A forwarding note about this plan from Oklahoma's Secretary of Science and Technology:

It is important that States as ours develop strategic plans that focus on targeted areas of research and technologies of importance to the economy and/or quality of life of all. I feel the Oklahoma Science and Technology plan will be a map to lead us into the future by setting a course for the growth of "Centers of Excellence and Innovation."

Dr. Joseph Alexander
Oklahoma Secretary for Science and Technology

OKLAHOMA'S STRATEGIC PLAN FOR SCIENCE AND TECHNOLOGY

Technology and Innovation

In the 2006 Southern Growth Policies Board 2006 Report on the Future of the South, "Innovation with a Southern Accent," a V^3 strategy was developed focusing on increasing the value, volume, and velocity of innovations that occur in the South. The recommendations in this report are tied to the notion of innovation's co-conspirator—"technology." So inextricably linked in usage and concept are "technology" and "innovation" that they have become virtually synonyms. Southern Growth opted for a very pragmatic definition of "technology," one that makes clear the relationship to its partner:

> Technology: the new ideas or knowledge (usually scientific) used in the innovation process.

Technology, then, is the primary tool for achieving innovation.

Knowledge Economy

Knowledge can be organized into three categories: creation, accumulation, and application.

The creators of new knowledge may be responsible for inventions, patents, papers, theories, basic or applied science, and art, music, literature, or design. The existence of a strong creative base in the state is crucial to the development of a vibrant, healthy knowledge economy.

Those responsible for accumulating knowledge include people and institutions engaged in workforce development, pre-K initiatives, K-12 systems, community colleges, technical institutions, online learning, libraries, and more.

The application of knowledge is the ultimate path to empower and nurture the state. If Oklahoma is to fully function in a knowledge-intensive economy, we must understand how to create, accumulate, and apply knowledge.

If Oklahoma is to be a truly innovation-based economy, it will need a fundamental cultural shift toward valuing and celebrating knowledge, knowledgeable people, knowledgeable businesses, and knowledgeable institutions.

Economic Development Generating Excellence (EDGE)

In 2004 Governor Brad Henry initiated what came to be known as the EDGE Action Plan led by the Chancellor of Higher Education and the Secretary of Commerce. Among other

recommendations, the action plan called for Oklahoma to move toward becoming the "Research Capital of the Plains" through the establishment of "Centers of Innovation." Centers of Innovation require:

- Outstanding physical facilities
- Modern equipment
- Supportive infrastructure
- Access to venture capital
- Critical mass of research scientists, graduate students, and technicians

As a direct result of the EDGE Action Plan, several programs have been established in the State to support innovation and creativity.

- Endowed Chair Program

  This initiative provides a one-to-one-basis matching of State funds with private sector donations to support establishment of Endowed Faculty Chairs. Only interest earnings are available for a variety of expenditures, including salaries. The Chair may stand alone or be used to supplement an existing faculty position. The EDGE Action Plan facilitated passage of funding to eliminate the backlog of unmatched Endowed Chairs.

- EDGE Endowment Fund

  This fund has a goal of $1 billion with interest earning utilized to support research and innovation. The 2006 Oklahoma Legislature started the fund with an initial investment of $150 million.

  While the EDGE initiative has already led to some important advances, as discussed above, much more remains to be accomplished. The primary goal of EDGE was to transform Oklahoma into the Research Capital of the Plains. This was to be accomplished by a variety of mechanisms; foremost among them was the establishment of a $1 billion endowment for strategic investments in research and development. While it is notable that the legislature provided $150 million for EDGE in the 2006 session, it is disappointing that no further allocations were appropriated during the 2007 session. Since operating funds can only be allocated from interest on the EDGE endowment funds, the dollars available at present are far short of what is required to fulfill the EDGE promise.

  Full funding of the $1 billion EDGE endowment will yield approximately $50 million per year to invest in enhancing Oklahoma's research and development enterprise. This will have a dramatic impact on Oklahoma's capacity to compete for federal research and development funding. It is therefore critical that Oklahoma find a mechanism to fully fund the $1 billion EDGE endowment in the very near future.

