

# Racing toward the future. A vision for the OSU College of Veterinary Medicine



Carlos Risco, Dean CVM

Martin Furr, DVM, Dip ACVIM, PhD

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# ***A Vision Statement for the Oklahoma State University College of Veterinary Medicine***

## ***The Past***

The College of Veterinary Medicine was established and began operations in 1948, with Dr. Clarence H. McElroy serving as the first dean of the college. The first class of 26 Oklahoma A&M veterinarians graduated in May 1951. Over the ensuing years the college grew adding the Oklahoma Animal Disease Diagnostic Lab in 1974 and the Boren Veterinary Medical Teaching Hospital in 1981. McElroy Hall, which houses the administrative offices, as well as the departments of Physiological Science and Pathobiology, departmental faculty offices, and research and teaching laboratories was expanded and updated in 1964. In response to growth and expansion of the veterinary student class size (now up to 106 matriculating students), as well as the need to replace antiquated facilities, the Roger Panciera Teaching Building was added in 2020 providing dedicated modern instructional space; this remains the only addition to McElroy Hall since its completion, although there have been a number of renovations. In addition, the College also encompasses the CVM Ranch (used for equine reproductive services and student instruction in farm animal species), and the Equine Research Park. To date, the OSU CVM has been fully accredited by the American Veterinary Medical Association Council on Education (AVMA COE) until the downgrade to “Probationary” status in 2017; full accreditation was returned in 2019.

## ***The Present***

The state of veterinary medical education has changed dramatically in the last several decades. Unfortunately, however, for a variety of reasons the CVM has been unable to keep pace with these advances and contemporary standards of education and service. Recently the CVM conducted a strategic planning process to identify challenges and threats to the long-term ability of the CVM to meet its obligations, to maintain accreditation by the AVMA COE and to excel in its various mission areas. The following summarizes the findings and conclusions of that process regarding the current status of the OSU CVM.

Experiential education is a critical element of medical training and this has typically been achieved in the “Teaching Hospital” setting as described and codified by Abner Flexner in the pivotal 1911 Carnegie Foundation “Report on the Status of Medical Education in the US”. This has been the classic instructional delivery model followed by most veterinary programs for many decades, including the OSU CVM. Over recent years however challenges to funding with the subsequent focus on revenue generation, and the growth of veterinary specialties with the need to focus on advanced veterinary graduate training has led to gaps in the educational experience of final year veterinary

students and have demonstrated the weaknesses of this model in the current era. A further challenge, which is a national problem but appears particularly acute at the OSU CVM, is the difficulty of recruiting appropriately trained and credentialed clinical specialist to staff the hospital and teach. This has led to substantial challenges to manage and deliver the current curriculum and without correction we believe will further compromise and threaten our accreditation status. The student/faculty ratio at OSU is 4.2 (3<sup>rd</sup> highest among all schools), while the average of all other veterinary colleges is 3.3. Faculty shortages are considered a major threat to our future success.

A final feature threatening our ability to maintain our obligations to the students and stakeholders of the state relates to physical facilities. The OSU CVM Teaching Hospital (VTH) was constructed and put into service in 1981 being designed for a class size of roughly 85 students and supporting the technology and specialty services of the time. Currently, we have approximately 150 students in the VTH (including OSU students, as well as contract students), and there is limited student instructional space, and limited ability to expand to add workspace for new equipment and clinical services. Deficiencies in facilities and clinical faculty numbers in the VTH were major factors leading to the OSU CVM having its accreditation downgraded (placed on probation) following our last inspection. Failure to address current issues will place us further behind necessary national standards.

The CVM has outstanding faculty in multiple disciplines that perform innovative One Health research. According to the 2019 Comparative Data Report from the Association of American Veterinary Medical Colleges, after research funding is normalized to faculty numbers, we rank 13<sup>th</sup> of 30 US schools of veterinary medicine in research productivity. At the present time, we have growing research programs in Infectious Disease (via the Oklahoma Center for Respiratory and Infectious Disease, an NIH Center of Excellence), our INTERACT program, and our oncology research program. So far, we have been able to recruit top-shelf research scientists, however the quality and availability of research facilities and available state support are now a major impediment to further growth. Given the potential of researchers hired in the past 5 years, plus 5 more research-intensive hires in the next 2 or 3 years (3 already on board) we have the opportunity to sustainably generate an aggregate total of 10 to 12 NIH R01 grants (currently 4). Achieving this goal, however, is substantially threatened by our current physical plant and support staff shortcomings.

