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Demystifying the Academic Research Enterprise

Becoming a Successful Scholar in a Complex and Competitive Environment

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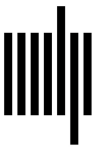

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Deep in Our Bones: Why and Where We Perform Research and Creative Activity

Chapter Overview and Learning Objectives

From providing a platform for understanding our history to conveying our ideas and emotions through artistic expression to exploring the most foundational questions of the universe, research and creative activity allow us to expand the frontiers of knowledge. They inspire us to pursue the impossible, unite us around shared goals, and guide us through life by providing solutions, comfort, and joy.

This chapter provides a foundation to the book by introducing the concepts of research and creative activity—where they take place, how they contribute to society, and how research administrative services (RAS) are organized at colleges and universities. After reading this chapter, you should

- Understand the meaning of the terms "research" and "creative activity" and the role played by curiosity in them;
- Be able to differentiate among the various subclassifications of research;
- Understand the sectors in which research takes place;
- Appreciate the roles of individuals and teams in performing research;
- Understand the importance of taxpayer funding in supporting fundamental research and the value to society of research outcomes;
- Realize that a delicate balance exists between focusing on the practical, quantifiable value to society of research and the need to engage in research and creative activity for the sole purpose of contributing to a body of knowledge and expression;
- Recognize the importance of incorporating multiple perspectives and expertise through a multidisciplinary, globally engaged approach to research in order to solve the world's most complex problems; and

- Understand how RAS are structured at colleges and universities, and options for obtaining needed resources if your institution does not provide them.

1.1 The Root of Curiosity and Emergence of Structured Inquiry

One of the world's most creative individuals, Walt Disney, said "We keep moving forward, opening new doors, and doing new things, because we're curious—and curiosity keeps leading us down new paths" (Walt Disney Archives n.d.). Physicist Albert Einstein said, "The important thing is to not stop questioning. Curiosity has its own reason for existence" (Miller 1955, 64). And author Zora Neale Hurston said, "Research is formalized curiosity. It is poking and prying with a purpose" (Hurston 1942, 182).

Curiosity! If I were to come up with a single word that embodies what research and creative activity are all about, that would be it.

Think of it! What is the earliest thing we do as children? We "get into things" when we begin to crawl and walk! This clearly demonstrates that curiosity is not something we develop over time, but rather is a fundamental part of our humanity. We are born curious! But what makes us curious? Animals are curious too. However, humans have the ability to utilize their curiosity to investigate and understand, express creatively, innovate, explain, and build upon that understanding. Thus, significant value, both quantitative and qualitative, exists in our curiosity—a point we will revisit in chapter 3.

Albert Einstein also is presumed to have said, "If we knew what we were doing, it would not be called research, would it?" This quote nicely captures the link between research and curiosity. However, the notion can be misleading because, in fact, we do know what we are doing when conducting research, as we will see in chapter 4. In fact, pursuing curiosity and getting paid to do it—which is what researchers do—may seem frivolous. However, the benefits of research are all around us. Examples include smartphones, laptop computers, flat-screen televisions, commercial and military airplanes, radars that detect the formation of tornadoes, and clothes that do not wrinkle.

These and other technologies, born out of research, do not reflect the totality of what research is about. Portraying the world in art is a form of research, as noted in the next section, providing insight into people and culture. You might wonder why we make paintings of things we can both see and photograph. It is because paintings capture more than the image—they capture the expressive intent of the artist in sometimes subtle but important ways. We also express abstract ideas and emotions in art and dance, as well as capture

history, preserve culture, and show important aspects of society such as conflict, tension, and change. Studying our past helps us understand the present and also the future. We are curious why people thought and behaved in certain ways, and sometimes we can only appreciate those things when viewed through the lens of history.

Despite the beauty and importance of curiosity, when it comes to research, curiosity cannot be pursued in an arbitrary manner. Consequently, beginning over two thousand years ago, philosophers such as Aristotle created structured approaches for studying the natural world, understanding the past, and creating music and plays. Rules and steps exist in research not only because we want to make sure we are correct in our understanding, but also because we want to build upon the work of others or interpret their work in our own way.

We test hypotheses, not only in the chemistry laboratory, but also in the dance studio. We test theories about the natural world to determine whether certain events occur randomly or for some other reason. Even some of the things we encounter continuously, and take for granted, such as gravity, are not fully understood.

It is important to recognize, however, that today's structured approaches to research—the rules and steps we follow—do not deny the tremendous value of lore, Indigenous knowledge, and tradition in research. Indeed, as discussed in chapter 4, these and other approaches to understanding the world increasingly are being embraced as a means for enhancing the overall research process.

The beauty of inquiry is that learning never stops, even though some questions may get answered. Yet in reality, research rarely provides immutable answers, but rather conveys the state of our understanding at any given time. Sometimes, we make major breakthroughs, but most of the time, our knowledge advances incrementally, one new revelation at a time. As Laurence Sterne noted, "The desire of knowledge, like the thirst for riches, increases ever with the acquisition of it" (Sterne 1759).

1.2 The Lexicon of Research: Understanding and Misunderstanding

The word "research" has a rather cumbersome but important formal definition in modern application. It generally refers to systematic "investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws" ("Research" n.d.). Wow!

Let us unpack this.