The Experimental Program to Stimulate Competitive Research (EPSCoR) was established by Congress to enable states that have been less competitive for federal research and development funding to build their infrastructure and thereby enhance their competitiveness. While Oklahoma's scientists have been very successful in competing for funding within the EPSCoR programs, the state remains well within the eligibility thresholds for each of the federal EPSCoR and EPSCoR-equivalent programs, such as the NIH IDeA (Institutional Development Award) Program. In fact, no state has been able to enhance its research capacity to the extent that it has been able to "graduate" from eligibility for the EPSCoR programs.

The recognition of the critical role research and development plays in global economic competitiveness has been highlighted in recent publications such as "Rising above the Gathering Storm." This reality has in turn been recognized by Congress, and federal support for research and development is increasing. This provides an unprecedented opportunity for states such as Oklahoma to leverage their research and development investments.

- National LambdaRail (NLR)
  Oklahoma was an early investor in the NLR. The State recognized the need to have high-speed connections with research laboratories across the nation.

- Physical Facilities
  In recent years, the State has made available significant capital construction funds at its two comprehensive research universities. These funds will significantly enhance the physical facilities for research in a variety of focus areas of innovation.

- Oklahoma Seed Capital
  The 2006 Legislature established the first state Oklahoma Seed Capital Fund. These monies are to be utilized to support promising start-up companies that are ready to commercialize their technology.

Given the limitations of resources, it is critical to focus the state's Centers of Innovation into clearly defined areas. Too broad an approach will only spread resources too thin and thereby compromise the likelihood these Centers will rise to national prominence.

The state has chosen Centers of Innovation...

- Where Oklahoma already has at least some strength in terms of facilities, equipment, and people.
- That will have a high likelihood of creating new inventions, technology transfer, new companies, and high paying jobs.

- That utilize the resources of the State's comprehensive research universities, as well as private sector research foundations and industry.
- That represent an area(s) where Oklahoma can truly compete to be the best in the country as opposed to trying to "play catch up" with other already established states.

Strategic Research Opportunities

Strategic research opportunities are defined as areas in which Oklahoma has strength and in which additional strategic investments into these areas make Oklahoma "the place" where research and development activities will grow in the future. The most critical element for success in research will be the continued recruitment of the best scientists, graduate students, postdoctoral candidates, and technicians in these strategic research opportunities. Oklahoma will recruit a critical mass of talented people and provide them with facilities, equipment, infrastructure, and resources for success. They will be the backbone of Oklahoma's knowledge economy. Areas targeted for Strategic Research Opportunities include:

- Alternative Forms of Energy

  Under the leadership of Governor Brad Henry and with the support of both houses of the State legislature, the Oklahoma Bioenergy Center (OBC) was created in the 2007 legislative session. The OBC is a four-year, $40 million collaboration among The Samuel Roberts Noble Foundation, Oklahoma State University (OSU), and the University of Oklahoma (OU) to coordinate research and deliver practical outcomes to (1) enable the competitive and sustainable production of liquid biofuels in Oklahoma, and (2) contribute to the national research effort to enable the United States to achieve prescribed levels of petroleum independence. The OBC received its first $10 million funding allocation during the 2007 legislative session.

  Both the Noble Foundation and OSU have well-established and nationally-recognized programs in breeding dedicated energy crops – crops that are planted and harvested to produce energy, in this case, transportation fuel. In addition to this expertise, both OSU and the University of Oklahoma bring expertise in developing technologies for converting biomass into transportation fuel.

  Over the course of the next four years, the OBC will undertake the following:

  - Strategically coordinate resources and research programs in the member institutions to address and undertake complex research facing the emerging biofuels industry in Oklahoma and in the nation.

- Advance Oklahoma's research capacity in the fields of biofuels and Bioenergy development and production along the production/value chain – from field to conversion to utilization.

- Assist Oklahoma in being a recognized leader in the fields of research and production of biofuels, bioenergy, and related biobased products.

- Serve as a focal point and resource for Oklahoma's emerging agriculture (biomass)-based biofuels, and bioenergy industry.

The primary research objections of the OBC are:

- Achievable sustainable, economic production of cellulosic ethanol in Oklahoma.

