ Foxwoods Stable
Londonderry Equine Clinic
Karen Long
Jeffrey S. Matthews
Frank Street Partners
Maggie McHugh
Manfred Menzi
Merial Inc.
Mill Creek Veterinary Service
James P. Morehead,
D.V.M., Family
Morning Sun Ranch
Gene and Michelle Morris

W.S. Morris III
Myristol Enterprises Inc.
Neil J. Mulholland
New Zealand Equestrian
Federation
Niangua River Ranch
Land & Cattle Co.
Art and Catherine Nicholas
North Ridge Ranch Inc.
Oasis Ranch
Lezlie O'Donnell
William T. O'Donnell Jr. Family
John and Bonnie O'Neil
Denise Opdahl
Pacific Coast Horse
Shows Association
Partnership Sulzer Biologics
Rick A. Pederson LLC
Performance Horse Partners
Rancho Petersen
ProMotion Studies
Pro Sports Club
Lezlie A. Rehagen
Joelle Rogers
Round & D'Angelo Partnership
R&P Medical Terry Riddle Inc.
T.K. and Lainea Sampson
Sampson Family Ranch
San Juan Ranch
Sanuwave Services LLC
Charles Henry Scoggin, M.D.
A.J. and Lynda Scribante
Charitable Foundation
SDM Quarter Horses Pty. Ltd.
Robert K. Shideler, D.V.M.
Siena Farm
Smart Lil Highbrow Partnership

Smart Little Jerry Syndicate LTD
Joy Smith
Wes Smith Family
Stacy Smitherman Family
Smokin Trona Syndicate LLC
Linda K. Souders
Spendthrift Farms
SR Instant Choice
Alexis Stephas
Terry Swanson, D.V.M. – Littleton
Equine Medical Center
Swiss Reinsurance Company
Swiss Re Corporate Solutions
Melanie and Robert L. Taylor II
Clint Tegartin
Thiry-O'Leary Foundation
Tokoroa & Dists. Veterinary
Paula and Kent Trahan
Transoceanic Marine Inc.
Trefethen Vineyard Winery
Inc. – Janet Trefethen
Twin Willows Ranch LLC
Valley Oak Ranch
Vernon Cutting Horses
Watercolors Racing LLC
Wichita Ranch
Wildenstein Family LLC
Cooper Williams
Ronald W. Williams
Worldwide Medical Inc.

\$100 to \$999
Robert D. and Donna M. Allen
American College of
Veterinary Surgeons
Lindsay and Luke Bass, D.V.M.

Andre de Bellefeuille
Sharmin E. Bock
Fernando Canonici, D.V.M.
Circle B Bar T
John Clark
Contract Veterinary Sales
William B. Cowan Jr.
Marcia Cox
Gerald L. Dancy
Michael Dinnell Family
Dutton Farms
Ann E. Dwyer, D.V.M.
John Eddy
Richard K. Elder
Robert D. Etherton
Falcon Seaboard,
Snaffle Bit Ranch
Friends of Horses Rescue &
Adoption – Dr. Richard Houck
Melissa Lyons Gardner
Tracy Glover
Ann Gorai
Bill Grant
Diana Hassel, Ph.D.
Zachary J. Heinrich
Hes Wright On Partnership
Lura S. Hill
J Diamond 3
Kristen E. Jones
Stan Jones
Julie Kahn
Armand S. Kafesjian
Lynn Kennedy
Michael E. Kent
King Ranch

Peter F. Klara, M.D., Ph.D.
Virginia Lautaret
Kenneth and Linda Lawson
Lindsey Cutting Horses
Jolene Lowry
Les H. Mayes, D.V.M.
Holly McLain
Judy E. Mears
Merck
Mountain Park Ranch Inc.
New England Equine Practice
North American Specialty
Insurance Company
Oklahoma Equine Hospital
Judy O'Neal
Cindy Perez
Kim K. Peterson, D.V.M.
Redfield Farm
Scott and Shirley Roberts
Rocky Mountain Quarter
Horse Association
Jeff and Sarah Schmidt
Carol B. Schultz
Mary Scollay Ward
Secretariat Foundation
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Promote the Repair and Optimal Health of Musculoskeletal Tissues

- a. Orthobiologics
- b. Pharmacologics and other therapeutics
- c. Surgical techniques
- d. Physical therapy and rehabilitation

There are a number of ways to utilize the body's own abilities to heal itself. Some are through employing the body's own natural defenses and regenerative capabilities to return (completely or almost completely) to the original state following injury. Other ways involve working with pharmacologics, orthobiologics, and physical therapies that assist the body in healing itself. The members of our team involved in this focus are busy examining, testing, and utilizing the healing effects of physical therapy, orthobiologics, and pharmacologics that help return joints, tendons, and bones and, specifically, the whole horse to realizing its utmost athletic potential.

1a. Orthobiologics: Orthobiologics are compounds that can help heal musculoskeletal tissues. They are often derived from blood, fat, muscle, or bone marrow. These tissues have abilities to heal our tissues and are at the very core of how our bodies heal themselves. It takes science and strong research efforts to understand how to exploit the natural healing abilities of these tissues. Research at the ORC by multiple researchers is contributing to significant advances in this area, and our collaborative efforts with our M.D. counterparts is allowing application of our knowledge to the human field. Multiple collaborative efforts are in place to study new biologics such as gene therapies, protein therapies, and mesenchymal stem cell therapies.

1b. Pharmacologics and other synthesized (or natural) therapeutics: Various pharmacological-based therapies exist to quell inflammation (corticosteroids, for example) or treat pain (naturally occurring compounds such as CBD). The ORC team has investigated these types of therapeutics for decades now and has validated all the commonly used products as well as continuing to validate new therapeutics (such as gene therapies and extracellular vesicles) as they are studied and developed. The original evaluation of therapeutic treatments for joint disease was of intra-articular corticosteroid therapies to treat joint inflammation and definition of beneficial vs. harmful effects for each commonly used product, and if they could be used in a safe and nondamaging way. This was originally investigated by Dr. Wayne McIlwraith with surgical residents and graduate students, which has led to decades of research into joint therapies.

1c. Surgical techniques: Arthroscopic techniques in the horse was one of the leading factors that brought treatment of joint problems into the "next century" through Dr. McIlwraith's initial investigative efforts, as he established the early research phases within the ORC. New surgical techniques for joint disease and tendon disease, and new methods of minimally invasive approaches continue to be developed within our program. A fellowship within the American College of Veterinary Surgeons, Minimally Invasive Surgery in Equine Orthopedics (encompassing arthroscopy, tenoscopy, and bursoscopy, and fracture repair) was initiated by several ORC collaborators (Drs. McIlwraith, Chris

Kawcak, David Frisbie, and Laurie Goodrich) as well as two others outside our group (Drs. Larry Bramlage, Rood and Riddle Equine, and Alan Nixon, Cornell University). Dr. Kyla Ortvad (University of Pennsylvania) has recently joined this fellowship. Dr. Bradley Nelson, CSU equine surgeon, is in the final stages of completing his fellowship at CSU and will be the first fellow to train in this program.

1d. Physical therapy and rehabilitation: Physical therapy and rehabilitation has been known to influence the horse's ability to return to its full athletic potential. It has been considered a "soft science" because of the lack of scientific documentation. Dr. Melissa King and her team of rehabilitation specialists have proven, over the last several years, not only how physical therapy and rehabilitation works but also have instituted new techniques into the clinical service. This has led to many successes in the equine rehabilitation service, translating into a positive impact in our equine patients, and some of this work translates directly to humans, dogs, and other species

Publications/Presentations 2019-2021

2021 Textbook Chapters

1. **Contino E.** Pharmacotherapy and regenerative therapy of tendon and joint disease. In: Hinchcliff, Kaneps, Geor, van Erck. *Equine Sports Medicine and Surgery*, 3rd ed. Elsevier. In press.
2. **Goodrich LR.** Osteomyelitis. In: *Fracture Repair in the Horse*, 2nd ed., Nixon AJ, (ed). Wiley-Blackwell.
3. **Nelson BB, Goodrich LR.** Elbow and shoulder. In: Hinchcliff, Kaneps, Goer. *Equine Sports Medicine and Surgery*, 3rd ed. Saunders/Elsevier. Submitted.
4. **Nelson BB.** Complications of muscle surgery. In: Rubio-Martinez LM, Hendrickson DA. *Complications in Equine Surgery*, 1st ed. Wiley. Chapter 53, pp. 757-768. Ames, IA.
5. **King MR, Ellis K, Daglish J.** Equine rehabilitation following fracture repair. In: *Fractures in the Horse*, Wright IM, (ed). Hoboken. John Wiley & Sons. In press.

2020 Textbook Chapters

1. **Haussler KK.** Acupuncture treatment of limb lameness and back pain. In: Adams and Stashak's *Lameness in Horses*, 7th ed., Baxter GM, (ed). Elsevier, pp. 921-924.
2. **Haussler KK.** Manual therapy techniques. In: Adams and Stashak's *Lameness in Horses*, 7th ed., Baxter GM, (ed). Elsevier, pp. 925-928.
3. **Haussler KK.** Evaluation of proper saddle fit. In: Adams and Stashak's *Lameness in Horses*, 7th ed., Baxter GM, (ed). Elsevier, pp. 1166-1169.

2019 Textbook Chapters

1. **McIlwraith CW.** Carpal fractures (Chapter 23) In: *Fractures in the Horse*, Wright IM, (ed). Elsevier. In press.

2021 Refereed Publications

1. **Bergtrom T, Frey M, Rao S, Bass L.** Comparison of postoperative inflammatory response in horses undergoing elective castration treated preoperatively with ceftiofur crystalline free acid or procaine penicillin G. *Equine Veterinary Education*, January 2021.
2. **Lehman M, Bass L, Gustafson D, Rao S, O'Fallon E.** Clinical efficacy, safety, and pharmacokinetics of a novel long-acting intramuscular omeprazole in performance horses with gastric ulcers. *Equine Veterinary Education*, August 2021.
3. **Yocom A, O'Fallon E, Gustafson D, Contino E.** Pharmacokinetics and safety of an oral cannabidiol product in horses. *J Equine Veterinary Science*. Submitted.
4. **Garbin L, Contino E, Olver C, and Frisbie D.** A safety comparison of allogeneic freeze-dried platelet-rich plasma or conditioned serum to autologous frozen products in equine healthy joints. *BMC Vet Research*. Accepted.
5. **Ellis K and Contino E.** Treatment using cannabidiol in a horse with mechanical allodynia. *Equine Vet Ed*, 33(4), e79-82.
6. **Mejia S, Duerr FM, Griffenhagen G, McGrath S.** Evaluation of the effect of cannabidiol on naturally occurring osteoarthritis-associated pain: A pilot study. *JAAHA*, 2021 Mar 1; 57(2):81-90.
7. **Zanotto GM, Liesbeny P, Barrett M, Zlotnick H, Frank E, Grodzinsky AJ, Frisbie DD.** Microfracture augmentation with trypsin pretreatment and growth factor-functionalized self-assembling peptide hydrogel scaffold in an equine model. *Am J Sports Med*, 2021 Jul; 49(9):2498-2508. PMID: 34161182.
8. **Zanotto GM, Frisbie DD.** Current joint therapy usage in equine practice: Changes in the last 10 years. *Equine Vet J*, 2021 Jun 18. PMID: 34143532.
9. **Knott LE, Fonseca-Martinez BA, O'Connor AM, Goodrich LR, McIlwraith CW, Colbath AC.** Current use of biologic therapies for musculoskeletal disease: A survey of board-certified equine specialists. Submitted to *Veterinary Surgery*, 2021.
10. **Arzi B, Webb TL, Koch TG, Volk SW, Betts DH, Watts A, Goodrich L, Kallos MS, Kol A.** Cell therapy in veterinary medicine as a proof-of-concept for human therapies: Perspectives from the North American Veterinary Regenerative Medicine Association. *Front Vet Sci*, 2021 Nov 30; 8:779109. PMID: 34917671; PMCID: PMC8669438.

