In discussing the essential characteristics of research universities, I will draw heavily on the experience of American and some European universities. Before detailing those characteristics, however, it is worthwhile to consider the great extent and variety of American research universities. The Carnegie Classification of Institutions of Higher Education describes two types of doctoral/research universities: extensive and intensive. Both offer a wide range of baccalaureate programs and are committed to graduate education through the doctorate. The extensive institutions are those that award 50 or more doctoral degrees per year across at least 15 disciplines. Intensive institutions award at least 10 doctoral degrees per year across three or more disciplines or at least 20 doctoral degrees per year overall.

In its year 2000 report, the Carnegie institution classified over 4,000 U.S. higher educational institutes, of which 261 universities were classified as research universities, with 151 being extensive and 110 being intensive. There is enormous diversity among these 261 universities. Some are strongest in the liberal and fine arts, others are strong in science and technology, while others are best known for their agricultural research. Some are private while others are supported by the 50 states that make up the United States.

This diversity of institutions is illustrated by my home state, California, where there are several high quality private research universities. These include the California Institute of Technology, which specializes in science and technology, and Stanford University, which offers advanced degrees in the humanities, social sciences, natural sciences, engineering, law, medicine and business. The private universities receive no direct support for their operations or instruction from the federal or state government. Instead, endowment yield, gifts and tuition provide the income for general operations and instruction. Some are established by, and partly funded by, religious organizations. Research is funded partly by these sources but more importantly by research grants from, and contracts with, the federal and state governments, private foundations and industry. The bulk of these research funds are obtained via competitive systems discussed below.

The State of California does fund large portions of the general operations and instruction, as well as some research, directly at over 20 universities with considerable diversity. One of these is the world-famous University of California, Berkeley that consistently ranks with Stanford among the top five research universities in the United States. Even though the State of California provides support for instruction and operations, most of the research funding at these state universities also comes from the same sources supporting research at the private institutions.
The California research universities contribute heavily to the San Francisco Bay area's having the highest per capita productivity in the world. Stanford University and the University of California, Berkeley have played major roles in the development of Silicon Valley as a center for information technology. They are joined by the University of California, San Francisco in providing support for the development of the biotechnology industry. The less well known, but superb, University of California, Davis has played a major role in the constantly increasing quality of California wines.

While these universities are known throughout the world for their contributions to the economy of the San Francisco Bay area, it is important to point out that they excel in fundamental research and scholarship. A hint of that is provided by the fact that these four institutions collectively have more Nobel laureates than virtually all of the world's nations. (That is also true of the Harvard-MIT complex.) They provide scholars for the faculties of higher educational institutions around the world and professionals to meet the needs of the State, the nation and the world. Although government "management" of them is essentially chaotic compared to the management of other research universities throughout the world, they succeed on a grand scale and attract students and scholars from around the world. Their ability to make economic contributions is directly related to their excellence in fundamental research and scholarship.

There are no federal universities included in the Carnegie list of research universities. There is no federal ministry governing the U.S. research universities. Yet, these universities perform approximately 60% of government-funded basic and long-term applied research. The nation's economy, health and security depend critically upon them. As a consequence, the relationship between the government and the universities is managed by means of a complex and often contentious partnership.

One must necessarily take this absence of central management and diversity into account when discussing the role of American research universities and seeking to understand essential characteristics. One should take the diversity into account when considering the establishment of new research universities as they may find that some types of institutions included in this classification offer better models for their needs and goals than do others. Nevertheless, I believe that all high quality research universities share the characteristics discussed below.

Briefly stated, these characteristics are:

- High quality faculty committed to research and teaching
- High quality graduate students who want to learn to perform research or function with advanced expertise
- An intellectual climate that encourages scholarship
- Facilities in which teaching and research can be performed effectively
- Funding for operations and instruction
• Research funding
• Research infrastructure
• High quality leadership

It is desirable, but not essential, to have a high quality undergraduate student body as well. As discussed later in this paper, however, there may be circumstances in which it would be wise to establish a graduate-only institution.

Faculty

No single aspect of a good research university is more important than having a high quality faculty devoted to both teaching and research. To achieve that, its faculty search and selection processes must be aimed directly at that goal. Search committees should look and advertise broadly to ensure that almost all qualified candidates around the world are likely to learn of the position, whether it be junior or senior - tenured or untenured. The position should be defined sufficiently broadly so that there is an appreciable sized pool of very good candidates.

Those institutions with a tradition of hiring faculty only from among their own graduates lose out in two ways: (a) They fail to obtain the services of better people from other institutions and (b) they lose an important source of new ideas and techniques brought by outsiders.

The selection processes should identify the very best candidates in a truly just and careful manner. They must be free of nepotism, cronyism and the like.

Those appointed or promoted to tenured positions should have proven their research capabilities through publications that have significantly influenced their scholarly fields. Sheer numbers of paper should be insufficient. Instead, the contributions must be real and important. Similarly, the candidates should have demonstrated high-qualities teaching capabilities.