- Conduct integrated research in a "wholesystem" approach for each state of the…
  - Biofuels production/value chain
  - Feedstock development
  - Crop management and production
  - Harvest, storage, and transport
  - Conversion (feedstock to ethanol)

Secondary research projects are as follows:

- Strategically conduct research to influence critical processes in the production of noncellulosic ethanol.
- Biodiesel
- Starch-ethanol (corn-based)
- Direct fermentation (sweet sorghum-based)

- Human & Animal Health

  The strategic focus for Human and Animal Health has two related, but independent, components. The first is to emphasize research and development that has particular relevance and opportunity in Oklahoma. The second is to utilize key assets and resources to address issues relevant around the world. The nexus between the two components is a set of unique skills and resources.

  The local needs and opportunities in human health are several-fold but have a common origin in the distinctive ethnic composition of Oklahoma with its large population of American Indians. While the specific health issues vary among tribes, in general there is a substantially increased burden of ***obesity and diabetes***, and Oklahoma ranks among the most challenged states in dealing with these major threats to health and longevity. Additionally, autoimmune disorders, including diabetes but

also various forms of arthritis, have a high prevalence and, in many cases, features that are distinctive from patients in European-derived populations.

Diabetes research is a broad effort ranging from basic mechanisms to clinical trials, with projects being pursued at the University of Oklahoma Health Sciences Campus (OUHSC), the University of Oklahoma at Tulsa, and the Oklahoma Medical Research Foundation (OMRF). The clinical research includes strategic partnerships across the state.

Immunology and autoimmune disorders likewise has broad and deep participation at the academic centers across the state. These efforts range from internationally renowned basic research to clinical studies that examine the distinctive challenges faced by American Indians to innovative clinical trials of new diagnostic methods and therapies. A detailed study by Battelle Corporation reported that the expertise in Immunology and Autoimmune Disorders is competitive with groups around the world and recommended a focus on further strengthening of these groups to both address unique problems in Oklahoma and to apply their expertise to global issues. This area of emphasis has the additional benefit of having immediate cross-application for both human and animal health.

Infectious diseases are a central focus of scientists at OSU, where the emphasis is on animal health, and at OUHSC and OMRF, where humans are studied. The strength in immunology is a major asset and much of the work is targeted on understanding and modifying the response of the host to an infection. Studies of infectious diseases have been assigned a high priority for the future as it is certain that new infections will appear and that the likelihood of a global pandemic is markedly enhanced by the ever-increasing international interactions—the world certainly is flat for infectious agents.

The ***genetic component of common diseases*** is another area of emphasis. Again, this is an area in which the distinctive composition of the population mandates an effort to understand the basis for differential expression of disease in different ethnic and racial groups in the human population of Oklahoma, which has a distinctive composition. Likewise, genetic studies have been employed to great advantage in understanding animal traits and related diseases. In humans the current areas of genetic study within the state are diverse including psychiatric and neurological disorders, pediatric diseases, cancer, heart disease and autoimmune diseases. The studies are conducted at OUHSC, the Warren Foundation, OU-Tulsa, OU-Norman, OMRF, and OSU.

These areas of research emphasis address particular local health challenges but in every case offer unique assets that can be applied to compelling global issues. This theme "local need, global application" will drive the strategic planning as we go forward.

- Information Technology & Cyber Security

  The Center for Information Security (CIS) at The University of Tulsa (TU) was founded in 1996, and has developed a reputation as an international leader in information assurance and digital forensics. TU CIS faculty, researchers and students conduct and participate in education, research, and outreach activities with the common goal of working to protect information systems and electronic infrastructures.

  In May 2000, the National Security Agency (NSA) designated TU as a Center of Academic Excellence for Information Assurance Education. CIS faculty spearheaded certifications in all six federal standards for cyber security training (CNSSI 4011-16), making TU the first university in the country fully compliant with the federal standards for information security. Since 2001, 798 certifications have been awarded.

  TU is a lead institution in the NSF and DoD Cyber Corps programs, which train students for security positions within the U.S. government and military. TU has graduated over 150 Cyber Corps students, an overwhelming percentage of whom go to work at the National Security Agency. In 2002, NSA designated CIS as one of two national centers for the development of cyber security faculty at colleges, universities, and community colleges across the country. The NSF awarded TU an Advanced Technological Educational Training (ATE) Center grant in order to spur the development of a cyber-savvy workforce by working collaboratively with the community colleges in a six-state region and the Oklahoma career and technology education system.