11. **Pezzanite L, Chow L, Griffenhagen G, Dow S, Goodrich L.** Impact of three different serum sources on functional properties of equine mesenchymal stromal cells. *Front Vet Sci*, 2021 Apr 30; 8:634064. PMID: 33996964; PMCID: PMC8119767.
12. **Pezzanite L, Chow L, Johnson V, Griffenhagen GM, Goodrich L, Dow S.** Toll-like receptor activation of equine mesenchymal stromal cells to enhance antibacterial activity and immunomodulatory cytokine secretion. *Vet Surg*, 2021 May; 50(4):858-871. PMID: 33797775.
13. **Pezzanite LM, Hendrickson DA, Dow S, Stoneback J, Chow L, Krause D, Goodrich L.** Intra-articular administration of antibiotics in horses: Justifications, risks, reconsideration of use and outcomes. *Equine Vet J*, 2022 Jan; 54(1):24-38. PMID: 34459027.
14. **Siegal-Willott JL, Anikis P, Neiffer DL, Barthel T, Goodrich LR.** Use of intracarpal interleukin receptor antagonist protein (irap) and hyaluronic acid in a multimodal therapeutic regime for osteoarthritis in an Asian elephant (*ELEPHAS MAXIMUS*). *J Zoo Wildl Med*, 2021 Apr; 52(1):401-405. PMID: 33827205.
15. **Pezzanite L, Chow L, Hendrickson D, Gustafson DL, Russell Moore A, Stoneback J, Griffenhagen GM, Piquini G, Phillips J, Lunghofer P, Dow S, Goodrich LR.** Evaluation of intra-articular amikacin administration in an equine non-inflammatory joint model to identify effective bactericidal concentrations while minimizing cytotoxicity. *Front Vet Sci*, 2021 May 21; 8:676774. PMID: 34095281; PMCID: PMC8175670.
16. **Nelson BB, Stewart RC, Kawcak CE, Freedman JD, Patwa AN, Snyder BD, Goodrich LR, Grinstaff MW.** Quantitative evaluation of equine articular cartilage using cationic contrast-enhanced computed tomography. *Cartilage*, 2021 Apr; 12(2):211-221.
17. **Nelson BB, Mäkelä JTA, Lawson TB, Patwa AN, Snyder BD, McIlwraith CW, Grinstaff MW, Goodrich LR, Kawcak CE.** Cationic contrast-enhanced computed tomography distinguishes between reparative, degenerative, and healthy equine articular cartilage. *J Orthop Res*, 2021 Aug; 39(8):1647-1657. PMID: 33104251.
18. **Newman R, Chow L, Goodrich L, Lambrechts N, Dow S, Pezzanite L.** Susceptibility of canine chondrocytes and synovial cells to antibiotic cytotoxicity in vitro. *Veterinary Surgery*, 2021; 50(3):650-658.
19. **Pezzanite L, Chow L, Piquini G, Griffenhagen G, Ramirez D, Dow S, Goodrich L.** Use of in vitro assays to identify antibiotics that are cytotoxic to normal equine chondrocytes and synovial cells in monolayer and explants. *Equine Veterinary Journal*, 2021; 00: 1-11.
20. **Pezzanite L, Contino E, Kawcak C.** Response to Drs. Dyson, Nagy, and Murray letter regarding

'Lameness originating from the proximal metacarpus/tarsus: A review of local analgesic techniques and clinical diagnostic findings.' *Equine Vet Educ*, 2021; 33:615-616.

21. **Parkinson S, Zanotto G, Maldonado M, King M, Haussler K.** The effect of capacitive-resistive electrical therapy on neck pain and dysfunction in horses. *JEVS*. Submitted April 2021.
 22. **Nankervis K, Tranquille C, McCrae P, York J, Lashley M, Baumann M, King M, Sykes E, et al.** Development of guidelines for water treadmill use. *Animals*, 2021; 11(305).
 23. **King MR, Seabaugh KA, Frisbie DD.** Effects of a bio-electromagnetic energy regulation blanket on thoracolumbar epaxial muscle pain in horses. Accepted with major revisions to *Journal of Equine Veterinary Science*, December 2021.
 24. **Moorman V, Pezzanite L, Griffenhagen G.** Liposomal bupivacaine provides longer duration analgesia than bupivacaine hydrochloride in an adjustable sole-pressure model of equine lameness. *Am J Vet Res*, 2021. Accepted.
 25. **Newman R, Chow L, Goodrich L, Lambrechts N, Dow S, Pezzanite L.** Susceptibility of canine chondrocytes and synovial cells to antibiotic cytotoxicity in vitro. *Vet Surg*, 2021.
 26. **Pezzanite L, Griffenhagen G, Krause D, Hendrickson D.** Retrospective evaluation of association between perioperative antimicrobial protocol and complications following elective equine synovial endoscopy. *Vet Med Sci*, 2021.
 27. **Aldrich ED, Cui X, Murphy CA, Lim KS, Hooper GJ, McIlwraith CW, Woodfield TBF.** Allogeneic mesenchymal stromal cells for cartilage regeneration: A review of in vitro evaluation, clinical experience, and translational opportunities. *Stem Cells Transl Med*, 2021 Nov; 10(11):1500-1515. PMID: 34387402; PMCID: PMC8550704.
- ### 2020 Refereed Publications
1. **Pezzanite L, Chow L, Piquini G, Griffenhagen G, Ramirez D, Dow S, Goodrich L.** Use of in vitro assays to identify antibiotics that are cytotoxic to normal equine chondrocytes and synovial cells in monolayer and explants. *Equine Vet J*, 2020; 00: 1-11.
 2. **Haussler KK, King MR, Peck K, Adair HS.** The development of safe and effective rehabilitation protocols for horses. *Equine Vet Educ*, 2020.
 3. **Pezzanite L, Chow L, Soontarak S, Phillips N, Goodrich L, Dow S.** Amikacin induces rapid dose-dependent apoptotic cell death in equine chondrocytes and synovial cells in vitro. *Equine Vet J*, 2020; 52: 715-724.
 4. **Colbath AC, Kisiday JD, Phillips JN, Goodrich L.** Can extracorporeal shockwave promote osteogenesis of equine bone marrow-derived mesenchymal stem cells in vitro? *Stem Cells and Development*, 2020; 15:29(2):110-118.

5. **Colbath A, Dow S, McIlwraith CW, Goodrich L.** Mesenchymal stem cells for treatment of musculoskeletal disease in horses: Relative merits of allogeneic versus autologous stem cells. *Equine Veterinary Journal*, 52(5), 654-663.
6. **Haussler KK, Wilde SR, Davis MS, Hess AM, McIlwraith CW.** Contrast therapy: Tissue heating and cooling properties within the equine distal limb. *Equine Vet J*, 2020; PMID: 32386069.
7. **Kamm JL, Parlane NA, Riley CB, Gee EK, Dittmer KE, McIlwraith CW.** Blood type and breed-associated differences in cell marker expression on equine bone marrow-derived mesenchymal stem cells including major histocompatibility complex class II antigen expression. *PloS One*, 14(11), e0225161.
8. **Haussler KK, Manchon PT, Donnell JR, Frisbie DD.** Effects of low-level laser therapy and chiropractic care on back pain in quarter horses. *J Equine Vet Sci*. PMID: 32067657.
9. **Ellis KL, King MR.** Relationship between postural stability and paraspinal muscle adaptation in lame horses undergoing rehabilitation. *J Equine Vet Sci*, 2020.
10. **Garbin LC, McIlwraith CW, Frisbie DD.** Evaluation of allogeneic freeze-dried platelet lysate in cartilage exposed to interleukin 1- β in vitro. *BMC Veterinary Research*, 2019; 15(1), 1-10.
11. **Kamm JL, Parlane NA, Riley CB, Gee EK, Roberts JM, McIlwraith CW.** CellTrace Violet™ inhibits equine lymphocyte proliferation. *Veterinary Immunology and Immunopathology*, 2020.
12. **Kisiday JD, Schwartz JA, Tangtrongsup S, Goodrich LR, Grande DA.** Culture conditions that support expansion and chondrogenesis of middle-aged rat mesenchymal stem cells. *Cartilage*, 2020; 11(3), 364-373.
13. **Potenza KN, Hugogns NA, Jones ARE, Rosanowski SM, McIlwraith CW.** Racing performance following arthroscopic surgery of the metacarpophalangeal and carpal joints in thoroughbred racehorses rehabilitated using conventional and underwater treadmill therapy. *Vet Record*, 2020. Accepted.

2019 Refereed Publications

1. **Pascual-Garrido C, Aisenbrey E, Rodriguez-Fontan F, Haneda M, Kisiday JD, Payne K, Bryant S, Goodrich LR.** Mesenchymal stem cells delivered in a novel cartilage mimetic hydrogel for the treatment of focal chondral lesions in an equine animal model. *Orthopaedic Journal of Sports Medicine*, 2019.
2. **Balducci JJ, Barrett MF, Moorman VJ.** Surgical treatment of an osseous cyst-like lesion in the middle phalanx communicating with the distal interphalangeal joint of a horse. *Journal of Equine Veterinary Science*, 2019.

3. **Ball AN, Phillips JN, McIlwraith CW, Kawcak CE, Samulski RJ, Goodrich LR.** Genetic modification of scAAV-equine-BMP-2 transduced bone-marrow-derived mesenchymal stem cells before and after cryopreservation: An “off-the-shelf” option for fracture repair. *J Orthop Res*, 2019; 37: 1310-1317.
4. **Daniel AJ, Leise BS, Selberg KT, Barrett MF.** Enhanced ultrasonographic imaging of the equine distal limb using saline injection of the digital flexor tendon sheath: A cadaver study. *The Veterinary Journal*, 2019.
5. **Hoaglund EL, Seabaugh KA, Selberg KT, Hess A, Bass L.** Comparing the clinical success rate of the dorsolateral approach to the medial approach for injection of the centrodistal joint in the horse. *Equine Vet J*, 2019; 51(6):795-801.
6. **Moorman VJ, Bass L, King MR.** Evaluation of the effects of alpha-2 adrenergic agonists alone and in combination with butorphanol tartrate on objective measurements of lameness in horses. *Am J Vet Res*, 2019; 80(9):868-877.
7. **Krueger CR, Lewis RB, McIlwraith CW, Major MD, Brakenhoff JE, Hand DR, Rowland AL, Hess AM, Johnson SW, Hackett ES.** A retrospective cohort study of racing performance in Quarter Horses undergoing prosthetic laryngoplasty for treatment of recurrent laryngeal neuropathy. *JAVMA*, 2019; 254: 496-500.
8. **Camargo-Garbin L, McIlwraith CW, Frisbie DD.** Evaluation of allogeneic freeze-dried platelet lysate in cartilage exposed to interleukin 1- β in vitro. *BMC Vet Res*, 2019 Nov 1; 15(1):386. PMID: PMC6824121.
9. **Colbath AC, Dow SW, Hopkins LS, Phillips J, McIlwraith CW, Goodrich LR.** Single and repeated intra-articular injections in the tibiotarsal joint with allogeneic and autologous equine bone marrow-derived mesenchymal stem cells; stem cells are safe but did not reduce acute inflammation in an experimental interleukin-1 β model of synovitis. *Equine Vet J*, 2020.
10. **Colbath AC, Dow SW, McIlwraith CW, Goodrich LR.** Mesenchymal stem cells for treatment of musculoskeletal disease in horses: relative merits of allogeneic versus autologous stem cells. *Equine Vet Journal*, 2019. Accepted.
11. **Colbath AC, Kisiday JD, Tangtrongsup S.** Effect of culture duration on chondrogenic preconditioning of equine bone marrow mesenchymal stem cells in self-assembling peptide hydrogel. *Journal of Orthopaedic Research*, 2019 Jun; 37(6):1368-75.
12. **Kamm JL, Parlane NA, Riley CB, Gee EK, Dittmer KE, McIlwraith CW.** Blood type and breed-associated differences in cell marker expression on equine bone marrow-derived mesenchymal stem cells including major

histocompatibility complex class II antigen expression. *PloS One*, 2019; 14(11): 1-16.