The processes by which junior faculty are promoted to tenure are critical quality control mechanisms for research universities. There is no automatic or quasi-automatic promotion to tenure in first-rate research universities. Generally, well under one-half of the untenured faculty receive tenure. The remainder leave the institution, rather than occupying positions that could be held by those with greater capabilities.

The process for assessing the contributions of those being considered for promotion to tenure must also be rigorous and fair. Scholars outside the university should participate in the assessment of the research contributions. The junior faculty should have adequate time, five or six years, to prove their research capabilities.
It’s important that faculty at research universities teach courses. Generally, the process of developing courses and the subsequent interactions with high quality students deepens faculty understanding of their fields and leads to better research. In addition, good teaching in graduate courses tends to attract good students to research and helps to develop the next generation of researchers. It is also important, however, that teaching loads allow adequate time for research. Good research is truly time-consuming.

Before closing this section, let me say why I have stressed research contributions in the tenure decision in spite of the importance of teaching at research universities. Tenured faculty serve their institutions for many years. It is important that they remain enthusiastic about, and current in, their scholarship and teaching throughout those years. In my experience, those most likely to do so are those who are successful — and recognized as successful — in research.

Student Quality

High quality faculty tend to attract high-quality students. Research universities should take advantage of this and be selective in their admissions to ensure that the students, and particularly the graduate students, are of high quality. This is important because students are major participants in the research at these universities. If the research is to be successful, the students must be intellectually gifted and prepared to devote considerable energy and time to it.

In addition, students learn a great deal from each other. That mutual learning process is most effective when all of the students are bright and eager. The presence of very good students also makes it easier to hire high-quality faculty.

In many cases, however, it is only possible to continue to attract high-quality students if there is appropriate employment for them after the completion of their studies. Those developing new research universities should take this into account.

Intellectual Climate

If research universities are to be truly successful, they must exist in an atmosphere of intellectual freedom. The university must have an intellectual climate that is truly tolerant of diverse views and open to new findings. It must ensure that neither ideology nor dogma hinder intellectual exploration and exposition. The faculty themselves must, for the most part, determine their own scholarly research directions. They must be able to publish the outcomes of their research freely. Only under such conditions will the university be able to attract and retain the very best scholar-teachers and graduate students. Only under such conditions will the university host the research that will advance the society and economy effectively.
There is, of course, an apparent inconsistency between the faculty determining their own scholarly research directions and the achievement of societal goals (usually economic). To this I respond first that most university research outcomes that have had major economic impacts were unanticipated by societal leaders or research funders. No group of central scientific administrators or scientists, no matter how wise, can anticipate the creative inventions and discoveries of a healthy scientific community. Wise strategic planning and scientific funding incorporates this concept deeply.

Societal goals can be achieved, however, by the structure of the university. Strong engineering, computer science and physical science departments will yield advances in information technology. Strong biological sciences programs are likely to advance biotechnology. Similarly, strong agricultural research is likely to advance agricultural productivity. Institutions may influence the outcome by building scholarly strength in areas where they seek to advance the economy. Once they have obtained the high-quality scholars, however, they should let the scholars choose the fruitful research areas.

Facilities for Research and Teaching

It is vital that a research university have facilities that are consistent with the types of research and teaching to be performed. Effective education of graduate students requires libraries (increasingly digital these days), seminar rooms, classrooms and teaching laboratories of reasonably high quality. Of even more importance are the laboratories in which research is to be performed.

In almost every university of which I'm aware, space is at a premium. There should be a space allocation system that is fair and perceived to be fair. It should be allocated in a manner that allows junior faculty to develop programs that are independent of the senior faculty.

Operations Funding

I am not aware of any major research university in the world that obtains its operations funding completely from tuition. Universities established by government usually receive significant allocations for funding operations, instruction and capital improvements. These are supplemented by tuition, gifts and, in some cases, endowment. Private universities do not generally receive the allocations from government bodies. Instead, non-research income is a mix of tuition, gifts and endowment. At Stanford University, income from tuition and endowment are roughly equally important, while expendable gifts form a significantly smaller income component. Less heavily endowed universities depend considerably more on tuition.

Research Funding
Research is expensive and requires adequate funding. Various funding mechanisms are employed throughout the world:
- funding in a block grant to the university
- funding in block grants to departments or large subgroups
- funding to individuals or small groups

I strongly favor the process in which most research funding is provided by an outside agency, or agencies, in competitive, peer-review processes to individuals or small groups (as opposed to block grants to departments or institutions). The process of selecting those who would receive funding should be based on a fair and unbiased selection process that assesses the merits of the proposal and the proposer. While faculty often dislike writing proposals, the process serves a very important function for them. It forces them to determine what is the most important and achievable research that they might perform. Such a determination is an extremely valuable, but often overlooked, aspect of high quality research. The peer review process also tends to ensure that the agencies' money is well spent and that research of high quality and importance is performed.