  CIS researchers address a wide range of challenges in cyber security. Projects include research in the areas of critical infrastructure protection, digital forensics, and enterprise security. Within critical infrastructure protection, CIS has led research on network, telecommunications and SCADA system security. In digital forensics, CIS projects have explored storage device, network and volatile memory system data extraction and preservation solutions. Research in enterprise security has focused on novel methods for risk analysis (e.g., extending the NSA IAM), security engineering (enhancing the ISSEP and Common Criteria), cryptographic protocol analysis, and network attack management systems. Other research efforts include projects in intrusion detection systems, operating system security, access control policy mediation, and software security.

In 2005 TU and CIS researchers sold a U.S. patent designed to protect copyrighted material in Peer-to-Peer (P2P) networks. In the past four years, three CIS student researchers have taken ideas from the laboratory and started companies, all thriving in the information assurance industry. These companies are Digital Forensics Professionals, Inc. (2004), Digital Enterprise Security Associates, Inc. (2005), and Meketrex Technologies, Inc. (2007).

TU's CIS faculty and students are involved in a range of outreach activities, including; providing digital forensics support to the City of Tulsa Police Department's Cyber Crimes Unit, the Oklahoma State Bureau of Investigation and the U.S. Secret Service; offering volunteer cyber security assistance to Oklahoma State Agencies, the City of Tulsa, and Tulsa County; and advising the Oklahoma State House and Senate on crafting Homeland Security legislation. CIS is a member of the Institute for Information Infrastructure Protection (I3P), and contributed to its National Cyber Security Research and Development Agenda, released in January, 2003. CIS is playing an active role in helping the I3P define a national research agenda for SCADA system security.

CIS faculty and students have published articles and given congressional testimony in the areas of information assurance, digital forensics, and telecommunications security. They have briefed the National Security Council at the White House, the Federal Trade Commission and the Pentagon on their findings. In addition, CIS researchers have given briefings to Fortune 500 companies in critical infrastructure sectors on vulnerabilities and mitigation techniques targeting their enterprise and production networks.

In 2004, TU created an Industrial Security Program to facilitate U.S. Government classified research. This program operates a 6,500 sq ft DoD DCID 6/9 compliant Secure Compartmentalized Information Facility (SCIF) dedicated to special government research and instruction programs. These initiatives include programs and training in TU's CIS and other disciplines.

In 2007, the University determined that the Center for Information Security (CIS) was well-positioned to benefit from the transition to The University of Tulsa Institute for Information Security (iSec) with a broaden mission. iSec is an interdisciplinary initiative involving faculty from computer science, electrical engineering, and mechanical engineering. iSec encourages technology commercialization and service to the private as well as the government sector as a means of advancing a high tech INFOSEC workforce, and the Oklahoma economy.

Cyber Security and Information Technology research, economic development, and outreach is by no means confined to TU. Significant expertise exists throughout Oklahoma. At OSU the Center for Telecommunications and Network Security relies on the expertise of multiple colleges, with Principal Investigators from Computer Science, Electrical and Computer Engineering, and Management Information Systems. Their broad range of expertise spans from advanced DoD encryption mechanisms to educational privacy, with ongoing projects in SCIP, forensics, deception detection, and traffic analysis.

The OU Information Technology Office has been working over the past year and a half on a project targeted at realizing network and system-based threats across a geographical/logical area and then effecting an appropriate response towards blocking or mitigating the incoming threat; the benefits of which to be shared by all participating institutions. An example of this includes OU, OSU, and OneNet, where one of the three institutions would recognize the attack directly, or through sharing the information and escalating the threat based on a calculated rating. The concept centers upon that of a self-healing network, but in this case, rather than limited in scope to only the OU network, it would extend across the state and by association provide such protection to all non-participants as well, so that K-12 schools, libraries, and government agencies would benefit as well.

- Meteorological Sciences

  History: The weather enterprise in Oklahoma began formally in 1960 with funding by the National Science Foundation of a proposal to create a meteorology curriculum in the OU Department of Physics. Two years later, the National Severe Storms Project (NSSP), then located in Kansas City, Missouri, established its Weather Radar Laboratory on OU's North Campus. This laboratory became the focal point for studying severe spring storms, and in 1963 it was decided that the NSSP as a whole would operate more efficiently in Norman, and would benefit by being in close proximity to the new meteorology group at OU. The move of the NSSP to Norman was completed in 1964, at which time it was renamed the National Severe Storms Laboratory (NSSL).