13. **Giunta K, Donnell JR, Donnell AD, Frisbie DD.** Prospective randomized comparison of platelet rich plasma to extracorporeal shockwave therapy for treatment of proximal suspensory pain in Western performance horses. *Res Vet Sci*, 2019; 1;126:38-44.
14. **Pezzanite L, Easley J.** ‘Update on surgical treatment of wobblers’ in *Vet Clin North Am Equine Pract*, 2019; 35: 299-309.
15. **McCoy AM, Smith RL, Herrera S, Kawcak CE, McIlwraith CW, Goodrich LR.** Long-term outcome after stifle arthroscopy in 82 Western performance horses (2003-2010). *Vet Surg*, 2019; 48: 956-965.
16. **Graham RJTY, Rosanowski SM, McIlwraith CW.** A 10-year study of arthroscopic surgery in racing Thoroughbreds and Quarter Horses with osteochondral fragmentation of the carpus. *Equine Vet J*, 2019.
17. **Pezzanite L, Leary D, LaRue S, Hackett E.** Aryepiglottic lymphoma in a 19-year-old Paint gelding treated with excision and strontium radiation. *Equine Vet Edu*, 2019; 31(3): 130-133.
18. **Tangtrongsup S, Kisiday JD.** Differential effects of the antioxidants n-acetylcysteine and pyrrolidine dithiocarbamate on mesenchymal stem cell chondrogenesis. *Cellular and Molecular Bioengineering*, 2019; 12(2):153-63.
19. **McIlwraith CW, Latterman NC.** Intra-articular corticosteroids for knee pain – what have we learned from the equine athlete and current best practices. *J Knee Surg*, 2019; 32:9-25.

2021 Research Abstracts/Presentations/ Proceedings

1. **Yocom A, Swain E, Contino E.** Pharmacokinetics and safety of an oral cannabidiol product in horses.
2. **Zanotto GM, Frisbie DD.** Current joint therapy usage in equine practice: Changes in the last 10 years. *Am Assoc Equine Pract*, Nashville, TN, 67:361. Accepted: 67th Annual Convention American Association Equine Practitioners.
3. **Liebig B, Goodrich L, Kisiday J.** Adult equine chondrocytes are capable of extensive in vitro expansion and express CD146 with time in culture. *CSU CVMBS Research Day*, Fort Collins, CO. Poster.
4. **Liebig B, Goodrich L, Kisiday J.** Suppression of stimulated lymphocyte proliferation by adult equine chondrocytes increases with culture expansion. *University of Colorado Orthopedic Research Symposium and D'Ambrosia Diversity Lectureship*, virtual and in-person conference. Poster.

5. **Parkinson S, Maldonado M, Haussler KK.** The effect of deep tissue heating on cervical pain and dysfunction in horses. In: 22nd Annual CVMBS Research Day, Colorado State University, Fort Collins, CO.
6. **Maldonado M, Parkinson S, Haussler KK.** The effect of chiropractic treatment on lameness and concurrent axial skeleton pain and stiffness in horses. In: 22nd Annual CVMBS Research Day, Colorado State University, Fort Collins, CO.

2020 Research Abstracts/Presentations/ Proceedings

1. **Contino E.** How to manage back pain in horses, In: *Proceedings 66th Annual Convention American Association Equine Practitioners*, pp 232-239.
2. **Kisiday JD, Liebig BE, Goodrich LR.** Adult ovine chondrocytes in expansion culture adopt progenitor cell properties that are favorable for cartilage tissue engineering. *Transactions of the 66th Orthopaedic Research Society Meeting*, Phoenix, AZ.
3. **Sikes K, Timkovich A, Sanford J, Fernandez K, Burnett D, Hurley E, Haut-Donahue T, Afzali M, Santangelo K.** Development of full and partial models of mid-substance ACL rupture using tibial displacement. *Orthopaedic Research Society*, Phoenix, AZ, 2020.
4. **Pezzanite L, Nout-Lomas Y, Aldrich E, Bayless R, Nelson B, Seim H, Easley J.** Outcomes after cervical vertebral stabilization using polyaxial pedicle screw and rod constructs in 10 horses (2015-2019). *ACVS Conference*, podium presentation; online due to COVID-19.
5. **Pezzanite L, Piquini G, Chow L, Phillips N, Lunghofer P, Griffenhagen G, Gustafson D, Moore R, Stoneback J, Hendrickson D, Dow S, Goodrich L.** Amikacin induces dose-dependent increases in collagen degradation products and biomarkers of joint inflammation in equine tarsocrural joints in vivo. *ACVS Conference*, poster presentation; online due to COVID-19.
6. **Pezzanite L, Piquini G, Chow L, Phillips N, Lunghofer P, Griffenhagen G, Gustafson D, Moore R, Stoneback J, Hendrickson D, Dow S, Goodrich L.** Identification of antibiotics with minimal cytotoxicity for local administration in septic arthritis. *Orthopedic Research Symposium & D'Ambrosia Diversity Lectureship*, poster presentation; online due to COVID-19. Mack Clayton Visiting Poster Award, 1st place overall.
7. **Pezzanite L, Piquini G, Chow L, Moore R, Stoneback J, Gustafson D, Lunghofer P, Phillips N, Dow S, Goodrich L.** Amikacin induces dose-dependent cartilage degradation products and biomarkers of inflammation in equine joints in vivo. *CSU CVMBS Symposium*, poster, 1st place overall.

8. **Newman R, Pezzanite L, Chow L, Lambrechts N, Goodrich L, Dow S.** Optimizing antibiotic selection in treatment of canine septic arthritis to minimize joint cytotoxicity. CSU CVMBS Symposium, podium speech.
9. **Newman R, Pezzanite L, Chow L, Goodrich L, Lambrechts N, Dow S.** Toxicities of different concentrations of commonly-used antibiotics on canine chondrocytes and synovial cell cultures. VOS Symposium, accepted for poster.
10. **Pezzanite L, Chow L, Piquini G, Dow S, Goodrich L.** Identification of five antibiotics with minimal cytotoxicity to equine joint cells. CSU CVMBS Symposium, poster, 2nd place overall.
11. **Strnadova A, Chow L, Pezzanite L, Maranon F, Martabano B, Dow S, Wotman K.** Novel ocular immunotherapy induces regression of corneolimbic squamous cell carcinoma in horses. CSU CVMBS Symposium, poster.
12. **Gitterman S, Pezzanite L, Hendrickson D, Moorman V, Griffenhagen G.** The pharmacokinetics of liposomal bupivacaine in the horse: A first investigation to improve postoperative and chronic pain management in horses. CSU CVMBS Symposium, podium presentation.
13. **Pezzanite L, Griffenhagen G, Krause D, Hendrickson D.** Postoperative antibiotic administration for elective arthroscopies is associated with increased risk of complication. CSU CVMBS Symposium, poster.
14. **Johnson SA, Chicco AJ, Selberg KT, King MR, Dunkle ZP, Owens JG, Frisbie DD.** Short-term effects of blood flow restriction training on equine skeletal muscle oxidative capacity. Orthopedic Research Society. Accepted for poster presentation.
15. **King MR, Seabaugh K, Frisbie DD.** Objective assessment of pulsed electromagnetic field therapy on horses with clinical back pain. Proceedings, American Association of Equine Practitioners. Las Vegas, NV. Oral presentation.
16. **Ellis KL, King MR.** Relationship between postural stability and paraspinal muscle adaptation in lame horses undergoing rehabilitation. Proceedings, American Association of Equine Practitioners. Las Vegas, NV.

2019 Research Abstracts/Presentations/Proceedings

1. **Haussler KK, King MR, Peck K, Adair H.** Review of the development of safe and effective rehabilitation protocol in horses. In: Proceedings of the 65th Annual Convention of the American Association of Equine Practitioners. Denver, CO. pp. 229-236.
2. **Connor M, Ellis K, King MR.** How to perform objective outcome measures in equine rehabilitation. Proceedings, American

Association of Equine Practitioners. Denver, CO. Oral presentation.

3. **Daglish J, Ellis KL, King MR.** Clinical use of pressure algometry in equine musculoskeletal rehabilitation. BEVA Congress. Birmingham, UK. Oral presentation.
4. **Ellis K, King MR.** Review of current literature of common rehabilitation modalities. Proceedings, American Association of Equine Practitioners. Denver, CO.
5. **Haussler KK.** Chiropractic and acupuncture diagnostic approaches in equine sports medicine. In: Proceedings of the American Association of Equine Practitioners Summer Focus Conference: Sports Medicine. Fort Collins, CO. July 29-31, pp. 4-10.
6. **Haussler KK, McIlwraith CW, Wolfer SR.** Tissue heating and cooling properties of a contrast therapy device applied to the equine distal limb. Acta Veterinaria Scandinavica, 2019; 61(Suppl 1):A38.
7. **Piquini G, Pezzanite L, Chow L, Dow S, Soontararak S, Goodrich L.** Amikacin is cytotoxic to equine joint cells and mesenchymal stromal cells at clinically relevant doses. Boehringer Ingelheim National Veterinary Scholars Symposium, poster.
8. **Pezzanite L, Chow L, Phillips N, Soontararak S, Dow S, Goodrich L.** Amikacin toxicity against normal joint cells and mesenchymal stem cells in horses. CSU CVMBS Symposium.
9. **Pezzanite L, Chow L, Phillips N, Soontararak S, Piquini G, Dow S, Goodrich L.** Antibiotic cytotoxicity against joint cells and mesenchymal stromal cells in horses. NAVRMA Symposium. ACVS Symposium. AAEP Symposium.
10. **Strnadova A, Chow L, Pezzanite L, Maranon F, Marabano B, Dow S, Wotman K.** Topically applied liposomal toll-like receptor ligand complexes to treat equine corneolimbic squamous cell carcinoma. Boehringer Ingelheim National Veterinary Scholars Symposium, poster.
11. **Griffenhagen G, Pezzanite L, Hendrickson D, Moorman V.** Comparison of two bupivacaine formulations using an experimental model of equine sole pain. AAEP Symposium. IVECCS Symposium. ACVS Symposium.