Hence, we currently have both facility and programmatic deficiencies that we feel are substantial threats to our long-term viability as a program of instruction and service, as well as substantially threatening our status as a fully accredited college of veterinary medicine.

*The Future*  
IS HERE

To meet the challenges of the future to continue to train veterinarians and meet the expectations and obligations of our stakeholders, we propose the following major strategic steps:

### **Strategic Goal #1)**

#### **Re-structure the service and 4<sup>th</sup> year veterinary student education model**

This process is necessary to align these activities with current student needs and contemporary medical education practices, as well as increasing our service availability to a broader group within the state and region. This includes developing a network of satellite practices in the state which would be the site for a portion of the primary care instruction of veterinary students, while the current teaching hospital would remain in service for referral of more advanced cases, and student and House Officer training. Major renovation, or ideally replacement, of the current VTH remains a pressing need. Satellite practices will be developed through OSU ownership or by forming partnerships with existing privately-owned facilities. Embedded OSU faculty would provide service and student instruction within these satellites. We envision these satellites to be in more populous urban centers of the state, as well as in underserved and rural regions as part of our planned **“Center for Rural Veterinary Medicine”**. We also propose to expand our involvement and participation in Shelter Medicine as a mechanism to provide critical service to the state, as well as a fruitful training ground for our final year students.

### **Strategic Goal #2)**

#### **Develop a “Center for Rural Veterinary Medicine”**

Veterinarians are critical to the success of rural communities and rural economies via their support of food and fiber animal industries, health of companion animals, identification of zoonotic diseases, and their role in disease surveillance to protect US agriculture. There is an ongoing and growing challenge to rural veterinary medicine. The number of veterinarians serving rural communities is continuing to decline. The most recent report from the American Veterinary Medical Association (AVMA) indicates that between 2008 and 2013 the number of veterinarians serving rural communities has decreased by 15% and continued to decrease an additional 17% between 2013 and 2018. This results in a vulnerability trend for these rural communities, resulting in a decrease in financial, human, and social community capital. Causes for this trend are incompletely understood and have been investigated in only very cursory fashion.

We propose to develop a unique, “first of its kind” program consisting of a team-based approach to studying rural veterinary medicine and its impacts

upon communities, methods to improve the success of rural veterinarians and increase veterinary services in rural communities, and the training of veterinarians with a specific interest in rural practice to prepare them for the unique challenges of this type of practice. We envision a service component in underserved/rural regions, as well as outreach programs to mentor youth in these regions to help prepare them for STEM careers, including veterinary medicine.

### **Strategic Goal #3**

#### **Develop an undergraduate pre-veterinary program**

Undergraduate student preparation for veterinary medical school is often inconsistent and has been identified as a major problem by faculty teaching in the first two years of the program. We propose to develop and deliver the pre-veterinary curriculum to undergraduate students to ensure their optimal preparation for the transition to a medical professional program. In addition, this will provide an additional revenue stream to the CVM and align with current progressive program models in veterinary medical education.

### **Strategic Goal #4**

#### **Expand “One-Health” research capacity**

The CVM has a robust and growing research activity which, based upon current trends and recently added programs and faculty members, has the potential to double our research expenditures in the next 5-7 years. However, current facilities are over-full or beyond serviceable life (primarily in McElroy Hall, constructed in 1965) and a new research building is needed to support Phase 3 of the NIH OCRID Center of Excellence grant, expanding infectious disease programs, growth of the INTERACT program, and a growing oncology program. Based on current faculty numbers plus a modest expansion of 5 to 8 additional research faculty, we need about 2x the amount of code 250 lab space plus 2 or 3x the amount of code 255 support space totaling about 30,000 net or 45,000 gross square feet.