The key points here are "systematic," which means a structured approach that follows established or accepted steps and processes; "discovery," which

means either creating new understanding or refining existing understanding; and also "practical application," which includes the translation of new and/or previous research outcomes into new services, devices, procedures, processes, or activities that might benefit society.

A close cousin of research is the term "creative activity," which often is used in colleges and research universities. It makes clear that research is not solely the domain of the physical sciences, life sciences, engineering, social and behavioral sciences, and medicine, but also includes areas such as the humanities, and the arts and fine arts (e.g., English and other languages, literature, history, classics and letters, art, music, theater). One thus frequently hears "research and creative activity" used together in the context of academic scholarship.

However, this separation is a bit unfortunate because individuals working in fields such as science and engineering (often referred to as STEM disciplines, encompassing science, technology, engineering, and mathematics) apply a great deal of creativity in their work. Likewise, fields such as history and the arts test hypotheses about the past—for example, regarding human movement and expression in musicals (STEM is sometimes expanded to STEAM to include the arts, though not simply by adding it but rather by integrating it with the other elements of STEM). A better term to encompass all of research and creative activity is "scholarship," which covers all the bases but can be confused with special awards of funding to pay for education. The incorporation of lore and other sources and approaches enriches the broad concept of scholarship.

Throughout this book, I use the terms "research" and "research and creative activity" synonymously unless otherwise noted.

Having described the formal definition of research and creative activity, it is important to recognize that three subclassifications exist in research, often termed basic or fundamental research, applied research, and development (table 1.1). As shown in the table, basic research simply refers to research performed without a clear practical use in mind. That is why we also call it fundamental, discovery- or curiosity-based research—to make clear it is not "basic" in the sense of being simple. Studying the structure of atoms, the fundamental properties of materials and compounds, and the nature of black holes are good examples of fundamental research. The federal government funds the bulk of fundamental research in the US, and we examine in chapter 2 the broader spectrum of research funding.

The second subclassification, known as applied research, often is referred to as use-inspired research. It emphasizes using the outcomes of fundamental and other research for solving problems or developing new processes, products, or techniques that have practical value for a specific application or purpose. Often this purpose is linked directly to societal value or economic or

Table 1.1
US government executive branch definitions of research.

Basic research is systematic study directed toward a fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind. Basic research, however, may include activities with broad applications in mind.
Applied research is systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.
Experimental development is creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products or processes or improving existing products or processes. Like research, experimental development will result in gaining additional knowledge.
Research and development (R&D) equipment includes acquisition or design and production of movable equipment, such as spectrometers, research satellites, detectors, and other instruments. At a minimum, this category includes programs devoted to the purchase or construction of research and development equipment.
Research and development facilities include the acquisition, design, and construction of, or major repairs or alterations to, all physical facilities for use in R&D activities. Facilities include land, buildings, and fixed capital equipment, regardless of whether the facilities are to be used by the government or by a private organization, and regardless of where title to the property may rest. This category includes such fixed facilities as reactors, wind tunnels, and particle accelerators.

Source: Office of Management and Budget (2018a, 205).

business benefit. Examples of applied research include the development of a heart pacemaker using available circuitry, batteries, and medical implantation procedures.

The third and final subclassification is development, which sometimes is broken into applied development and product development. Here, multiple alternatives to a particular application are evaluated and the best chosen to go forward based upon which have the fewest risks or possibilities of failure. At this point, market forces come into play as some alternatives may be more expensive or less marketable than others. Note that the US government recently replaced "development" with "experimental development" (table 1.1).

If you think the above classification is complex, the US Department of Defense (DOD) has taken it a step further, both in terms of expanding the framework of fundamental research to applied research to development, but also structuring it via a numbering system that runs from categories 6.1 to 6.7.

As shown in table 1.2, category 6.1 is basic research, while 6.7 represents upgrades to operational capabilities. A new category, 6.8, now covers pilot programs in software and digital technology. Traditionally, a logical, linear progression has been envisioned to exist in which basic research begets applied research begets development and then leads to products. In chapter 3, however, we show that the real world is far more complicated.

Table 1.2
US Department of Defense research, development, test, and evaluation budget activity codes and descriptions.

Code	Description
6.1	Basic research
6.2	Applied research
6.3	Advanced technology development
6.4	Advanced component development and prototypes
6.5	System development and demonstration
6.6	RDT&E management support
6.7	Operational system development
6.8	Software and digital technology pilot programs

Source: Congressional Research Service (2021a).

In addition to these classifications of research is the notion of translational research. Usually applied in the context of human health, a precise overall definition has yet to be agreed upon. However, in general, translational research—which can be applied in domains broader than health—involves research that rapidly translates discoveries and research outcomes into practice for the benefit of society. Examples include fundamental discoveries in tumor structure that lead to new cancer therapies and research using radar data in computer models of the atmosphere to improve the prediction of severe storms (an example of R2O, or research to operations transition; http://vlab.noaa.gov/web/osti-r2o).

Another term commonly used in the context of research is "innovation." It generally is accepted that innovation describes the process by which research outcomes, technologies, and ideas are converted into goods, services, processes, or other things having value for society. For example, Apple did not fund or conduct the fundamental research that led to what lies inside an iPhone (like the battery, touch screen, electronic circuitry, wireless technology). Rather, Apple brilliantly innovated using all of these things and more to produce a product that has transformed society in ways unimaginable just a decade ago. The next time you use your smart device to make a call, surf the Internet, or send a text message, think of all of the research and innovation that made possible those capabilities.