  This early partnership between OU and the Federal meteorology community foreshadowed the development of the largest meteorological education-operations-research enterprise of its kind in the world, the nation's third largest concentration of meteorological talent, and an environment that has both attracted and produced some of the world's leading authorities on the atmosphere, the latter including directors of both the National Weather Service and the National Hurricane Center, Oklahoma's first member of the National Academy of Sciences, and a Space Shuttle Astronaut.

Public-Private Alliances: The new National Weather Center building at the University of Oklahoma is home to a unique confederation of more than a dozen Federal, State, and University of Oklahoma organizations – employing some 700 professionals – that work together in partnership to improve understanding of atmospheric events ranging from tornadoes lasting a few minutes to multi-decadal changes in climate. This work includes creating and applying new observing systems, developing tools for government operations, establishing and testing new theories, and using supercomputers to model the atmosphere. Unique and complementary to this enterprise is a growing private sector presence in weather and weather-related disciplines on OU's Research Campus, now comprising nearly 200 individuals. The intentional synergy among government, academia and industry provides pathways for bringing research outcomes to practice, unprecedented learning opportunities for students, new high-paying jobs and incentives for graduates to remain in Oklahoma, and a framework for broadening OU's research portfolio via participation in large industry-government procurements both nationally and internationally. The overall economic impact of the weather enterprise to Oklahoma now exceeds $230 million per year.

Radar as a Focus: Building upon long and successful history in radar meteorology, the weather enterprise has chosen to invest strategically in radar as a means for attaining international prominence and stimulating private industry involvement. In addition to eight new faculty positions, all of which have been filled, as well as several Federal hires focused on radar-related research, current activities include a new multi-decade, multi-million effort to develop a follow-on to the present NEXRAD national radar system that also will be able to track aircraft; a prestigious National Science Foundation Engineering Research Center (CASA, or Center for Collaborative Adaptive Sensing of the Atmosphere) which is developing low-cost, low-power Doppler radars that can be placed on cellular towers and buildings for far better resolution of severe storms; new mobile radars for observing tornadoes and hurricanes; and a new cross-disciplinary graduate and undergraduate curriculum across meteorology and electrical engineering. OU recently created a $1.3 million Radar Innovations Laboratory (RIL), designed for fabricating prototypes, that is stimulating collaboration with industry. Techrizon, a Lawton-based company that builds artillery-tracking radars, has opened an office on the OU Research Campus across from the RIL and discussions are underway with a number of other radar and technology companies who are considering doing the same.

Economic Development: The Missing Component: Although the Oklahoma weather enterprise has achieved notable success in its academic programs, basic research and Federal operations – thus yielding a substantial economic *impact* – it has not made significant inroads in

commercializing its own technologies – for economic *development*. It has an opportunity to do so now in all aspects of weather radar, ranging from component manufacturing and system integration to data processing and distribution, decision support systems, user training, and maintenance and support. Importantly, weather radar is highly synergistic with numerous other strategic development areas in Oklahoma including sensing, computing, data storage, telecommunications, and visualization; thus, an investment in radar implicitly would be an investment of much greater breadth. Further, weather radar provides a strategic launching point for military and other types of radars, all of which are becoming increasingly important given today's challenges in homeland defense and border security.

Finally, it is important to note that the market for weather radar extends well beyond the US. Numerous countries are seeking to purchase turnkey weather observing and prediction systems, especially radars large and small, to protect their citizens and compete in the increasingly global technology economy. Indeed, OU is involved with such initiatives but Oklahoma has nothing to offer in the way of radar technology; it can provide such resources only by working with companies beyond its borders. The State of Oklahoma could make no better investment today than in growing the commercial side of its weather radar enterprise.

- Sensors & Sensor Technology

  The State of Oklahoma has long been active in the development of sensors and sensor technologies for multiple applications, establishing it as one of the nation's leading areas for sensor development. Through its multidisciplinary nature, research into Sensors and Sensor Technologies (S&ST) brings together scientists, engineers and industrial partners from across the state. The industry develops strategic alliances and partnerships among educational institutions, government agencies, businesses, and other industries in order to identify and develop applications for next-generation sensor technology.