2021 Oral Presentations

1. **Goodrich L.** From horses to humans: Studying OA and cartilage repair. North American Veterinary Medical Association, invited speaker. Fort Collins, CO.
2. **Goodrich L.** Autologous protein solution in horses. AAEP, invited speaker. Nashville, TN.
3. **Goodrich L.** Advanced OA; Olecranon fractures; Management of osteomyelitis. AO, invited speaker. Virtual.

4. **Kawcak C.** The use of bisphosphonates in equine orthopedics. XXI ABRAVEQ International Conference. Virtual.

2020 Oral Presentations

1. **McIlwraith CW.** The Equine Regenerative Medicine and Orthobiologics Summit. Virtual.
2. **Goodrich L.** Lameness rounds; Stem cell therapy: How, what and when?; IRAP and PRP: Uses in joint and tendon disease; Rational use of corticosteroids and hyaluronan. Lake Tahoe Equine Conference, invited speaker. Tahoe, NV.
3. **Goodrich L.** Regenerative medicine in sports medicine. Equine Orthobiologics Group, invited speaker and moderator, Virtual.
4. **Goodrich L.** Stem cell therapy in equine athletes. ACVS, invited speaker. Virtual.
5. **Goodrich L.** AAVI-1ra gene therapy for osteoarthritis. American Association of Gene and Cell Therapy, invited speaker. Virtual.
6. **Kawcak C.** Ways to optimize cartilage function in equine fracture repair. AO. La Jolla, CA.

2019 Oral Presentations

1. **Contino E.** Treatment and rehabilitation of back and SI pain. Florida Association of Equine Practitioner's 15th Annual Promoting Excellence Symposium, Fort Myers, FL.
2. **Contino E.** A pain in the back(side): Diagnosing, treating and rehabilitating horses with back pain. Colorado State University Annual Conference, Fort Collins, CO.
3. **Frisbie DD.** Autologous conditioned serum – A pathway to an off the shelf product. Dorothy Russell Havemeyer Foundation on Translational Orthobiologics, Dorothy Russell Havemeyer Foundation, Fort Collins, CO.
4. **Frisbie DD.** AAEP General Assembly, Federation of European Equine Veterinary Associations.
5. **Kawcak C.** Table topic: Bisphosphonates. AAEP. Denver, CO.
6. **Kawcak C.** Bisphosphonate use in Western performance horses. Descra Round Table meeting. Denver, CO.
7. **King MR.** Rehabilitation of the equine athlete: The scientific viewpoint. Proceedings, AAEP Focus on Sports Medicine Meeting: Diagnosis, Treatment, and Rehabilitation of the Equine Athlete. Fort Collins, CO.
8. **Goodrich L.** Case Based Discussion on Stifle Disease; Treatment of cartilage, ligaments, and meniscal injuries in the stifle: Basic to advanced; Updates on the art and science of diagnosing stifle disease in the adult horse. World Equine Veterinary Association, invited speaker. Verona, Italy.

9. **Goodrich L.** Medical and surgical management of stifle disease; Diagnosing stifle disease: From traditional to new approaches; Rational use of intra and extra articular corticosteroids, HA, and non-biologics; Biologics and Joint Disease: How are they working and what is the evidence. World Equine Veterinary Association, invited laboratory speaker. Santiago, Chile.
10. **Goodrich L.** Lameness originating from the stifle and practical treatment; Joint therapies – how are they working?; What years of nerve blocks, MRIs, and bursoscopies have taught me about foot lameness; Lameness rounds. Lake Tahoe Equine Conference, invited speaker. Tahoe, NV.
11. **Goodrich L.** Woman in leadership, veterinary orthopedic surgery. International Cartilage Repair Society, invited speaker. Vancouver, BC, Canada.
12. **Goodrich L.** Preclinical models session. Orthopedic Research Society, workshop organizer. Austin, TX.
13. **Seabaugh KA.** To cut or not to cut. Colorado Veterinary Medical Association annual conference, Keystone, CO.
14. **Seabaugh KA.** Managing horses under USEF and FEI rules. AAEP Focus on the Sport Horse Symposium, Fort Collins, CO.
15. **McIlwraith CW.** Global perspective of the use of veterinary orthobiologics – where are we? Translational Symposium. Co-chair of symposium.
16. **McIlwraith CW.** “Clinician-scientists career in equine orthopaedic research and translation beyond the horse.” Keynote Lecture – when receiving the AVMA Lifetime Excellence in Research Award. National Veterinary Scholars Symposium, Tufts University Cummings School of Veterinary Medicine.
17. **McIlwraith CW.** Rod Mor Trust Lecture Series. “How can I fix my injured equine star? The latest in stem cells and other therapies.” Lectures in five cities with Dr. Lacy Kamm. “Biologic therapies for traumatic injuries to joints and osteoarthritis.” New Zealand Blood Stock Sales Complex, Gallagher Academy of Performing Arts University of Waikato; Addington Raceway, Christchurch; Ascot Racecourse, Sydney; Awapuni Racecourse, Palmerston North.
18. **McIlwraith CW.** Equine orthopaedic research and translation beyond the horse. Veterinary Innovation Summit, Colorado State University, Fort Collins, CO.
19. **McIlwraith CW.** Honorary lecture: Horses and humans – building a translational research program on osteoarthritis and cartilage repair. 15th World Congress, International Cartilage Regeneration & Joint Preservation Society, Vancouver, Canada.

Investigations of the Origins of Musculoskeletal Disease

- a. Musculoskeletal pain pathways
- b. Biomechanics and sensory input
- c. Repetitive stress response
- d. Cell markers
- e. Ganglionitis

Musculoskeletal diseases cannot be optimally prevented or treated without understanding the origins of the specific diseases; namely, why they happen and the pathophysiology behind them. As an example, catastrophic injury is a major problem in the equine athlete and, consequently, a major problem in the equine athletic industry. Dr. Chris Kawcak, in his Ph.D. work with Drs. Bob Norrdin, Sue James, and Wayne McIlwraith first demonstrated that these severe fractures and injuries start as microdamage and microfractures in the subchondral bone. It is important to understand bone and its response to repetitive stress and the origins of subchondral bone disease. Further, we need to understand the mechanisms of pain, hypersensitivity to ongoing pain, and the neurological pathways associated with the pain response. Much work in this area, including the use of imaging and fluid biomarkers to detect early microdamage, has continued under the leadership of Drs. Kawcak, David Frisbie, and McIlwraith, and is continuing into the next generation with Drs. Brad Nelson and Holly Stewart.

2a. Musculoskeletal pain pathways: Pain has very complex pathways starting from the periphery and progressing up to the spinal cord and on to the brain. Understanding these pathways gives insight into how and where to intercede to better control and treat pain.

2b. Biomechanics and sensory input: Sensitivity response to repetitive impact and the biomechanics of how a horse changes or alters the response to repetitive motion will offer insight into motion, recognition of pain, and physical response to pain. This area offers initial understanding of complex physiology of what our equine athletes undergo with motion.

2c. Repetitive stress response: With any repetitive motion to muscle, bone, cartilage, and tendons/ligaments there is a physiological response. Sometimes it makes our athletes stronger but often, if not controlled or applied too quickly or too strongly, tissues can and will break down. Understanding the response and how to control it so that tissues only become stronger (and not break down) will lead to less injury to our patients.

2d. Cell markers: There are cell responses in the origins of musculoskeletal disease and understanding these responses at the cellular and molecular level will translate to being able to detect disease through the study of biomarkers (in Focus 3). The biology and pathophysiology of cell responses are crucial to our understanding of the pathogenesis of disease.

2e. Dorsal root ganglion: When pain is recognized by the central nervous system it is actually “processed” in the dorsal root ganglions within the central nervous system. Understanding how pain responses are processed and how ongoing pain translates to increased sensitivity to pain is important to breaking the pain cycle.

Publications/Presentations 2019-2021

2020 Textbook Chapters

1. **McIlwraith CW.** Arthropathies in large animals. In: Merck Veterinary Manual, 11th ed. Merck & Co. Inc., 2016: 1060-1064.
2. **McIlwraith CW.** Lameness in horses: Tendonitis. In: Merck Veterinary Manual, 11th ed. Merck & Co. Inc., 2016: 1121-1123.
3. **McIlwraith CW.** Joint injuries and disease in osteoarthritis. In: Adams and Stashak's Lameness in Horses, 7th ed. Baxter GM, (ed). Wiley, 2020: 801-819.
4. **McIlwraith CW.** Fractures and luxations of the fetlock. In: Equine Fracture Repair, 2nd ed., Nixon AJ, (ed). Wiley-Blackwell, 2020: 320-340.
5. **McIlwraith CW.** Fractures of the carpus. In: Equine Fracture Repair, 2nd ed., Nixon AJ (ed). Wiley-Blackwell, 2020: 480-514.
6. **McIlwraith CW.** Osteochondrosis. In: Adams and Stashak's Lameness in Horses, 7th ed., Baxter GM (ed). Wiley, 2020: 1071-1080

2021 Refereed Publications

1. **Ellis K, Contino E, Nout-Lomas Y.** Poor performance in the horse: Diagnosing the non-orthopedic causes. Equine Vet Ed. Submitted.
2. **Thampi P, Tabbaa SM, Johnstone B, Wimmer MA, Laurent MP, McIlwraith CW, Frisbie DD.** Surface topography as a tool to detect early changes in a posttraumatic equine model of osteoarthritis. J Orthop Res, 2021 Aug 27. PMID: 34449916.
3. **Johnson SA, Biscoe EW, Eilertson KE, Lutter JD, Schneider RK, Roberts GD, Cary JA, Frisbie DD.** Tissue predictability of elastography is low in collagenase induced deep digital flexor tendinopathy. Vet Radiol Ultrasound, 2021 Sep 28. PMID: 34585463.
4. **Johnson SA, Donnell JR, Donnell AD, Frisbie DD.** Retrospective analysis of lameness localization in Western performance horses: A ten-year review. Equine Vet J, 2021 Nov; 53(6):1150-1158.
5. **Thompson R, Meyers M, Pukazhenth PS, Hollinshead F.** Evaluation of growth, viability, and structural integrity of equine endometrial organoids following cryopreservation. Cryobiology. In print Nov. PMID: 34788682.
6. **Parsons AM, Bruemmer JE, Hollinshead FK, Bouma GJ.** The corpus luteum, a source and target of androgen. Journal of Women's Health, Issues and Care, 2021; Vol 10, Issue 8.