1.3 The Many Homes of Research and Creative Activity

Having established motives for research and creative activity as well as the associated classifications, consider where research actually takes place. The "how" of research—that is, research methods and the rules and procedures discussed in the previous section—is addressed in chapter 4.

The bulk of fundamental research in the US is performed at research universities. This includes comprehensive institutions that offer doctoral, master's and baccalaureate degrees (Carnegie R1 and R2 classification; http://carnegieclassifications.acenet.edu) and have the performance of research and creative activity as part of their mission, along with teaching, community engagement, and public and professional service. Such institutions also tend to have excellent research support resources (section 1.6). Research also is performed at institutions that offer only doctoral/professional, master's or baccalaureate degrees (Carnegie D/PU and M1 to M3 classification), or that focus principally on instruction (PUIs and community colleges). The latter institutions tend to have fewer administrative support resources, though increasingly are becoming more active in research via their own strategic directions as well as special funding opportunities offered by federal agencies and other sources.

Historically, demonstrated success in research and creative activity was one of the most important requirements for receiving academic tenure[1] at comprehensive institutions. Yet a tension has long existed between teaching and research in evaluating faculty performance and awarding tenure, with success in research tending to dominate, even though mentoring students in research clearly involves teaching. At other types of institutions, and even now many comprehensives, teaching is the clear metric by which tenure is awarded, even though faculty often perform research as well. The importance of instruction more generally now is recognized as a key value proposition for tenure across all types of higher education institutions, and an increasing amount of research is being conducted by undergraduate students, sometimes in classroom settings.

In addition to conducting the bulk of fundamental research in the US, academic institutions also conduct applied research, especially in disciplines such as business, engineering, law, journalism, and education, though such scholarly areas also do their share of basic research.

As detailed in chapter 2, the federal government traditionally has been the largest funder of fundamental research owing to the lack of a clear purpose for its outcomes and thus the financial risk it poses were it funded principally by the private sector. Many federal agencies—so-called mission agencies—conduct research in their own laboratories and centers, and this sort of work is called intramural research. Examples include, for the US Department of Energy (DOE) (http://energy.gov), National Laboratories such as Los Alamos, Sandia, Lawrence Livermore, Oak Ridge, and the National Renewable Energy Laboratory; for the National Oceanic and Atmospheric Administration (NOAA) (http://noaa.gov), its National Severe Storms Laboratory; and for the US DOD (http://defense.gov), the Army Research Laboratory and Naval Research

Laboratory. These and other agencies also fund research at academic institutions and private companies by providing them with competitive grants and contracts (chapter 6), and such work is termed "extramural" research because it is performed outside of government-owned and -operated organizations.

For-profit private companies conduct huge amounts of research as well (chapter 2), mostly in the areas of applied R&D that leads to products and services that can be commercialized. Use of company funds for this purpose is often termed IR&D, which stands for internal R&D. The sectors where such research most often takes place include chemicals, computers and electronics, aerospace, defense, automotive, and software.

An example of a major for-profit research organization, which unfortunately no longer exists, is the venerable Bell Laboratories, where the transistor was first demonstrated. Today, Google, another massive for-profit organization, conducts large amounts of research on topics ranging from self-driving cars to high-altitude balloons for advanced communication.

Independent research institutes are another important part of the research landscape. Typically, they are funded via philanthropy and focus on very specific topics such as poverty, global health, the environment, and social justice. The more familiar examples in science include the Howard Hughes Medical Institute (http://hhmi.org), Cold Spring Harbor Laboratory (http://cshl.edu), and the Danforth Plant Science Center (http://danforthcenter.org). Additionally, numerous private foundations also provide significant funding for research conducted in academia (chapter 2).

In the area of the arts, fine arts, and humanities, a vast array of nonprofit and philanthropic-based organizations fund research and creative activity. These organizations exist at the community level, as well as the state and national levels. Most depend upon some form of public support, with occasional funding from federal agencies via grants. Several are organized as coalitions, consortia, or performing companies. As described further in chapter 3, this area of the research and creative activity enterprise has far fewer opportunities for federal support yet is vitally important to society.

1.4 From Individual Researcher to a Globally Engaged Team

Because research and creative activity—irrespective of discipline or idea—ultimately spring forth from human curiosity or societal need, the pathway to discovery, interpretation, or answers rests with people. Yet, the manner in which people tackle research problems depends upon a number of factors.

For example, if you wish to study a particular problem or pursue an idea, the first question you must ask yourself—assuming the problem or idea is viable—is

whether you have sufficient expertise to do so by yourself. For the moment, we are setting aside issues such as funding, necessary equipment, space, and so on. In other words, is the scope of the problem within your own skill set?

Historically, scholars tended to work on their own, pursuing their ideas and sharing their findings with others via publications, presentations, and performances. Many problems still can be tackled in this manner, which is the so-called single investigator approach that often leads to the highly coveted sole author journal article, recital, or book. Yet, single investigators almost always build upon work performed previously, perhaps as far back as several decades. Even Albert Einstein, who published many single-author papers, benefited from the work of others in establishing his theories.