  Existing points of focus have been in the areas of weather technology, aerospace, environment, medicine, and in chemical, biological and radiological sensors, homeland security, and defense. Scores of scientists are active in these areas across the state, from Oklahoma State University, the University of Oklahoma, Tulsa University, as well as from many private sector groups. Many of the state's most successful start-up companies grew out of the sensor and sensor technology industry (e.g. ICX-Nomadics, NanoBioMagnetics, Landauer, etc.).

  With the growth of the sensor industry in Oklahoma and the nation, a critical need has emerged for independent test and evaluation facilities, particularly in the defense and security sector. To meet this need,

Oklahoma has established a unique facility known as the OSU-University Multispectral Laboratory (UML) in Ponca City and Stillwater. The UML will operate as a national, "trusted agent" test and evaluation center, initially servicing federal (defense and security) customers but expanding to the commercial sector in future years. The center will focus on rapid concept development to device commercialization and will facilitate rapid sensor technology transfer to users on the frontline of industry, medicine, homeland security, and the Global War on Terror (GWOT). To this end the UML has established partnerships with federal agencies, (e.g. USSOCOM, SPWARSYSCEN Charleston, DHS), national labs (LLNL, LANL, Edgewood, Idaho National Lab.) universities (e.g. John Hopkins Applied Physics Lab., Penn State Applied Research Lab., Univ. of Kentucky Biometrics Fusion Center), private sector partners (e.g. SAIC), and small businesses, as well as state and local government. In addition to increased federal funding, the "trusted agent" test and evaluation status of the center will attract S&ST companies and businesses to Oklahoma in order to work through the UML to establish their technologies as certified for use in defense and security applications. Oklahoma is becoming the "go to" state for sensor and sensor technology development.

- Nanotechnology & Advanced Materials

  The State of Oklahoma has placed an emphasis on the importance of nanotechnology and advanced materials to its economic development. Since 2000, a considerable investment has been made in this area through the formation of the Oklahoma Network for Nanostructured Materials (NanoNet), a statewide network of academic nanotechnology researchers. NanoNet has provided research projects for two successful NSF EPSCoR Research Infrastructure Improvement Grants (RII).

  The first NanoNet proposal focused on interdisciplinary research for semiconductors for electronics, polymer and semiconductor colloids for composite materials and sensors, and carbon nanotubes while the second provided funds for research groups on carbon nanotubes, fuel cell materials, novel electromagnetic devices, and the interface of biology and nanotechnology materials. Through these efforts, along with additional funds from the Oklahoma Regents for Higher Education, considerable infrastructure is now available. This infrastructure includes electron and optical microscopes at major university institutions available statewide to nanotechnology researchers, technical personnel to maintain these instruments, interdisciplinary postdoctoral researchers, and the hiring and support of 12 young faculty members.

  In addition to these successful proposals, a subgroup of NanoNet researchers at the University of Oklahoma, along with scientists at the University of Arkansas, were awarded an NSF Material Research Science and Engineering Center called C-SPIN for research on semiconductor

nanotechnology. The C-SPIN grant was renewed for another five years in 2005.

In 2002 the Oklahoma Legislature created the Oklahoma Nanotechnology Initiative (ONI) for the purpose of development of nanotechnology business. The ONI is led by the State Chamber of Commerce, and funded through the Oklahoma Center for the Advancement of Science and Technology (OCAST), a state agency funded at $23 million in fiscal year 2008 to support applied research at universities and companies. Nearly $1.25 million of OCAST funds were awarded to five companies for development of nanotechnology products. There were 26 applications for the five commercial ONAP R&D grants. Private sector nanotechnology R&D has grown to about 20 companies, such as icX Nomadics (sensors for defense and homeland security), Southwest Nanotechnologies (carbon nanotubes for displays and hydrogen fuel cells), NanoBioMagnetics, Inc. (targeted drug delivery), Nanolight, Inc. (infrared laser and detector systems for human health), XetaComp (sunscreen particles), Access Optics (medical-related endoscopic equipment), Martin Bionics (nanoparticle products for amputees), and Rupture Pin Technology (safety devices.)

Nanotechnology in Oklahoma is advancing rapidly in universities and industry. The EPSCoR RII grants have stimulated interdisciplinary research that nobody dreamed possible in 2000 and have provided infrastructure for continued growth. The State through ONI, OCAST, and EDGE has had an equally powerful effect on business R&D. Oklahoma is poised to become the Research Capital of the Plains in selected areas of nanotechnology and advanced materials.