7. **Gadomski B, Labus K, Puttlitz C, McGilvray K, Regan D, Nelson B, Seim III H, Easley J.** Evaluation of lumbar spinal fusion utilizing Recombinant Human Platelet Derived Growth Factor-B Chain Homodimer (rhPDGF-BB) combined with a bovine collagen/ β -Tricalcium Phosphate (β -TCP) matrix in an ovine model. JOR Spine, 2021 Jul 2; 4(3):e1166.
8. **Yang YP, Labus KM, Gadomski BC, Bruyas A, Easley J, Nelson B, Palmer RH, McGilvray K, Regan D, Puttlitz CM, Stahl A, Lui E, Li J, Moeinzadeh S, Kim S, Maloney W, Gardner MJ.** Osteoinductive 3D printed scaffold healed 5 cm segmental bone defects in the ovine metatarsus. Sci Rep, 2021 Mar 23; 11(1):6704.
9. **Nelson B, Steward K, Smanik L, Koch D, Rawlinson J, Easley JT.** Pedicle screw external fixation to stabilize oblique mandibular fractures in three standing, sedated horses. Vet Surg, 2021 Apr; 50(3):659-667.
10. **Yang Y, Gadomski B, Bruyas A, Easley J, Labus K, Nelson B, Palmer R, Stewart H, McGilvray K, Puttlitz CM, Regan D, Stahl A, Lui E, Li J, Moeinzadeh S, Kim S, Maloney W, Gardner M.** Investigation of a prevascularized bone graft for large defects in the ovine tibia. Tissue Eng Part A, 2021 Jun 11.
11. **Krakoff E, Smanik L, Nelson B.** What is your diagnosis? J Am Vet Med Assoc, 2021 Nov 1; 259(11):1267-1270.
12. **Frank S, Nelson B, Simpson K, Holt T, Callan R, Hackett E.** Investigation of neonatal disorders in New World camelids and factors associated with death during and after hospitalization of affected crias. J Am Vet Med Assoc, 2021 Apr 15; 258(8):892-898. PMID: 33825531.
13. **Hector R, Rezende M, Nelson B, Monnet E.** Cardiopulmonary function and intestinal blood flow in anaesthetized, experimentally endotoxemic horses administered a constant rate infusion of dexmedetomidine. Equine Vet J, 2021. Accepted.
14. **Pezzanite L, Easley J, Bayless R, Aldrich E, Nelson B, Seim H 3rd, Nout-Lomas Y.** Outcomes after cervical vertebral interbody fusion using an interbody fusion device and polyaxial pedicle screw and rod construct in 10 horses (2015-2019). Equine Vet J, 2021. Accepted.
15. **Dandu N, Nelson B, Easley J, Huddleston H, DeFrody S, Bisazza K, Garrigues G, Yanke A.** Quantifying magnitude of local tendon injury by electrosurgical cautery: A cadaveric study. J Shoulder Elbow Surg, 2021 Sep 25; S1058-2746(21)00692-3.
16. **King MR, Seabaugh K, Frisbie DD.** Effects of a bio-electromagnetic energy regulation blanket on thoracolumbar epaxial muscle pain in horses. JEVS, December 2021. Accepted.

17. **Moorman VJ, King MR.** Angular orientations derived from a portable media device to determine postural stability during quiet standing in the horse. EVE, 2021.
18. **Pezzanite L, Hackett E, McCreedy E, Easley J.** Outcomes following single, caudally based bilateral versus unilateral frontonasal sinusotomy for treatment of equine paranasal sinus disease. Vet Med Sci, 2021.
19. **Pezzanite L, Frank C, Koch D, Moss A, Landolt G.** Abdominal aortic thromboembolism and subsequent pelvic limb myositis secondary to colitis and septicemia in a 5-day-old Oldenburg colt. Equine Vet Edu, 2021.
20. **Pezzanite L, Contino E, Kawcak C.** Response to Drs. Dyson, Nagy, and Murray letter regarding 'Lameness originating from the proximal metacarpus/tarsus: A review of local analgesic techniques and clinical diagnostic findings.' Equine Vet Edu, 2021; 33: 615-616.
21. **McDermott JE, Pezzanite L, Goodrich L, Dow S, Santangelo K, Chow L, Wheat W.** Equine innate immunity and osteoarthritis. Animals, 2021. Accepted.
22. **Krause D, Pezzanite L, Griffenhagen G, Hendrickson D.** Comparison of equine synovial sepsis rate following intrasynovial injection in ambulatory versus hospital settings. Equine Vet J, 2021.
23. **Smith RKW, McIlwraith CW.** "One Health" in tendinopathy research: Current concepts. J Orthop Res, 2021: 0-0.
24. **Berger D, Centeno C, Kisiday J, McIlwraith CW, Steinmetz N.** Colony forming potential and protein composition of commercial umbilical cord allograft products in comparison with autologous orthobiologics. Am J Sports Med, 2021 Oct; 49(12):3404-3413. PMID: 34398643.
25. **Story M, Nout-Lomas Y, Aboellail T, Selberg K, Barrett M, McIlwraith CW, Haussler KK.** Dangerous behavior and intractable axial skeletal pain in performance horses: A possible role for ganglioneuritis (14 cases; 2014-2019). Front Vet Sci, 2021 Dec 10; 8:734218. PMID: 34957274; PMCID: PMC8702524.

2020 Refereed Publications

1. **Barrett MF, Bass L, Bergstrom T, Daglish J, Griffin J, Moorman V.** Complex pastern injuries involving the scutum medium in ten horses. Equine Veterinary Education, 2020 January 13. Accepted.
2. **Virk M, Luo W, Sikes K, Li J, Plaas A, Cole B.** Gene expression profiling of progenitor cells isolated from rat rotator cuff musculotendinous junction. BMC Musculoskeletal Disorders, 2020; 21 (194). PMID 32222148.

3. **Ellis K, Smanik L, Goodrich L, Contino E.** What is your diagnosis? J Amer Vet Med Assoc, 2020; 256(11), 1205-7.
4. **Pezzanite L, Contino E, Kawcak C.** Lameness originating from the proximal metacarpus/tarsus: A review of local analgesic techniques and clinical diagnostic findings. Equine Vet Ed, 2020; 32(4), 204-17.
5. **Kisiday JD, Liebig BE, Goodrich LR.** Adult ovine chondrocytes in expansion culture adopt progenitor cell properties that are favorable for cartilage tissue engineering. Journal of Orthopaedic Research, 2020; 38(9): 1996-2005.
6. **Stewart HL, Werpy NM, McIlwraith CW, Kawcak CE.** Physiologic effects of long-term immobilization of the equine distal limb. Veterinary Surgery, 2020; 49: 840-851.
7. **Moorman VJ, King MR.** Angular orientations derived from a portable media device to determine postural stability during quiet standing in the horse. EVE, October 2020. Accepted.
8. **Kisiday JD.** Expansion of chondrocytes for cartilage tissue engineering: A review of chondrocyte dedifferentiation and redifferentiation as a function of pp growth in expansion culture. Regenerative Medicine Frontiers, 2020; 2(1):e200002.

2019 Refereed Publications

1. **Adrian C, Haussler K, Kawcak CE, Reiser RF, Riegger-Krugh C, Palmer RH, McIlwraith CW, Taylor R.** Gait and electromyographic alterations due to early onset of injury and eventual rupture of the cranial cruciate ligament in dogs: A pilot study. Vet Comp Orthop Traumatol, 32(S 03): A1-A12.
2. **Katzman SA, Spriet MP, Beck BR, Barrett MF, Hendrickson DA.** Incomplete fracture of the talus secondary to maladaptive stress remodeling in a horse. Journal of the American Veterinary Medical Association, 2019.
3. **Haussler KK, Clayton HM, Pool RR.** Characterization of bony changes localized to the cervical articular processes in a mixed population of horses. PLoS ONE, 14(9): e0222989. PMID:31557207; PMCID: PMC6762202.
4. **Turlo AJ, Cywinska A, Frisbie DD.** Revisiting predictive biomarkers of musculoskeletal injury in thoroughbred racehorses: Longitudinal study in Polish population. BMC Vet Res, 2019 Feb 26; 15(1):66. PMC6390350.

2021 Research Abstracts/Presentations/Proceedings

1. **Acutt E, Contino E, Frisbie D, Barrett M.** Deep digital flexor tendon lesions in the pastern are associated with the presence of distal tendinopathy. 67th Annual Convention American Association Equine Practitioners.
2. **Liebig B, Goodrich L, Kisiday J.** Culture expansion of adult equine chondrocytes induces CD146 expression and increases immunomodulatory properties. North American Veterinary Regenerative Medicine Association Conference, Fort Collins, CO.
3. **Stewart HL, Easley JT, Selberg KT, Puttlitz CM, Kawcak CE.** Long-term evaluation of an experimental model of bone marrow lesions in the ovine femoral condyle. University of Colorado 3rd Annual Orthopedic Research Symposium & D'Ambrosia Diversity Lectureship; online format. Mack Clayton Visiting Trainee Poster Award Finalist.

2019 Research Abstracts/Presentations/Proceedings

1. **Adrian C, Haussler K, Kawcak CE, Reiser RF, Riegger-Krugh C, Palmer RH, McIlwraith CW, Taylor R.** Gait and electromyographic alterations due to early onset of injury and eventual rupture of the cranial cruciate ligament in dogs: A pilot study. 46th Annual Veterinary Orthopedic Society Conference. Breckenridge, CO.
2. **Contino E.** Going the extra mile: Working up cases of poor performance. In: Proceedings Focus on Sport Horses. American Association Equine Practitioners, pp 11-13.
3. **Kisiday JD, Liebig BE, Goodrich LR.** Adult ovine chondrocytes possess a strong propensity for chondrogenesis after extensive expansion. Biomedical Engineering Society annual meeting. Philadelphia, PA.
4. **Seabaugh KA.** A pain in the hock. Colorado Veterinary Medical Association annual conference. Keystone, CO.

2021 Oral Presentations

1. **Frisbie D.** The management of subchondral bone cysts in the stifle. BAVA/AAEP Transatlantic Equine Clinic.

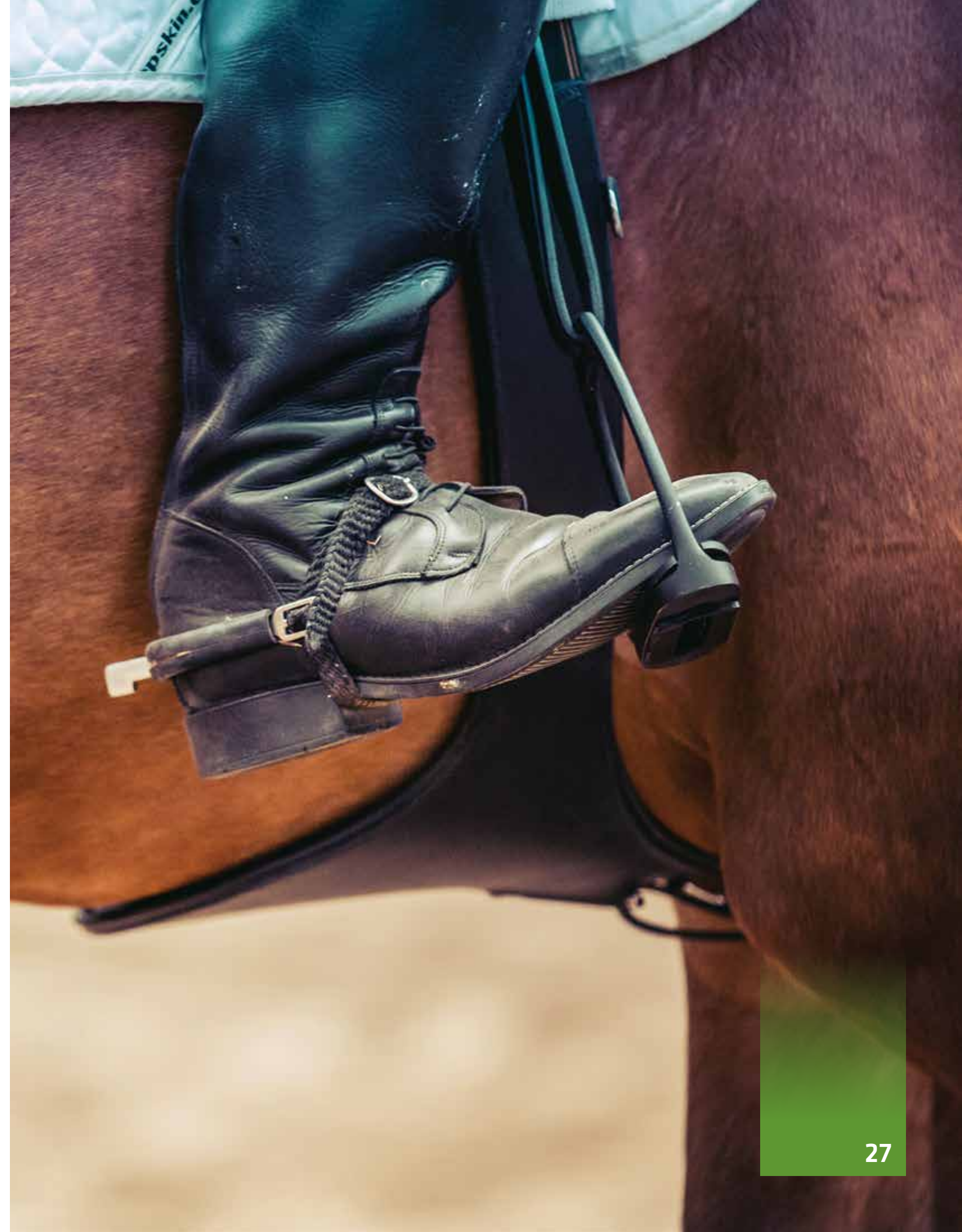
2. **Damone J, Bass L, Moorman V, et al.** Histologic and biomechanical evaluation of biopsy samples of the equine digital cushion from forelimbs. American Association of Equine Practitioners convention.
3. **Stewart HL, Kawcak CE.** Development of an experimental model of bone marrow lesions using the rat femoral condyle. CVMBS Research Day, Fort Collins, CO.