## **APPENDIXES**

**APPENDIX 1:** Overall financial summary of OSU CVM Strategic Plans 2022

**APPENDIX 2:** Specific Physical Plant Needs for Veterinary Teaching Hospital

**APPENDIX 3:** Develop a Center for Rural Veterinary Medicine

**APPENDIX 4:** Develop an undergraduate pre-veterinary program

**APPENDIX 5:** Specific Physical Plant Needs for Expansion of Research and Discovery

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## **APPENDIX 1**

### **Overall financial summary of OSU CVM Strategic Plans 2022**

#### **Strategic Plan Objective #1**

##### **Restructure 4<sup>th</sup> Year Education Experience**

Remodel VTH to achieve instructional and service goals	27,850,000
Additional Faculty (10)	
Additional Staff (10)	

#### **Strategic Plan Objective #2**

##### **Develop a Center for Rural Veterinary Medicine**

Flagship Rural Hospital	4,100,000
Additional Satellite Hospital (updates/renovations)	550,000
Additional Faculty (4) (largely offset by clinical revenues)	
Additional Staff (4) (largely offset by clinical revenues)	

#### **Strategic Plan Objective #3**

##### **Develop an undergraduate pre-veterinary program**

Additional faculty (3)	
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#### **Strategic Plan Objective #4**

Expand biomedical research facilities	32,000,000
Architectural Design support (conceptual)	250,000

#### **TOTAL**

Capital expenditure	<b>64.65M</b>
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## **APPENDIX 2**

### **Specific Physical Plant Needs for Veterinary Teaching Hospital**

#### **1) Instructional Space**

##### **A. Small group teaching/Rounds room**

At present, there are an inadequate number of teaching spaces for small group instruction of students while on specific clinical rotations. Currently, several spaces have been repurposed from other uses, including storage rooms and stalls or are being used as multi-purpose areas. This is sub-optimal and does not optimize the learning environment of the VTH. We anticipate a need for 7 new or updated instructional spaces (3500 sq/ft) incorporating appropriate IT access, computer terminals, projection, etc. (\$1.75M)

##### **B. Faculty Offices**

At present, there are inadequate numbers of offices for faculty and House Officers. House officers in particular currently do not have appropriate work and study space for the academic aspects of their training. With the need to increase faculty numbers to improve service and instructional delivery, we anticipate the need for 15 more faculty offices, and office space for 10 house officers. Anticipated cost is \$2.25M.

#### **II) Clinical Service Space**

##### **A. Food Animal Isolation Area**

At the present time there is not an adequate and appropriate isolation facility for food animal patients. While the current isolation facility does have space for 1 isolated large animal patient, there is very difficult access (almost impossible for some types of patients), and it is largely unusable for the primary types of patients which need to have isolation for potential zoonotic or infectious diseases. Currently cases are isolated in makeshift stalls in which adequate biosecurity precautions are impossible. Requirements for this space include biosecurity level two,

conditioned air, animal holding and treatment area and equipment/supply storage. Anticipated cost \$2.0M.

## **B. Imaging Center**

At the present time our imaging facilities are substantially out of date, and we have to send patients to private hospitals to have some procedures performed (particularly for equine patients). A modern imaging center is needed for the states flagship veterinary hospital and should include MRI, standing LA MRI, computed tomography, and nuclear scintigraphy. This will require facilities to support general anesthesia and recovery of large animal patients (primarily horses), as well as “clean stalls” for clearance of horses that have had nuclear scintigraphy. Cost estimate to include imaging equipment is \$3.75M.

## **C. Dedicated Primary/Outpatient Care Center**

Primary out-patient care is a growing area of practice for the VTH and an instructional area that is core to our mission of training practice-ready veterinarians. Current space is inadequate for the volume of patients which can be seen and does not create a proper primary care training space for our students as it does not emulate (physically or functionally) the future work environments of our graduating students. We envision a free-standing primary care center with an anticipated cost of \$4.1 M.

## **D. Oncology Center**

A growing area of expertise within the college and an identified research growth area for the college, dedicated space for clinical oncology must be developed to achieve our vision. Anticipated construction cost is \$10M.

## **III) Modernize Teaching Hospital**

As noted, the current VTH was constructed in the early to mid-1980's and many of the facilities are not up to current standards of quality or optimal animal handling and disease management. In addition to safety concerns and the negative impacts upon student and staff morale, this creates a negative image potentially impacting recruitment, and compromises our ability to provide state of the art veterinary medical care at the states to the stakeholders of the state and region, as well as a quality learning environment for our students. Deficiencies in our physical plant were the primary cause of our recent accreditation crisis, and this situation only worsens with time. Listed changes are necessary to correct these long-standing shortcomings in the VTH.