In many cases, however, problems are so broad in scope or so complex that they require capabilities and knowledge well beyond what a single individual possesses, even if they have been in the field for several decades. For example, the oft-asked question "What causes tornadoes to form?" is so complex that, to be answered, it requires experts in the fields of fluid dynamics, thermodynamics, mathematics, engineering, physics, and computer science. And even then, once the cause or causes become known, the ultimate goal is to prevent people from dying, which involves research in human behavior, communication science, and sociology. In other words, to keep people from dying in tornadoes, many disciplines must come together to study the problem in an integrative, holistic manner. We discuss collaborations, team-oriented scholarly activity, and "convergent research" in chapter 13.

Additionally, the solution to a problem in one part of the world, or in one industry, may not be applicable in other contexts for many reasons—such as culture, religion, economic conditions, or corporate philosophy. In such cases, it is necessary to engage researchers across broad domains and regions in order to bring the necessary perspectives and expertise to bear on the problem.

Climate change is a good example. Although the fundamental physics of climate change apply to the planet as a whole, the manner in which these changes are manifest, and the impacts they have, are highly variable and local. Thus, understanding and mitigating the impacts of climate change require not only a multidisciplinary approach, but a globally engaged one as well.

1.5 Outcomes, Impacts, and Assessing Purpose and Value

The performance of research and creative activity requires funding—ranging from the salary of those performing the work to funding for space, equipment, instruments, technicians, graduate and undergraduate students, materials, publications, performances, exhibits, professional meetings, and travel.

Consequently, those providing the funding—which includes taxpayers (usually via federal agencies or foundations), companies, and philanthropists—want to ensure the work is of the highest quality, is relevant, adheres to the highest ethical standards, and has meaningful value and impact.

Unfortunately, it is not always easy, as noted further in chapter 3, to connect the dots from fundamental research to marketable product or public service. Also difficult is accepting the fact that, in many cases, years to decades pass before a fundamental research outcome makes a transformational impact on society, as did the iPhone, the global positioning system (GPS), the laptop computer, and the Internet. Nor is it always easy to argue for the great value wrought to society by the arts, fine arts, and humanities. Paintings, performances, and the study of ancient cultures may not cure cancer, but they are as important to our humanity as the activities that seek to find such cures. Indeed, modern medicine increasingly includes the arts in a holistic approach to therapy, with very impressive results.

The historical social compact between the taxpayer and the research enterprise, which has allowed our society to thrive, is being questioned today. Why? Generally, as a result of budget challenges, which lead to less tolerance for funding research (by Congress in particular) that does not demonstrably produce outcomes of immediate practical value. It has been said that, had researchers at the start of the Industrial Revolution listened to what society thought was most important, the steam engine, telegraph, and airplane would have been long delayed.

Assessing the value of research to society is a very difficult task and needs to consider not one aspect of research but the entire process—from idea to outcome. Not surprisingly, it is a mistake to presume all value can be monetized, or that practical outcomes are the sine qua non of research. It equally is unwise to assume all research will produce beneficial or positive results. Failure is an essential element of fundamental research and even product commercialization, and boldness of ideas and risk of failure are inseparable. And failure is never without the learning it brings. Charles Kettering aptly captured this sentiment in a quote often incorrectly attributed to C. S. Lewis, "Failures, repeated failures, are finger posts on the road to achievement. One fails forward toward success" (O'Flaherty 2018, 37).

Perhaps it is most appropriate to speak not in terms of the value of research, but rather the purpose. For even seemingly esoteric studies in pure mathematics, investigations into the evolution of obscure languages, or the study of an essentially unknown artist, have a purpose in contributing to the body of knowledge and expression we know as research and creative activity. Judging which such efforts should be funded, though an imperfect task performed via

peer or merit review (chapters 6 and 7), has served the US well and made us the envy of the world. Indeed, we should measure the associated outcomes and impacts of research that can be quantified, but also be comfortable knowing those things that are more qualitative in character are of tremendous value to society as well.

1.6 Research Leadership at Academic Institutions

Throughout this book, I mention numerous resources provided by academic institutions to support the scholarly endeavors of students, faculty, and other researchers. However, not every institution is able to provide these resources, and even if they do, the variation across institutions can be significant. As a student conducting research for the first time, or as a postdoctoral researcher or early career faculty member, it is important that you understand how academic institutions organize their research administration leadership and resources so you can benefit from them to the maximum extent possible. And even more important is that you understand where to turn if your institution does not or cannot provide the resources you need.

At the highest levels of institutional leadership, most colleges and universities have a similar administrative structure. Namely, a chancellor or president who serves as the chief executive officer of the campus (some colleges and universities are part of a system, led by a chancellor or president). They also have a provost (also often carrying the title senior vice president), who serves as the chief academic officer of the campus, along with academic deans, who oversee individual colleges typically organized by discipline or groupings of disciplines (e.g., engineering, arts and science, fine arts, business, social and behavioral sciences, graduate studies). Rounding out the leadership are department chairs, heads, or directors, who oversee individual academic units (e.g., department of modern languages).

Numerous other positions exist as well, such as chief legal counsel, chief diversity officer, vice president or vice chancellor for student affairs, and directors of centers and institutes. Members of the senior leadership team (president or chancellor and vice presidents or vice chancellors) function as executive officers, most of whom report directly to the president or chancellor and compose the cabinet.