2020 Oral Presentations

1. **Contino E.** How to treat back pain. American Association of Equine Practitioners 66th Annual Convention, virtual (selected via competitive submission process; included refereed proceedings).
2. **Contino E.** Saddle fit in horses table talk. American Association of Equine Practitioners 66th Annual Convention, virtual.
3. **McIlwraith CW.** The TMI history, mission, and orthobiologic horizons. Arthrex Workshop Human Shoulder Arthroscopic Surgery. C. Wayne McIlwraith Translational Medicine Institute, Colorado State University. Fort Collins, CO.
4. **Sikes KJ.** Meniscal injury in rodent and rabbit models. Orthopaedic Research Society, Joint Preclinical Models and Meniscus Section meeting. Phoenix, AZ.

2019 Oral Presentations

1. **Contino E.** Equine lameness wetlab. American Association of Equine Practitioners Focus on Sports Medicine meeting. Meeting chair. Fort Collins, CO.
2. **Contino E.** Things that make you go hmmm – interesting sports medicine cases. Colorado State University annual conference. Fort Collins, CO.
3. **Sikes KJ.** Metabolic and mechanical 'tendon'-cies of soft tissue injuries. The University of Colorado Denver, Department of Orthopaedic Surgery. Denver, CO.
4. **Story, M.** The axial skeleton. AAEP Focus on Sports Medicine. Fort Collins, CO.



Improve the Detection of Musculoskeletal Disease

- a. Imaging modalities
- b. Correlation between imaging findings and clinical signs
- c. Biomarkers
- d. Novel diagnostic techniques

This focus includes the development of novel imaging techniques (present and future), body fluid biomarkers, and molecular monitoring. The uses of these early diagnostic techniques include a) evaluation of the pathogenesis of musculoskeletal disease, b) early detection of disease processes, and c) monitoring of therapy, with the long-term goal of preventing severe osteoarthritis, failure of joints, tendons, ligaments, and menisci, and catastrophic injury. Work in biomarkers has progressed into imaging biomarkers with particular emphasis on the use of ultrasonography, MRI, and computed tomography in diagnosing early disease change in the limb. Considerable work has also been accomplished using subject-specific finite element modeling of the equine metacarpal phalangeal joint, which helps us better understand the stresses that play a role in injury of this critical joint.

3a. Access to imaging modalities and strategies:

We have two board-certified radiologists (Drs. Kurt Selberg and Myra Barrett) and board-certified surgeons (Drs. Chris Kawcak and Brad Nelson), along with several graduate students who have led significant efforts in developing our imaging equipment and protocols. This is one of the fastest-growing areas that is rapidly changing our ability to detect subchondral bone disease prior to catastrophic injury. Detection of early injury through these mechanisms will change the landscape of diagnosing repetitive injuries in our athletes.

3b. Correlation between imaging findings and clinical signs:

Detection of imaging findings and correlation to clinical signs will be important for practitioners in the field. Without this, clinical use and recommendations to actually “order” the correct imaging modality will not result in clinical impact. This correlation is crucial to bringing the clinical implications to practice.

3c. Predicting disease before it manifests clinically through biomarkers:

Fluid biomarkers have been studied at the ORC for 25 years in work led by Drs. David Frisbie and Wayne McIlwraith, with critical contributions from experts of human OA biomarkers. We have published multiple publications on detection of early disease and developed a combination of ELISA and biochemical techniques that could predict musculoskeletal injury six weeks to six months before musculoskeletal injury occurs, but were thwarted in developing an affordable commercial panel. Armed with proof of principle, work demonstrating strong value using metabolomics, Drs. McIlwraith and Frisbie have combined forces with Dr. John Belisle’s group to pursue the development of a metabolomic platform that can be used to diagnose pre-OA changes as well as identify horses at risk for musculoskeletal injury (including catastrophic injury). This concomitantly involves establishment of a core facility in metabolomics at the TMI with the installation of two mass spectrometers funded by two significant donors to our program.

3d. Validating novel diagnostic techniques:

Novel diagnostics, such as the lameness locator,

force plate analysis, and the computer software developed to better interpret lameness and subtle lameness, are being intensively developed within the ORC. Even more novel is wearable technology that detects, in real time, how a horse's movement and parameters (heart rate and respiratory rate) may change in response to the beginning of an injury. This research is being led by Dr. Chris Kawcak and is involving multiple collaborations. We hope to decrease the subjectivity from lameness examinations and instead develop more diagnostic techniques to detect and quantify pain/lameness in our athletes.

Publications/Presentations 2019-2021

2021 Refereed Publications

1. **Temple-Wong MM, Raleigh AR, Frisbie DD, Sah RL, Mcllwraith CW.** Effects of an articular cartilage lubrication with a viscosupplement in vitro and in vivo following osteochondral fractures in horses. *Am J Vet Res*, 2021 Aug; 82(8):611-618. PMID: 34296945.
2. **Acutt EV, Contino EK, Frisbie DD, Barrett MF.** Deep digital flexor tendon lesions in the pastern are associated with the presence of distal tendinopathy. *Equine Vet J*, 2021 May 29. PMID: 34050982.
3. **Johnson SA, Valdés-Martínez A, Turk PJ, Mcllwraith CW, Barrett MF, McGilvray KC, Frisbie DD.** Longitudinal tendon healing assessed with multimodality advanced imaging and tissue analysis. *Equine Vet J*, 2021 Jun 8. PMID: 34101888.
4. **Story MR, Haussler KK, Nout-Lomas YS, Aboellail TA, Kawcak CE, Barrett MF, Frisbie DD, Mcllwraith CW.** Equine cervical pain and dysfunction: Pathology, diagnosis and treatment. *Animals (Basel)*, 2021 Feb. PMID: 33562089; PMCID: PMC7915466.
5. **Estrada McDermott J, Pezzanite L, Goodrich L, Santangelo K, Chow L, Dow S, Wheat W.** Role of innate immunity in initiation and progression of osteoarthritis, with emphasis on horses. *Animals (Basel)*, 2021 Nov 13; 11(11):3247. PMID: 34827979; PMCID: PMC8614551.
6. **Haussler KK, Hesback AL, Romano L, Goff L, Bergh A.** (2021) A systematic review of musculoskeletal mobilization and manipulation techniques used in veterinary medicine. *Animals*, 11; 2787.
7. **Stewart HL, Kawcak CE, Inscoc CR, Puett C, Lee YZ, Lu J, Zhou OZ, Selberg KT.** Comparative evaluation of tomosynthesis, computed tomography, and magnetic resonance imaging findings for metacarpophalangeal joints from equine cadavers. *Am J Vet Res*, 2021 Nov; 82(11):872-879.

8. **Stewart HL, Siewerdsen JH, Nelson BB, Kawcak CE.** Use of cone-beam computed tomography for advanced imaging of the equine patient. *Equine Vet J*, 2021 Sep; 53(5):872-885.
9. **Nelson BB, Stewart RC, Kawcak CE, Freedman JD, Patwa AN, Snyder BD, Goodrich LR, Grinstaff MW.** Quantitative evaluation of equine articular cartilage using cationic contrast-enhanced computed tomography. *Cartilage*, 2021 Apr; 12(2):211-221.
10. **Nelson BB, Lawless SP, Mcllwraith CW.** Slab fractures of the third carpal bone involving both radial and intermediate facets and outcomes after surgical repair in racing Quarter Horses. *Equine Vet J*, 2021. Accepted.
11. **Ford MG, Nelson BB, Ford TS, Souza CRS, Easley JT, Hackett ES.** Complications in foals undergoing surgical repair for uroperitoneum. *J Equine Vet Sci*, December 2021. Accepted.
12. **Ellis KL, King MR, Seabaugh K.** Retrospective analysis of horses with ultrasound evaluation of the sacroiliac region and response to sacroiliac joint injection: 42 cases. *J Equine Vet Sci*, 2021; 102.

2020 Refereed Publications

1. **Hoaglund EL, Barrett MF.** Magnetic resonance imaging changes of the navicular bursa following navicular bursoscopy in seven horses. *Equine Veterinary Education*, 2020.
2. **Ellis K, Barrett MF, Selberg K, Frisbie D.** Magnetic Resonance Imaging and histopathological evaluation of equine oblique sesamoidean ligaments. *Equine Vet J*. Accepted author manuscript.
3. **Koch DW, Barrett MF, Jackman BR, MacDonald D, Goodrich LR.** Comparison of lameness outcomes in horses with acute or chronic digital lameness that underwent magnetic resonance imaging. *New Zealand Veterinary Journal*, 25 March 2020. Accepted.

2019 Refereed Publications

1. **Aldrich ED, Goodrich LR, Contino EK, Kawcak CE, Barrett MF, King MR, Valdés-Martínez A.** Usefulness of caudomedial-cranio lateral oblique radiographic views for the diagnosis of injury to the origin of the cranial cruciate ligament in two horses. *JAVMA*, 2019; 254(4):508-511.
2. **Hoaglund L, Barrett M, Daglish J, Contino E.** Intermediate patellar ligament desmopathy often occurs in conjunction with stifle abnormalities. *Vet Rad and Ultrasound*, 2019; 60, 416-22.
3. **Dadone L, Olea-Popelka F, Stout E, Foxworth S, Klaphake E, Johnston MS, Han S, Barrett MF.** Clinical conditions found radiographically in the front feet of reticulated giraffe (*Giraffa camelopardalis reticulata*) in single zoo. *Journal of Zoo and Wildlife Medicine*, 2019.