## **A. Air condition/ventilation of the Large Animal Hospital**

At the present time the Large Animal Hospital including patient examination, treatment and housing areas are not air conditioned. In the heat of the summer this is an oppressive work environment, to say the least, and is very challenging for many of our sick patients, making management of their illness more difficult. Patients with some conditions cannot be accommodated in the summer months due to the heat. Upgrading the ventilation in the Large Animal hospital will improve the working, teaching, learning, and service components of our mission. Anticipated cost \$2.0 M.

## **B. Small Animal Client Reception area**

Currently very outdated and does not represent the VTH as the flagship veterinary hospital in the state. Remodel and update (\$0.5M).

## **C. Staff Break-rooms**

Staff and faculty currently have very limited areas to have breaks or lunch. Correcting this we believe will improve staff morale and hopefully improve recruiting and retention. Anticipated cost \$0.5 M.

## **D. Renovate and update LA surgery**

Current facility is out-of-date, and in poor repair. In addition, the design of the anesthetic induction and recovery facilities are very antiquated and does not provide the opportunity for surgical procedures on large animals that is consistent with current standards of care. Anticipated remodeling cost \$1.0M.

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## **APPENDIX 3**

### **Physical Plant and Support to achieve Strategic Goal #2**

#### **Develop a Center for Rural Veterinary Medicine**

Strategic goal #1 encompasses the need to re-structure the 4<sup>th</sup> year instructional program, which requires alterations to the current veterinary teaching hospital as well as development and acquisition of alternative experiential learning environments, some of which are in support of our planned **Center for Rural Veterinary Medicine** (Strategic Goal #2)

#### **I) VISION**

The **Center for Rural Veterinary Medicine** (CRVM) represents a team-based, programmatic approach to the study of rural veterinary medicine and associated challenges and shortages, and the development and implementation of strategies to mitigate these challenges. Specific objectives include:

- a) to determine the impacts of limited veterinary service upon local and regional communities
- b) develop and validate methods to improve the success of rural veterinarians
- c) develop methods to increase veterinary services in rural communities
- d) to provide support for veterinarians in private rural practice (technical, wellness, business, continuing education, consultation)
- e) provide service in underserved communities associated with our training of veterinarians
- f) to engage underrepresented populations in underserved communities in support of recruitment and career opportunities
- e) to train veterinarians with a specific interest in rural practice to prepare them for the unique challenges of this type of practice.
- h) to engage youth in rural communities in support of future STEM careers

#### **II) Benefits to OSU CVM and University**

- a) Opportunities to reach currently underserved communities with associated recognition of OSU CVM
- b) Additional revenue stream (diversification)

- c) Additional case resources for training of veterinary students
- d) Enhanced profile of OSU CVM as an industry leader, generating novel programs for the advancement of veterinary education and service which will have national impact
- e) Opportunity to develop diversity recruiting initiatives in underserved communities

### **III) Physical Components and Required Resources**

We propose that the Center be located in a rural region of the state to leverage the high concentration of production animal species and to provide a “real-life” rural practice training setting for our students.

#### **A) Physical Space**

- i) A programmatic “Flagship” multi-species clinical hospital for care of small animal, food animal and equine species. This stand-alone facility will mimic the typical multi-species rural animal hospital but will also include some instructional space (for veterinary students as well as continuing education meetings), and student living quarters. Estimated building costs for a 5500 square foot hospital (excluding land purchase) is \$3.0 M, while construction of the teaching space and student living quarters is estimated at \$600,000. Equipping the hospital is anticipated to cost 500,000, resulting in an initial start-up cost of \$4.1 M (excluding land acquisition).
- ii) Additional satellite practices to be acquired with will likely require some remodeling, and staffing will be needed to operate the hospital. Practices may be acquired by purchase followed by transitional operations over the OSU CVM as part of our rural center and program of experiential education. Purchase price and operation costs will vary widely depending upon the location and practice size, etc. We predict an average purchase price of \$300,000 with \$250,000 of necessary renovations and upgrades. Due to the unique fiscal environment of many large animal practices there is the opportunity to work with the OSU Foundation to acquire some hospitals through philanthropic giving.

#### **B) Staffing**

The Center will require a Director to oversee the development and operations of the clinical program as well as the scholarly activities of faculty. Initial consideration is a faculty of 4 veterinarians providing a combination of clinical service for all species, student instruction,

referral consultations, professional continuing education efforts. In addition, we anticipate 2 faculty dedicated to programmatic research studying rural medicine delivery and impacts in rural environments. Anticipate technical staff of at least 3 at the flagship hospital. Operational costs will largely (but not completely) be offset by hospital revenues.