The institutions themselves are governed by boards of regents, trustees, or overseers, the members of which usually are selected by the governor (in the case of public institutions), though sometimes are elected by alumni, the citizenry, or the boards themselves. Such governing bodies have full legal authority over the institution and function as its fiduciary, subject to federal and

state laws. They hire the president or chancellor, authorize the awarding of degrees, create and enforce policy, approve strategic plans, budgets, and the academic curriculum, approve hiring of all faculty and staff (though at some institutions, the president/chancellor or provost have this responsibility), and in general are responsible for overall institutional success.

Because the aforementioned positions and structures are common to most colleges and universities, their roles and responsibilities generally are understood by faculty and staff. Although an undergraduate student, graduate student, and postdoctoral scholar may generally be aware of this institutional structure, they tend to be more familiar with individuals or offices directly impacting their scholarly work—namely, their college dean, department chair or director, and faculty mentor. Students and postdocs also interact with and thus tend to be most familiar with the financial aid office, learning and writing center, center for student life, and student social and intramural athletic organizations.

Ironically, one leadership position that is among those least understood is the senior research officer (SRO). Despite being responsible for one of the three major dimensions of academic institutional success (teaching, research, and service/community engagement), the role of the SRO can be somewhat of a mystery. Why? Because in contrast to the aforementioned senior leadership positions, the SRO function, scope of responsibility, and level of resources provided can vary dramatically from institution to institution. Some SROs are responsible solely for research while others have numerous additional responsibilities, including research compliance (chapter 10), graduate education, and economic development (chapter 12).

Depending upon the size and type of academic institution, the SRO may hold the title of vice president or vice chancellor for research (as well as dean if overseeing a graduate college or program), reporting directly to the president or provost. In some cases, especially for smaller institutions, the SRO is an associate vice president or vice provost and even a midlevel staff position.

Not surprisingly, executive officers, faculty, and staff view the SRO through vastly different lenses. Presidents/chancellors and provosts generally view the SRO as someone who can dramatically and sustainably increase external research funding to the institution in the form of grants and contracts (chapter 6) and intellectual property licenses (chapter 12) and can also oversee graduate student and postdoctoral policies—all of which can lead to improved institutional outcomes and rankings. Deans, department chairs/directors, and faculty generally view the SRO as someone who provides services to support the preparation and submission of grant proposals, and the management of grants once awarded. They also see the SRO as providing matching funding for externally sponsored grants and contracts, funding for the purchase and repair of equipment, space for

scholarly activity, start-up funds for new faculty hires, and support for travel and publishing, exhibiting, or performing scholarly outcomes.

Graduate and undergraduate students, and postdoctoral scholars, rarely interact with the SRO during their professional development. However, if they wish to pursue careers as academic scholars or even work in government or industry (which frequently have a position equivalent to an SRO), they quickly come to understand that the SRO is a key resource for their success. Consequently, it is important for you, as a next-generation researcher, to become familiar with the SRO so you can make maximum use of the associated resources both during your formal studies and afterward in your professional endeavors.

The actual roles and responsibilities of the SRO position can best be organized within the six general categories shown below. A summary of the activities associated with each follows. Note again that not all categories are present within all institutions, and consequently, throughout this book, suggestions are provided so you can obtain the resources you need when they do not exist at your own institution.

- Institutional strategic planning
- Research development
- Research administrative services
- Internal funding
- Economic development and community engagement
- Research compliance and integrity

Institutional strategic planning Most colleges and universities have comprehensive strategic plans encompassing academic success and student achievement, research and creative activity, community engagement, affordability and accessibility, diversity enhancement, local and regional impact, economic development, and other topics. The SRO leads the component of the plan involving research and creative activity (and contributes to others as well, especially economic development), often resulting in three to five pillars of institutional strategic emphasis in research based upon factors such as historical strengths, a desire to create new areas of excellence, and alignment with national, regional, state, and local activities and directions. The research component of the plan frequently contains a list of goals, objectives, and strategies or tactics for attaining them, along with required resources, usually in the form of new funding and/or facilities, as well as metrics for assessing progress.

The most effective strategic plans are developed by obtaining input from all stakeholders, including next-generation researchers. Consequently, it is

important for you, as such an individual, to be aware of your institution's planning activities and to become involved with them. Do not wait to be asked! Be proactive, because the future of America's research enterprise belongs to you—and you can most effectively steward it by engaging strategically in helping determine its future directions as early as possible in your career.

Research development A relatively new capability that has emerged in many colleges and universities during the past decade, and that has grown dramatically in recent years, is research development (RD), which involves assisting faculty and postdoctoral scholars, and sometimes graduate students, in planning their scholarly activities. This includes but is not limited to identifying overall career goals and the scholarly activities along the way needed to achieve them; developing and framing ideas as the foundation of scholarly work (i.e., ideation); identifying appropriate sources of external funding; developing competitive grant proposals containing persuasive narratives that contextualize the work to be done and how the expected outcomes will contribute to the existing body of knowledge; identifying collaborators and building teams; guiding the development of research partnerships; creating mechanisms to broaden the participation of traditionally underrepresented groups and enhancing diversity, equity, inclusion, and belonging as part of the research process; identifying research impacts broader than those associated with the research itself; and understanding how a given project contributes to a scholar's overall career plan.