4. **Ellis KL, Barrett MF, Selberg KT, Frisbie DD.** Magnetic resonance imaging and histopathological evaluation of equine oblique sesamoidean ligaments. *Equine Vet J*, 2019 Nov 30. PMID: 31785167.
5. **Nelson BB, Mäkelä JTA, Lawson TB, Patwa AN, Barrett MF, Mcllwraith CW, Hurtig MB, Snyder BD, Moorman VJ, Grinstaff MW, Goodrich LR, Kawcak CE.** Evaluation of equine articular cartilage degeneration after mechanical impact injury using cationic contrast-enhanced computed tomography. *Osteoarthritis Cartil*, May 2019.
6. **Pezzanite L, Bass L, Kawcak C, Goodrich L, Moorman V.** The relationship between sagittal hoof conformation and hindlimb lameness in the horse. *Equine Vet J*, 2019; 51: 464-469.
7. **Sidky EY, Stewart HL, Kawcak CE, Mcllwraith CW, Duff MC, Pan X.** Bone sparsity model for computed tomography image reconstruction. In: *Proc SPIE*, 2019; Vol 11072.
8. **Stewart RC, Nelson BB, Kawcak CE, Freedman JD, Snyder BD, Goodrich LR, Grinstaff MW.** Contrast-enhanced computed tomography scoring system for distinguishing early osteoarthritis disease states: A feasibility study. *J Orthop Res*, 2019.

2021 Research Abstracts/Presentations/Proceedings

1. **Smanik L, Selberg K, Kawcak C, Stewart H, Goodrich L.** Computed tomography versus radiographic guidance for internal fixation of central tarsal bone fractures in non-racing horses. Poster presented at: Large Animal Residents Post Session, American College of Veterinary Surgeons Virtual Surgery Summit. Awarded second place.

2020 Research Abstracts/Presentations/Proceedings

1. **Ellis KL, Seabaugh K, King MR.** Retrospective analysis of horses with ultrasound evaluation of the sacroiliac region and response to sacroiliac region injection: 42 cases. *Proceedings, American College of Veterinary Surgeons*. Washington, D.C. Oral presentation.
2. **Hurley E, Santangelo KS, Sikes KJ.** The role of toll-like receptor 4 in murine model of tendinopathy. *Celebrate Undergraduate Research*. Colorado State University, Fort Collins, CO.

2019 Research Abstracts/Presentations/Proceedings

1. **Barrett MF.** How to perform ultrasound-guided intra-arterial stem cell injection of the median artery. *American Association of Equine Practitioners proceedings*.

2. **Barrett MF.** Imaging beyond the foot: Pastern, fetlock, and tendon sheath. *American Association of Equine Practitioners proceedings*.
3. **Burnett DJ, Frisbie DD, Jordan S, Sikes KJ.** Research and development of a cyclic loading device to induce an overuse injury on equine superficial digital flexor tendon explants. *Celebrate Undergraduate Research*. Colorado State University, Fort Collins, CO.
4. **Sikes KJ, McConnell A, Smith S, Frisbie DD, Santangelo K.** Altered gait parameters following injury in a novel rat quadriceps myotendinous junction model. *Orthopaedic Research Symposium*. University of Colorado Anschutz Medical Campus, Denver, CO.
5. **Sidky KY, Stewart HL, Kawcak CE, Mcllwraith CW, Duff MC, Pan X.** Bone sparsity model for computed tomography image reconstruction. *Fully 3D 2019*, Philadelphia, PA.
6. **Stewart H, Kawcak CE.** Physiologic effects of immobilization of the equine distal limb. *CVMB Research Day*, Fort Collins, CO.
7. **Posukonis M, Kawcak CE.** Fracture characterization via computed tomography in Thoroughbred racehorses. *CVMB Research Day*, Fort Collins, CO.

2021 Oral Presentations

1. **Kawcak C.** History, performance and physical examination, diagnostic analgesia: Looking beyond textbooks, navigating the complexity of therapeutics, parts 1 and 2. *Oregon Veterinary Conference*, virtual.
2. **Kawcak C.** Post-mortem surveillance program. *Colorado Racing Commission*, virtual.
3. **Kawcak C.** What is bone edema, bone bruise? The science, the histology, the outcome. *Equine Regenerative Medicine and Orthobiologics Summit*, virtual.

2020 Oral Presentations

1. **Mcllwraith CW.** Autologous conditioned serum (IRAP and IRAP II) research and clinical use in equine orthopaedics. *Celtic Advanced Life Science Innovation Network*, Ireland, webinar.

2019 Oral Presentations

1. **Contino E.** Ultrasound of the cervical spine and stifle wetlab. *American Association of Equine Practitioners and International Society of Equine Locomotor Pathology*. Fort Collins, CO.
2. **Contino E.** Musculoskeletal ultrasound wetlab. *American Association of Equine Practitioners Focus on Sports Medicine meeting*. Meeting chair. Fort Collins, CO.
3. **Contino E.** Diagnosing back and SI pain – clinical features and diagnostic imaging. *Florida Association of Equine Practitioners 15th Annual Promoting Excellence symposium*. Fort Myers, FL.

4.

Contino E. A look at non-traditional causes of poor performance. Florida Association of Equine Practitioners 15th Annual Promoting Excellence symposium. Fort Myers, FL.

5.

Contino E. Diagnostic anesthesia. Texas Equine Veterinary Association’s summer symposium. Marble Falls, TX.

6.

Contino E. Imaging and treatment of neck, back and pelvis. Texas Equine Veterinary Association’s summer symposium. Marble Falls, TX.

7.

Contino E. Diagnosis and treatment of proximal suspensory disease. Texas Equine Veterinary Association’s summer symposium. Marble Falls, TX.

8.

Kawcak C. Characterizing personal tissue stress in the athlete. Veterinary Innovation Summit. Fort Collins, CO.
9.

Kawcak C. Joint disease – what do we know? Rood and Riddle Equine Hospital intern symposium. Lexington, KY.

10.

Kawcak C. Advances in diagnostic imaging of equine injuries. Savannah River National Laboratories. Aiken, SC.

11.

Kawcak C. Fact finding: History, physical exam and diagnostic analgesia. AAEP focus meeting. Fort Collins, CO.

12.

McIlwraith CW. “Intra-articular biologic therapies for post traumatic osteoarthritis and cartilage repair.” Australasian Musculoskeletal Imaging Group, Queenstown Keynote Lecture

13.

McIlwraith CW. “Current problems in musculoskeletal disease” and discussant. Adaptive Design Workshop, CSU TMI Musculoskeletal Therapies – Translational Adaptive Design Network –



Grants

| INVESTIGATORS | SPONSOR | PROJECT TITLE | PERIOD | AMOUNT |
|--|---|---|-----------------|-----------|
| Erin Contino (PI), Elsbeth O’Fallon, Alicia Yocom (Co-PIs) | College Research Council – CRC | Pharmacokinetics and safety of an oral cannabidiol product in horses | 7/1/20-6/30/21 | \$24,996 |
| Felix Duerr (PI), Laurie Goodrich (Co-PI) | College Research Council – CRC | Intra-articular gene transfer of interleukin-10: Development of a new strategy for the treatment of canine osteoarthritis | 7/1/20-6/30/21 | \$23,764 |
| Kevin Haussler (PI), Mindy Story, M. Maldonado (Co-PIs) | College Research Council – CRC | Effect of chiropractic treatment on concurrent limb lameness and back pain in horses | 7/1/20-6/30/21 | \$2,000 |
| Katie Seabaugh (PI), Kirk McGilvray, Sandro Colla, Kurt Selberg (Co-PIs) | College Research Council – CRC | No foot, no horse: Biomechanical assessment of the collateral ligament of the distal interphalangeal joint of the horse | 7/1/20-6/30/21 | \$12,015 |
| Laurie Goodrich (PI), Steve Dow, Lynn Pezzanite (Co-PIs) | College Research Council – CRC | The temporal course of the cytokine, immune, and transcriptomic response in osteoarthritis | 7/1/20-6/30/21 | \$24,921 |
| Christopher Kawcak (PI), Laurie Goodrich, Lauren Smanik, Holly Stewart, Kurt Selberg (Co-PIs) | College Research Council – CRC | In vivo evaluation of a modified subchondroplasty technique for the treatment of full-thickness articular cartilage defects in the medial trochlear ridge of the femur: A pilot study in three horses | 7/1/19-6/30/20 | \$21,150 |
| Laurie Goodrich (PI), Steve Dow, Lynn Pezzanite (Co-PIs) | College Research Council – CRC | Is the commonly used intra-articular antibiotic, amikacin, toxic to the cells of the equine joint as well as MSCs? | 7/1/19-6/30/20 | \$25,000 |
| Katie Seabaugh (PI), David Frisbie, Brad Nelson, Sherry Johnson, Kurt Selberg (Co-PIs) | College Research Council – CRC | Investigation of an equine meniscal destabilization model for initiating post-traumatic osteoarthritis | 7/1/19-6/30/20 | \$24,918 |
| Brad Nelson (PI), Christopher Kawcak, Kurt Selberg, Charles Ho, (Co-PIs) | College Research Council – CRC | Innovative and emerging quantitative MRI strategies for detection of early articular cartilage injury in horses | 7/1/19-6/30/20 | \$24,950 |
| John Kisiday (PI), Laurie Goodrich (Co-PI) | College Research Council – CRC | Generation of mesenchymal stem cells from unsorted populations of adult equine chondrocytes | 7/1/19-6/30/20 | \$19,112 |
| Christopher Kawcak (PI) | TMI TAP | Development of orthopedic wearable technology | 7/1/19-6/30/20 | \$38,881 |
| Christopher Kawcak (PI) | College Research Council – CRC | Racing CRC post-mortem | 7/1/19-6/30/20 | \$15,000 |
| Valerie Moorman(PI), Dean Hendrickson, Gregg Griffenhagen, Lynn Pezzanite (Co-PIs) | College Research Council – CRC | The use of liposomal bupivacaine for equine distal limb pain: an innovative approach to improve postoperative and chronic pain management in horses | 7/1/18-9/30/19 | \$25,000 |
| Erin Contino (PI), Christopher Kawcak, Gustavo Zanotto, David Frisbie (Co-PIs) | College Research Council – CRC | Feasibility and safety of radiofrequency nerve ablation of the deep branch of the lateral plantar nerve in horses | 7/1/18-9/30/19 | \$18,951 |
| Christopher Kawcak (PI) | College Research Council – CRC | Racing CRC post-mortem | 7/1/18-9/30/19 | \$15,000 |
| Felix Duerr (PI), Laurie Goodrich (Co-PI) | Morris Animal Foundation | Intra-articular gene transfer canine osteoarthritis | 10/1/20-9/30/22 | \$50,000 |
| David Frisbie (PI), Katie Sikes, Katie Ellis (Co-PIs) | American Quarter Horse Association | Metabolomic profiles of tendons and ligaments in equine patients | 10/1/19-9/30/20 | \$19,855 |
| David Frisbie (PI), Gustavo Zanotto, Ray Goodrich, Jon Dickens (Co-PIs) | TMI TAP | Freeze-dried conditioned serum for the treatment of osteoarthritis | 7/1/19-6/30/20 | \$45,000 |
| David Frisbie (PI) | TMI TAP | Creation and validation of a one-step closed system vessel for condition serum production | 7/1/20-6/30/21 | \$44,000 |
| David Frisbie (PI), Myra Barrett, Katie Seabaugh (Co-PIs) | Smith and Nephew Inc. | Evaluation of minced cartilage as a method for healing cartilage defects | 11/1/18-6/30/20 | \$359,755 |
| Laurie Goodrich (PI), Steve Dow (Co-PI), C. Wayne McIlwraith, Tom Schaer, Valerie Johnson, Lynn Pezzanite, Nikki Phillips (Co-PIs), Lauren Schnabel (Consultant) | Grayson-Jockey Club Research Foundation | Antimicrobial properties of equine mesenchymal stem cells: An approach to cure septic arthritis | 5/1/19-4/30/21 | \$198,056 |
| Laurie Goodrich (PI), Christopher Kawcak, Myra Barrett, Katie Seabaugh, David Frisbie, C. Wayne McIlwraith, Benjamin Cooper, Brian Snyder, Mark Grinstaff (Co-PIs) | Boston University | Polyacrylate gel to treat equine OA in an osteochondral chip fragment model | 1/1/18-9/14/18 | \$251,399 |