## **IV. Strategies**

- A)** Partner with an existing state-operated facility (e.g. Panhandle State University, Northwestern Oklahoma State, Northeastern Oklahoma State, Langston University).
  - B)** Partner with one of the Tribal Nations
  - C)** Benefits of partnering
    - i)** Location in rural area
      - a)** clinical service in underserved region
      - b)** integration with under-represented student programs
    - ii)** Integrate with Existing Programs to recruit students, etc.
    - iii)** Student housing availability
    - iv)** Availability of animal resources/facilities which can be re-purposed
    - v)** Don't need to acquire property
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## **APPENDIX 4**

### **Support to achieve Strategic Goal #3**

#### **Develop an undergraduate pre-veterinary program**

Developing an undergraduate pre-veterinary program which will directly lead to entry into the veterinary program will have substantial benefits for the college and the students. This will provide an opportunity to enhance student preparation and success in the program and will provide a revenue source for the college. New physical facilities are not anticipated, but additional faculty will be needed to support the instructional activities of the program.

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## **APPENDIX 5**

### **Specific Physical Plant Needs for Expansion of Research and Discovery**

#### **I. JUSTIFICATION**

The CVM has some traditional areas of focus, and these remain an important part of who we are and what we are known for. These include veterinary parasitology, veterinary pathology, and studies of the Bovine Respiratory Disease Complex. As we enter the second 70 years of our history, we are undergoing a significant turnover in our faculty with opportunities and new challenges. It is critical that we build transformational research capacity and productivity to enable CVM to compete on a national and international level for top-tier students, faculty, and resources for at least the next 20 years. This strategic goal of expanding research capacity is enabled by 1) expanding the number of competitive research scientist that we can recruit, retain, and support with appropriate facilities, and 2) build infrastructure with skills and technical abilities to support contemporary research investigation.

The University identifies several interdisciplinary strengths, including One Health, and several cross-cutting themes with which CVM efforts and future needs are aligned, including big data solutions, analytics and data mining, bioinformatics and health informatics, rural development, community-engaged research and defense-relevant research.

#### **II. Major Research Emphasis Domains**

There are several established and emerging programs that each hold great promise upon which to build. These include respiratory and infectious disease, parasitology, comparative oncology/nanomedicine, and comparative exercise physiology. From 2017 to 2020, the most prominent areas of scholarly output for faculty in CVM were viral diseases of cattle, respiratory viruses, innate immunity, and vector-borne diseases, amounting to more than 20% of the total publications generated. Emerging topics include interdisciplinary toxicology, minimally invasive clinical procedures, diseases of aging, microbiome science, and regenerative medicine. Each of these research domains falls into University, State, and Federal priority areas such as One Health.

##### **A) COVID Research**

Several OSU research groups interested in respiratory diseases and viral diseases, including the state-wide network of researchers affiliated with the Oklahoma Center for Respiratory and Infectious Disease (OCRID), are moving to put their expertise to work on the SARS-CoV-2 virus. Genomic analysis and both in vitro and in vivo analysis of the virus and the

pathogenesis of COVID-19 are underway or planned. Early on, most of these researchers are faculty in the CVM, OCRID and the Oklahoma Animal Disease Diagnostic Laboratory. In addition, we have collaborated with several researchers outside the CVM to test diagnostic tools for the virus, and we have contracted for live-virus testing of a SARS-CoV-2 vaccine adjuvant developed at the University of Oklahoma. Companies developing diagnostic tools and therapeutics have also contacted us about live-virus testing (Ophirex; DetectaChem; TechVen Systems; InnovaPrep). Proposed expansion of infectious disease research in the context of the Oklahoma Pandemic Center for Innovation and Excellence (below) promises additional opportunities.

In addition to morbidity and mortality resulting directly from infection with the SARS-CoV-2 virus, there are numerous co-morbidities that impact outcomes of COVID-19, including hypertension, obesity, diabetes, heart disease, lung disease, and age. Multiple scientists at OSU and around the state are already doing research on these co-morbidities and can make contributions to understanding the role they play in health outcomes for patients infected with SARS-CoV-2. Proposals to work on SARS-CoV-2 have been submitted to the National Institutes of Health, National Science Foundation, Department of Defense, Oklahoma Center for Adult Stem Cell Research, and the American Diabetes Association. These topics (CARS covid 19 and influence of co-morbidities) are current areas of strength within the college and represent substantial areas of growth and national impact.