Some institutions have RD offices or centers with professional staff to assist in the activities mentioned above. As a student, postdoctoral scholar, or early career (and even mid- or late-career) faculty member, you should determine if and where your institution provides such resources. And if it does not, consult the SRO to understand the mechanisms available to you to help plan your specific research activities and place them in the context of your career goals. One valuable resource is the National Organization of Research Development Professionals (NORDP) (http://nordp.org), comprising more than one thousand RD professionals across hundreds of academic institutions, nonprofit organizations, and private companies.

Research administrative services One of the most long-standing and important components of the SRO scope of responsibility is the provision of services supporting the processing of researcher grant proposals submitted to external funding sources (chapter 6), and the subsequent management of associated grants and contracts after they are awarded. Indeed, if one views RD as everything leading up to and including the preparation of the intellectual content of a grant proposal, RAS represent everything that follows. That is,

development of the proposal budget and all other information required by the funding source, followed by actual submission of the proposal to the funding source according to applicable policies and laws. Once a grant proposal or contract is funded, RAS helps ensure compliance with the "terms and conditions" of the awarding organization, including budget management, preparation and submission of progress reports, data capture, and monitoring of subcontracts to collaborators.

Typically, the RAS function is executed within an institution's office of sponsored programs (OSP), which usually has a reporting line to the SRO. When such an office does not exist, the principal investigator of the grant or contract is responsible for the aforementioned activities—a significant burden to be sure, and one that places the scholar at considerable risk owing to the numerous details contained in terms and conditions and the legal ramifications of violating them. Fortunately, staff within the OSP are highly skilled and many are formally credentialed. Also, in most institutions, only a few individuals in the OSP, including the SRO, have the legal authority to submit proposals on behalf of the institution and thus obligate it formally to the terms and conditions contained within.

If your institution does not have an OSP and you require the sorts of services it provides, contact your SRO or equivalent to determine how your needs can best be met. Some academic institutions, especially those that are resource-challenged, are partnering with larger institutions to provide SRO capabilities. Such multi-institutional shared services models provide economies of scale, thus improving the ability of all institutions to actively participate in America's research enterprise. They also promote a framework for developing multi-institutional research collaborations (chapter 13). Additionally, as in the case of RD, RAS has a number of supporting professional organizations, especially the National Council of University Research Administrators (NCURA; http://ncura.edu) and the Society of Research Administrators International (SRA International; http://srainternational.org/home). And finally, as noted in section 10.6, efforts are underway within the federal government to improve research administrative resources across the national academic enterprise.

Internal funding One of the most important roles of the SRO is to strategically allocate funding from internal resources[2] to support the scholarly endeavors of its students, postdoctoral scholars, and faculty. Although the capture of funding from external sources, such as federal agencies (e.g., the National Science Foundation [NSF; http://nsf.gov], the National Endowment for the Arts [NEA; http://nea.gov], the National Endowment for the Humanities [NEH; http://neh.gov], and the National Institutes of Health [NIH;

http://nih.gov]) and private nonprofit foundations (e.g., the John Templeton Foundation [http://templeton.org], the Bill and Melinda Gates Foundation [http://gatesfoundation.org], the James S. McDonnell Foundation [http://jsmf.org], the Alfred P. Sloan Foundation [http://sloan.org], the W. M. Keck Foundation [http://wmkeck.org], the Mellon Foundation [http://mellon.org], and the Ford Foundation [http://fordfoundation.org]) is the desired goal for most scholars, *internal funding* is critically important for several reasons.

First, scholars often need seed funding to obtain preliminary results in pursuit of a new research idea or project, especially one that is outside the mainstream of their expertise, so as to best position them to compete for external funding. The internal funding may support travel to interview subjects, collect data, attend a meeting, meet with potential collaborators, or view archives. It also may involve supporting a student for a short period of time to perform preliminary research.

Second, funds frequently are needed for publishing, exhibiting, presenting, or performing scholarly outcomes. Although costs for such items can be included in most external grants, some disciplines—especially the arts, fine arts, and humanities—have far less access to such external funding and therefore must rely upon institutional support. This is especially true for the publication of books, which are a principal mode of communicating scholarly outcomes for the humanities, but for which institutional subvention fees to publishers sometimes are needed given the often relatively limited distribution of such work.

Third, researchers often require funding to travel to professional conferences and meetings, give invited presentations or exhibitions, and serve on committees or as journal editors. Fourth, some external funding sources require institutional cost sharing as part of the proposal budget (section 6.2). That is, for every dollar obtained from the external funding source, the institution must provide a certain level of resources, either cash or in-kind. Fifth, researchers look to the SRO for assistance in purchasing and maintaining equipment such as microscopes, fabrication machinery, stage lighting and sound equipment, and video and audio recording equipment for interviews or other types of human subject or animal research. SROs also typically contribute funding to start-up packages for new faculty, retention packages for existing faculty, and space rental as needed if scholarly work is not performed in buildings owned by the institution. Bridge funding for students supported on external grants and contracts to ensure continuity of work across awards is another important contribution made by SROs.