| INVESTIGATORS | SPONSOR | PROJECT TITLE | PERIOD | AMOUNT |
|--|---|--|-------------------|-----------|
| Laurie Goodrich (PI), David Frisbie, Myra Barrett, Christopher Kawcak, C. Wayne McIlwraith, Jude Sanulski, Constance Chu (Co-PIs) | Stanford University, U.S. Department of Defense | Localized gene therapy for prolonged anti-inflammatory treatment to prevent or delay PTOA in an equine model | 1/15/20-8/31/22 | \$952,862 |
| Lynn Pezzanite (PI), Laurie Goodrich (Mentor), Steve Dow (Co-PI) | The Foundation for The Horse | The temporal course of the cytokine, immune, and transcriptomic response in osteoarthritis progression | 11/1/20-10/31/21 | \$19,660 |
| Laurie Goodrich (PI), Christopher Kawcak, Myra Barrett, Katie Seabaugh, David Frisbie, C. Wayne McIlwraith, Benjamin Cooper, Brian Snyder, Mark Grinstaff (Co-PIs) | Articulate Biosciences | Polyacrylate gel to treat equine OA in an osteochondral chip fragment model – amendment | 1/1/18-9/14/18 | \$121,685 |
| Laurie Goodrich (PI), David Frisbie, Myra Barrett, Christopher Kawcak, C. Wayne McIlwraith, Jude Sanulski, Constance Chu (Co-PIs) | Stanford University, U.S. Department of Defense | Development of diagnostic and treatment strategies for post-traumatic osteoarthritis | 9/1/18-8/31/21 | \$711,101 |
| Laurie Goodrich (PI), Jeremiah Easley (Co-PI) | Cayman Biomedical Research Institute | Evaluation of the use of small novel compounds KMN 159 and KMN 224, as osteogenic inducers in horse and sheep cultures | 11/16/20-11/15/21 | \$75,000 |
| Lynn Pezzanite (PI), Laurie Goodrich (Mentor), Steve Dow (Co-PI) | ACVS Foundation (American College of Veterinary Surgeons) | Investigation of equine MSCs antimicrobial properties | 8/1/18-8/1/19 | \$24,463 |
| Lynn Pezzanite (PI), Laurie Goodrich (Mentor), Steve Dow (Co-PI) | Grayson-Jockey Club Research Foundation | Antimicrobial and immunomodulatory properties of TLR ligand activated mesenchymal stem cells | 4/1/19-3/31/20 | \$15,000 |
| Laurie Goodrich (PI), Lauren Smanik, Kurt Selberg, Christopher Kawcak (Co-PIs) | American College of Veterinary Surgeons | Computed tomography versus radiographs guidance for internal fixation of central tarsal bone fractures in non-racing horses | 6/1/21-5/30/22 | \$15,000 |
| Kevin Haussler (PI), Melissa King, Mindy Story (Co-PIs) | INDIBA | Evaluation of diathermy for the treatment of neck pain and stiffness in horses | 7/1/19-7/31/21 | \$25,000 |
| Christopher Kawcak (PI), Brad Nelson, Holly Steward, Kelly Zersen, Kurt Selberg (Co-PIs) | The Foundation for The Horse | Validation of an innovative contrast subtraction technique to detect equine bone marrow lesions using CT | 10/1/20-9/30/21 | \$19,980 |
| Christopher Kawcak (PI), Holly Stewart (Co-PI) | Grayson-Jockey Club Research Foundation | Optimization of dual-energy CT for equine imaging | 4/1/19-3/31/20 | \$15,000 |
| Christopher Kawcak (PI), Holly Stewart, C. Wayne McIlwraith, Kurt Selberg (Co-PIs) | Grayson-Jockey Club Research Foundation | Development of limited view 3D imaging for the equine distal limb | 4/1/18-3/31/20 | \$198,836 |
| Melissa King (PI), David Frisbie (Co-PI) | Bemer USA LLC | Influence of bemer blanket technology on pain measures, biomechanics, and serum biomarkers in horses with back pain | 2/1/19-1/31/20 | \$73,821 |
| Sherry Johnson (PI), Melissa King (Co-PI) | Grayson-Jockey Club Research Foundation – Storm Cat Award | Validation of exercise with blood flow restriction for enhanced muscular development | 4/1/20-3/31/21 | \$15,000 |
| John Kisiday (PI) | American Kennel Club Canine Health Foundation Inc. | Characterizations of mesenchymal stromal cell properties of canine culture-expanded articular chondrocytes | 3/1/21-2/28/22 | \$14,973 |
| Sherry Johnson (PI) | TMI TAP | Sense validation for equine blood flow restriction | 7/1/20-6/30/21 | \$20,000 |
| Sherry Johnson (PI), Melissa King, David Frisbie, Christopher Kawcak, Adam Chicco, Katie Sikes (Co-PIs) | TMI TAP | Musculoskeletal effects of equine blood flow restriction training: A translational investigation | 7/1/19-6/30/20 | \$80,000 |
| C. Wayne McIlwraith (PI), Christopher Kawcak, Frances Peat, David Frisbie, Kurt Selberg (Co-PIs) | Grayson-Jockey Club Research Foundation | Thoroughbred sales radiology-ultrasonography study | 4/1/18-3/31/20 | \$143,624 |
| Brad Nelson (PI), Ben Gadomski, Christopher Kawcak, Kirk McGilvray, Tom O'Brien (Co-PIs) | American College of Veterinary Surgeons | Comparison of the osteocentric bone screw fastener to the AO buttress screw in an ex vivo model of equine midbody proximal sesamoid bone fracture repair | 5/1/21-5/1/22 | \$14,811 |

Revenue and Expense

| REVENUE | FY2019 | FY2020 | FY2021 |
|--|-----------|-----------|-----------|
| Total Interest * | 715,452 | 717,036 | 708,565 |
| Service Activity Total | 1,017,802 | 89,693 | 449,298 |
| Medical Center Clinical Services Total | 114,940 | 1,848 | 0 |
| Research Project Accounts Total | 783,887 | 1,394,285 | 665,533 |
| Continuing Education Activities | 43,232 | 59,350 | 23,360 |
| Stallion Auction | 14,174 | 13,300 | 19,598 |
| State Funds Total ** | 58,224 | 129,333 | 95,763 |
| Total Donations | 385,111 | 510,490 | 105,231 |
| TOTAL REVENUE | 3,132,822 | 2,915,335 | 2,067,348 |
| EXPENSE | FY2019 | FY2020 | FY2021 |
| Total Salaries † | 1,458,880 | 1,329,525 | 1,284,496 |
| Faculty Travel | 16,719 | 12,051 | 46 |
| Materials and Supplies | 357,130 | 399,878 | 254,697 |
| Other Direct | 1,179,307 | 588,166 | 523,096 |
| Building | 0 | 5,500 | 3,442 |
| Equipment | 38,937 | 0 | 0 |
| EXPENSE SUBTOTAL | 3,050,973 | 2,335,120 | 2,065,777 |
| FACILITY AND ADMINISTRATIVE OVERHEAD COSTS | 188,044 | 188,250 | 73,419 |
| TOTAL EXPENSE AND OVERHEAD | 3,239,017 | 2,523,370 | 2,139,196 |
| ACCOUNT BALANCE | (106,195) | 391,965 | (71,848) |




STEELE BURB

| REVENUE BREAKDOWNS | FY2019 | REVENUE BREAKDOWNS | FY2020 | REVENUE BREAKDOWNS | FY2021 |
|--------------------|--------|--------------------|---------|--------------------|--------|
| STATE FUNDS ** | \$ | STATE FUNDS ** | \$ | STATE FUNDS ** | \$ |
| Contino CRC Grant | 18,951 | Kawcak CRC Grant | 35,372 | Kawcak CRC Grant | 14,273 |
| Moorman CRC Grant | 25,000 | Goodrich CRC Grant | 24,981 | Goodrich CRC Grant | 24,921 |
| Kawcak CRC Grant | 14,273 | Seabaugh CRC Grant | 24,918 | Contino CRC Grant | 24,996 |
| | | Nelson CRC Grant | 24,950 | Haussler CRC Grant | 19,558 |
| | | Kisiday CRC Grant | 19,112 | Seabaugh CRC Grant | 12,015 |
| STATE FUNDS TOTAL | 58,224 | | 129,333 | | 95,763 |

| REVENUE BREAKDOWNS | FY2019 | FY2020 | FY2021 |
|--------------------------|---------|---------|---------|
| INTEREST ON ENDOWMENTS * | \$ | \$ | \$ |
| McIlwraith Scholarship | 7,076 | 7,141 | 6,795 |
| Cox Anthony Chair | 158,381 | 158,698 | 155,894 |
| Iron Rose Ranch Chair | 123,530 | 123,778 | 121,591 |
| Atkinson Chair | 55,311 | 55,513 | 54,318 |
| Kawānanakoa Chair | 109,528 | 109,747 | 107,808 |
| Malone Chair | 261,626 | 262,159 | 262,159 |
| TOTAL INTEREST | 715,452 | 717,036 | 708,565 |

| EXPENSE | FY2019 | FY2020 | FY2021 |
|-----------------------------|-----------|-----------|-----------|
| SALARIES † | \$ | \$ | \$ |
| Faculty Salaries | 392,141 | 587,611 | 526,423 |
| Research Associate Salaries | 383,229 | 401,570 | 415,719 |
| Administrative Salaries | 231,696 | 42,494 | 26,287 |
| Residents | 277,951 | 179,378 | 230,100 |
| Graduate Student Salaries | 0 | 0 | 0 |
| Hourly Students | 173,862 | 118,472 | 85,966 |
| TOTAL SALARIES | 1,458,879 | 1,329,525 | 1,284,495 |



The Orthopaedic Research Center at Colorado State University is known worldwide for joint problem prevention and healing research in horses, with complementary work in human athletes.

We are at the forefront of developing novel stem cell therapies that offer exciting treatment options for musculoskeletal disease and injury.

Your gift to the ORC will advance our research program, support innovation in clinical treatments and regenerative therapies, and advance translational research. If you have more questions about giving opportunities at the Orthopaedic Research Center, please contact Sarah Schmidt, executive director of development, at s.schmidt@colostate.edu.

You can also give online at

advancing.colostate.edu/ORCE

Learn so much more about the
ORC on our new website!

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