## **B) Oklahoma Pandemic Center for Innovation and Excellence**

OSU and the State of Oklahoma established a government-academia partnership to create a system for the rapid development, production and implementation of COVID-19 diagnostic tests. OSU was able to leverage on our existing infrastructure, knowledge and vendor relationships to quickly order and process COVID-19 diagnostic tests. The Oklahoma Governor has expanded on this partnership to launch the Oklahoma Pandemic Center for Innovation and Excellence (OPCIE) (<https://www.kjrh.com/news/local-news/oklahoma-state-department-of-health-announces-state-pandemic-center>) ([https://www.stwnewspress.com/news/local\\_news/local-leaders-welcome-public-health-lab-to-stillwater/article\\_d1efd5f6-d0b6-5a2d-affe-96bdca9ed0ac.html](https://www.stwnewspress.com/news/local_news/local-leaders-welcome-public-health-lab-to-stillwater/article_d1efd5f6-d0b6-5a2d-affe-96bdca9ed0ac.html)). Conceived on One Health principles, the OPCIE will be at the intersection of animal and human health, food safety research, testing and preparedness. This center will benefit from the combined knowledge and expertise housed within OSU's Colleges of Medicine, Veterinary Medicine and Agriculture. It will encompass the Oklahoma Animal Disease Diagnostic Laboratory, the State Department of Health Diagnostic Laboratory (relocated from Oklahoma City to Stillwater), a genetic biorepository, and a multi-disciplinary basic science lab for human, animal, plant and food-related bioterrorism research. OPCIE will be

Oklahoma's frontline of defense against any future threatening biosecurity diseases.

### **C) Institute for Translational and Emerging Research in Advanced Comparative Therapy (INTERACT)**

INTERACT was founded to strategically focus on developing and translating novel discoveries for patient therapy focused on the One Health mission objective. Ongoing efforts include development of novel biocompatible materials, nanomedicines, and minimally invasive robotic surgeries for use in veterinary practice. Conducting clinically relevant research provides significant opportunities to conduct government- and industry-sponsored research in translational medicine across a range of disciplines, benefitting veterinary patients and humans. We have partnered with medical schools to expand into the human health field as part of our One Health mission and expect to develop further such collaborations in the future.

## **III. NEEDS**

### **A) Space**

Based on the 2020 OSU Physical Facilities Inventory (University Budget, VP Administration and Finance), McElroy Hall has 149,159 net square feet of space. Of that amount 26,071 square feet is listed as "code 250" primary research laboratory and 7,035 is "code 255" service space for research. These spaces are further classified as A-D, where A denotes "suitable for the most scientifically competitive research in the field", B denotes "effective for most levels of research in the field but may need limited repair/renovation, and C-D denotes "requiring major renovation or replacement". Of the 26,071 square feet listed as 250 primary research laboratory, 18,421 square feet or 12.3% of the available floor space is listed as class A research space.

There are approximately 28 faculty, 14 post docs, 9 research staff, and 40 grad students in that space. This is about 200 gross square feet per person. For life sciences discovery research, one recommendation is to provide wet-lab space amounting to 10-12 linear feet bench space per person, or 300-400 gross square feet per person as primary workspace. Additional consideration for space should be given to so-called "adjacencies" in the design, meaning access to shared equipment spaces, cell/tissue culture space, cold rooms, supply storage, etc. Based on the number of people we have now, plus a modest expansion of 5 to 8 additional research faculty (see Weaknesses, above), we need about 2x the amount of code 250 lab space plus 2 or 3x the amount of code 255 support space totaling about 30,000 net or 45,000 gross square feet. At a rough cost estimate of \$600-\$700 per square foot would



result in a total cost of \$30-32 million. Given the potential of researchers hired in the past 5 years, plus 5 more research-intensive hires in the next 2 or 3 years, we should be able to sustainably generate an aggregate total of 10 to 12 NIH R01 grants (currently 4). Along with other sponsors, and with the opportunities in front of us, we should exceed \$20 million in annual research expenditure in less than 10 years.

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