Researchers early in their career, including students, typically have access to a broad array of funding, both internal and external to their institution. This includes funding for presenting results at conferences, support for materials,

and professional development training. Contact your SRO or equivalent, or your academic advisor, to determine the sources available to you, and ask for assistance in obtaining them.

Economic development and community engagement Increasingly, most SROs are charged with technology transfer and economic development (indeed, most SROs now carry the title of vice president or vice chancellor for research and economic development). In these roles, the SRO oversees the institution's portfolio of intellectual property (chapter 12), and makes decisions about licensing, intellectual property protection, and possibly institutional investment in companies spun out of the institution. The SRO also collaborates with local, state, and regional officials and organizations to maximize the impact of institutional research outcomes on economic development. In some cases, this might involve seeking federal funding with a consortium of corporate and/or academic partners to establish a regional research hub, say in artificial intelligence or advanced manufacturing (chapter 13). Or, it might involve partnering with philanthropic organizations to create a local center for the performing arts or a cultural museum.

In all cases, the SRO represents to external stakeholders the academic institution's scholarly portfolio and works to ensure that it is benefiting society to the maximum extent possible. Indeed, most institutions report annually on their economic and other impacts to the community and state in which they are located. The Carnegie Foundation for the Advancement of Teaching (http://www.carnegiefoundation.org) and the American Council on Education (ACE; http://acenet.edu), now sponsor elective classifications for community engagement to highlight "those institutions that have made extraordinary commitments to their public purpose."

As a next-generation scholar, you should both understand and be able to explain how your work contributes more broadly to society, beyond the contributions made to your specific discipline (chapter 11). Contact your SRO or equivalent to understand the economic development and community engagement programs in which your institution participates and learn how you can become involved with them. Maybe you can partner with a local school to assist students or help teach classes in your area of expertise. Or maybe you can begin an afterschool program for disadvantaged youth. Whatever you do, look beyond yourself and find ways of becoming a contributor to the world around you rather than only a consumer.

Research integrity and compliance Two of the most important yet time-consuming dimensions of the SRO position are research integrity and research

compliance.[3] So important are these topics to scholarly endeavors that entire chapters in this book are devoted to them (chapters 9 and 10, respectively). Insofar as the SRO position is concerned, research integrity involves ensuring research is performed following the highest standards of professional ethics and accountability, with the institutional provost usually charged with adjudicating cases of alleged misconduct. Research compliance involves oversight of personnel, activities, facilities, and committees to ensure that applicable institutional policies, as well as state and federal policies and laws, are followed.

As noted in chapter 10, the overall purpose of research compliance is to drive human behavior in desired directions such that scholarly activities are conducted with the highest standards of ethics, integrity, safety, and security. The universe of research compliance is huge and includes but is not limited to the following: protocols for research involving human and animal subjects; training in the responsible conduct of research; disclosure and management of potential personal and institutional conflicts of interest; laboratory and radiation safety; bioethics; management of controlled and toxic substances used in research; clinical trials; protection of data containing information that is sensitive, classified, or otherwise restricted; export controls and research security; intellectual property disclosure, protection and licensing; reporting to funding agencies; and negotiation of grant and contract terms and conditions.

The size, scope and importance of these and other research compliance topics places extraordinary demands of time and expertise on the SRO and associated staff, as well as on funding organizations such as federal agencies and especially on academic scholars. Indeed, three national surveys (Rockwell 2009; Federal Demonstration Project 2014; Schneider 2020), conducted roughly seven years apart, consistently found that college and university faculty spend 42 to 44 percent of their time on administrative activities associated with federal grant funding, unrelated to the research being conducted. That is a very large number and one that needs to be reduced. Every researcher agrees with the need for research compliance. However, it is important that research compliance policies and laws be thoughtfully formulated and informed by those who perform research, be implemented appropriately, and be regularly evaluated to ensure they are meeting their intended purpose.

While serving as director of the White House Office of Science and Technology Policy (OSTP; http://whitehouse.gov/ostp), I initiated a major effort within the National Science and Technology Council (NSTC; http://whitehouse.gov/ostp/nstc) to address the administrative workload associated with research compliance. Known as Coordinating Administrative Research Requirements (CARR), it operated as a subcommittee of the NSTC Joint Committee on the Research Environment (JCORE; National Science and Technology Council

2019) and built upon work of the National Science Board (2014) (NSB; http://nsf.gov/nsb). Although some progress was made, the task is enormous and continues. It is imperative that the extraordinarily large amount of time academic scholars spend on research compliance be addressed by eliminating compliance rules and regulations that have outlived their purpose or are providing no practical benefit. Others should be streamlined and unified in order to minimize the time burden for researchers, personnel costs for academic institutions and funding organizations, and duplication across funding sources (especially federal agencies).

As a next-generation scholar, you should actively participate in efforts to reduce the research administrative workload while ensuring research remains accountable and is conducted with the highest standards of ethics, integrity, safety, and security. To learn more, contact your SRO or national organizations such as the Council on Governmental Relations (COGR; http://cogr.edu), which is a consortium of academic institutions, teaching and research hospitals, and independent research organizations that works to ensure the effectiveness of policies for research and creative activity. Determine if your institution is a COGR member, and if so, speak with those who attend COGR meetings so they can direct you to the many valuable resources COGR provides.