It should be noted, however, that some universities construct, maintain and improve large facilities for use by many scientists. In this case, block funding is an appropriate and valuable funding mechanism.

If young people are to be attracted into the system, junior faculty should be able to compete directly for research funding. One of the great attractions of the United States to young researchers from other countries is that they have the freedom to propose and perform research independently. Too often in other countries, the research programs of the younger faculty are dictated by more senior faculty.

In many fields, a faculty member must have initial funding from the university for the establishment of a functioning laboratory in order to compete effectively for regular research funding. In the United States, that often means investments of between $500,000 and $2 million in new faculty members. This, of course, varies with the field. For example, starting costs for theoretical physicists tend to be less than those for experimental physicists.

**Infrastructure**

Often overlooked is the importance of university infrastructure to support research. Indeed, it is my view that the United States government under-funds such infrastructure, placing financial strains on that country's research universities. Those establishing research universities elsewhere should not repeat that mistake. Here are some of the infrastructure offices that I find important.
The Sponsored Research Office is typically the interface between the researcher and funding agencies. It assists the faculty member in meeting the requirements of the funding agency with respect to budget formulation, proposal formats and the like. It ensures that funding agency requirements in contracts are consistent with the university's policies. For example, most research universities in the United States will not accept limitations on a faculty member's right to publish the results of research. Occasionally, funding agencies want to limit that right. It is typically the Sponsored Research Office that performs the ensuing negotiation.

It is vital that there be an accounting function so that the researcher knows how much money is available to be expended on the research. This function also insures that expenditures are appropriate and consistent with the conditions set forth in the research grant her contract, as well as university policies.

If researchers are to have the instruments and supplies that are needed for research, there should be a Procurement Office that has the expertise to purchase those items and a Receiving Office that can receive them once they've been purchased and ensure that they reach the researcher. If these functions are not performed effectively, research can be delayed considerably.

A thriving research university is likely to generate intellectual property that may be commercialized and contribute to the economy. A good Office of Technology Licensing contributes to that process by evaluating new intellectual property for its marketability and then marketing it to industry. Too often in the United States, however, university leaders view intellectual property solely as a source of income, rather than as a means of improving the economy. In my own view, that is shortsighted. Only about ten universities get significant funds from their intellectual property. Almost all universities do get significant gifts from industry - and particularly from those companies that have been aided by the presence of the university. Thus, most universities do better financially in the long run by contributing to the regional economy.

There should be an Environment, Health and Safety Office ensuring that university functions are carried out in an environmentally benign, healthy and safe manner. This role can be a very sophisticated in institutions where advanced research is performed. The staff have to deal with circumstances ranging from the disposal of toxic chemicals to radiation safety to the safety of personnel caring for large primates.

Finally, institutions in which human subjects research is performed should have an office that ensures that such research is carried out properly with due regard for the well-being of the subjects.

Various mechanisms for funding infrastructure are employed around the world. In some cases, that funding is part of the university's budget. In the United States, where research funding is provided primarily by the federal government,
while the establishment and operation of the remainder of the university are funded by others, the indirect cost mechanism is employed. Here, indirect costs are costs that cannot be associated with the specific grant that funds the research. The infrastructure items discussed above are among those. This mechanism is a cause of constant strain between the universities and the government in the United States. Many of those funding the research would like to pay only the direct costs, but recognize that someone must pay for the indirect costs.

Undergraduate Education

Most research universities also educate undergraduates. Typically, these institutions attract outstanding students who can benefit from the intellectual sophistication of the faculty. The contact of the students with faculty heavily involved in research leads some of those students to pursue research careers themselves.

There are circumstances, however, in which it may be wise to establish graduate-only research institutions. States or countries may have undergraduate institutions of sufficient capacity and quality to meet their present needs. The faculty at these institutions may have focused on undergraduate education and not developed their research capabilities. It is extremely difficult to transform such institutions into first-rate research universities. Instead, it may be best to establish a new, graduate-only research university and staff it with new faculty who have the research capabilities needed.

Leadership

As implied above, the establishment and maintenance of a first-rate research university is a major undertaking. It requires visionary leadership that is committed to the educational and research goals. It requires leadership, as well, that is capable of managing a complex organization in which the faculty provide much of the intellectual leadership and in which, consequently, power is spread diffusely through the institution. Despite the goals of some who establish it, a new university is unlikely to yield major scholarly or economic advances in its early years. The leadership must have the political capability to withstand outside impatience and guide the institution's evolution towards great intellectual strength.

Fortunately, however, the university may soon benefit the local economy significantly by bringing outstanding researchers to a region where they can function as consultants to local industry and agriculture. In that consultant role, they themselves will learn of local needs and may have their research influenced accordingly. Similarly, they will attract outstanding students who can and will eventually contribute to the economy. These outcomes are likely, though, only if the leadership is committed to attracting and retaining first-rate the faculty and
students. To attract such faculty and students the leadership must ensure that they will have the opportunity to pursue their own ideas in a free and encouraging environment.