Finally, a study I led in 2016, while chairing the Council on Research (CoR) of the Association of Public and Land-grant Universities (APLU; http://aplu.org), involved a national survey to evaluate the roles of SROs at American research universities. The published results (Droegemeier et al. 2017) showed a number of interesting observations, perhaps the most disturbing of which is the lack of diversity in SROs across the country. At that time, 80 percent were male and 91 percent were White. Only 1 percent were Black or African American, and 5 percent were Asian. The results were not terribly sensitive to institutional Carnegie classification or Land-grant status. Although progress has been made during the past several years, a great deal more work needs to be done to improve SRO diversity and to better encourage and prepare individuals from all backgrounds to become SROs.

Assess Your Comprehension

1. Define the word “research” and list ways in which it differs from or is symbiotic with “creative activity.”
2. Describe the role played by curiosity in fundamental research and creative activity.
3. What is “fundamental” or “basic” research and how does it differ from “applied” or “use-inspired” research?

4. What is meant by the term "innovation" and how does it relate to research and creative activity?
5. What is translational research and how does it differ from other types of research?
6. By what type of organization is the bulk of fundamental research performed in the US?
7. The largest amount of funding for fundamental research in the US is provided by what source?
8. List the principal types of organizations responsible for performing research and development in the US.
9. Describe why scholarly activities in some disciplines, such as arts and humanities, often are not valued as highly as activities in science, engineering, and technology.
10. Why is it often difficult to show clear linkages between fundamental research outcomes and products and services that benefit society?
11. Why is the SRO position at academic institutions often not as well understood compared to positions such as president, provost, and dean?
12. List the principal responsibilities of, and services offered by, the SRO at academic institutions.

Exercises to Deepen Your Understanding

Exercise 1: All research and creative activity endeavors are valuable to society and contribute to our understanding of the world, regardless of the discipline in which they occur, or whether they are based solely on curiosity or seek to solve a specific problem. For this exercise, develop research questions that most interest you for both a basic (curiosity-inspired) and an applied research project. Discuss the significance, potential value to the discipline(s) involved, and relevance to society more broadly of obtaining answers to these questions. In so doing, provide a context for the work that needs to be performed with emphasis on how it would build upon previous research.

Exercise 2: In the US, twenty-six federal agencies fund research, as do numerous private foundations. Select one federal research funding agency and one private foundation and use information from their websites and other available sources to compare and contrast their approaches to supporting research and creative activity. Feel free to choose a particular topic that is supported by both organizations (e.g., brain cancer, clean energy technology,

environmental sustainability, world hunger, disease), and consider issues such as eligibility on the part of the researcher and their organization, the amount of funding available, the number of projects to be funded, project duration, and any special requirements or restrictions that might exist. What surprised you most about the information you gathered, and what, if anything, might you recommend as improvements to the funding organizations?

Exercise 3: Use the Internet to identify and explore a product, service, creation, or work in the world today that traces its origin to academic research. Describe how the item you selected evolved over time and the manner in which university research outcomes resulted in its creation and utilization. Also, discuss the impact of this item on society, using, as appropriate, both qualitative and quantitative measures.

Exercise 4: Use the Internet to locate a journal article in your field of study authored by a single individual, and compare and contrast the scope, methodology, and overall relevance and significance of this article with another authored by five or more individuals. What conclusions can you draw from this comparison, and what did you notice about the number of authors per article as you searched for the two required in this exercise?

Exercise 5: The US research enterprise consists of an array of government, academic, corporate, and nonprofit institutions that both fund research as well as perform it. Among this array are a number of independent research institutes. Identify several of them and compare and contrast their missions and structures with those of federal agencies. A good starting point for identifying the former is the Association of Independent Research Institutes (AIRI; http://www.airi.org/home). A list of federal agencies that fund research and development across all disciplines may be found at the Grants .gov website under the tab "Grant-Making Agencies." What differences did you find most surprising or interesting, and to what extent do you feel independent research institutes and federal agencies could improve their respective capabilities by borrowing certain features from each other?

Exercise 6: Visit the websites of the senior research officer (SRO) (e.g., vice president for research, vice chancellor for research) at six to ten academic institutions having the characteristics shown below and develop a table for the research support services they offer based upon those described in section 1.6. How do the services vary by institution? Which institutions have the greatest array of services, and what types of services are most common? Least common? To what extent does your scholarly work intersect with the services? Suppose you are located at an institution (select one

from your list) that has relatively few research support services. Examine the website of that institution to determine what steps would you take to locate needed support services.

Characteristics of institutions to be examined are shown below (consult the Carnegie Classification website at http://carnegieclassifications.iu.edu/classification_descriptions/basic.php to understand the terms used below and to select the institutions you wish to examine).

- Public Carnegie R1 (Very high research activity) institution
- Private Carnegie R1 (Very high research activity) institution
- Public Carnegie R2 (High research activity) institution
- Private Carnegie R2 (High research activity) institution
- Public Carnegie M1 (Master's Colleges and Universities—Larger programs) institution
- Public Carnegie M2 (Master's Colleges and Universities—Medium programs) institution
- Public Carnegie M3 (Master's Colleges and Universities—Smaller programs) institution
- Tribal Colleges and Universities (TCUs)
- Hispanic Serving Institutions (HSIs)
- Historically Black Colleges and Universities (HBCUs)

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