Oklahoma's workforce is in direct competition for jobs with lower-wage, highly skilled workers around the globe. Educational programs that support the application of microtechnology and nanotechnology are critical to Oklahoma's economic development that hinges upon our industries' ability to stay globally competitive. The Oklahoma Nanotechnology Education Initiative (ONEI) addresses workforce challenges by integrating micro and nanotechnology concepts into Career and Technology Education's career majors and by developing a two-year associate degree that will advance industries' use of microtechnology and nanotechnology. To advance this initiative ONEI has been awarded a $598,000 three-year an Advanced Technological Education National Science Foundation grant.

- Plant Science & Genomics

  Agriculture is recognized as one of Oklahoma's two "heritage" industries – the other being energy production. Today, Oklahoma research institutions, including the Noble Foundation and OSU, are conducting

significant research that is yielding new crops; new plant varieties; new traits for tomorrow's crops that will be introduced using biotechnology; and critical research tools and databases that are contributing and benefiting the international plant science community.

The existing plant science and genomics platform within the state enjoys a broad-spectrum of expertise and research, generally complementary in nature, that has produced world-renowned "niches" of expertise where Oklahoma has proven strength. These niches includes:

- **Genomics.** OSU and the Noble Foundation have recognized programs seeking to improve plant productivity, whether through tolerance of environmental conditions, enhanced disease or pest resistance or quality improvement (e.g., improved digestibility, compositional quality).

  The Noble Foundation is recognized internationally for its efforts to advance *M. truncatula* as the genomic model for the study of all legumes. The development of such resources affords researchers in Oklahoma, as well as researchers worldwide, new opportunities to discover new genes and metabolic pathways for improved plant productivity.

  - *Medicago* Functional and Translational Genomics.
    - Full genome sequencing. The Noble Foundation initiated the full sequencing of the *M. truncatula* genome through the provision of support to the Advanced Center for Genome Technology at the University of Oklahoma, a recognized center of excellence in the field of sequencing. The project used prior investments by the National Science Foundation (NSF) and resulted in the additional contribution of more than $11 million from NSF. **NSF has cited this sequencing project as a successful example of a public-private partnership to advance science and commit important research data to the public.**
    - Other genomic resources. In its effort to advance the publicly accessible scientific resources available to the international research community, the Noble Foundation has contributed more than 220,000 expressed sequence tags (ESTs) in *M. truncatula* to publicly accessible databases; collaborated with others to develop a commercially available Affymetrix GeneChip providing a tool to allow attribution of biological relevance to many unknown genes; and developed extensive mutant populations of *M. truncatula* to facilitate gene discovery.

- Platform technologies. Plant genomic research in Oklahoma benefits from a tremendous investment, both public and private, in technology platforms, including sequencing, proteomics, metabolomics and bioinformatics technologies.

- **Molecular Marker Development/Mapping.** Existing programs include the development and applications of molecular markers and other genomic resources for genetic improvement of forage and small grain species.

- **Metabolic Engineering.** Oklahoma researchers are identifying and engineering plant natural products to improve the utility of plants for both agriculture and human healthcare; this work is underpinned by genomics-based gene discovery, high throughput metabolomic analysis, enzyme structural biology and plant genetic transformation.

  These programs will enable Oklahoma's plant science researchers to productively interact with the state's human health research – blurring the lines between traditional plant science and human health research to find new solutions to human disease and conditions. Developmental collaborations are currently underway at the OUHSC, OMRF, the Dean McGee Eye Institute and the Noble Foundation in this field.

- **Plant-Microbe Interactions.** Existing programs seek to perform fundamental and targeted research to understand the mechanisms underlying disease and resistance to disease in plants, and the beneficial effects caused by symbionts and endophytes.

  For example, a group of researchers from the University of Oklahoma, OSU and the Noble Foundation, have formed the ***Oklahoma Consortium for Legume Research***, and are working to overcome the effects of cotton (Texas) root rot, a devastating fungal disease caused by *Phymatotrichopsis omnivora*. This disease affects more than 2,000 economically significant plant species throughout the southwest United States and Mexico. After only two years of research, which began in 2005, researchers are making significant gains in understanding this pathogen and developing a transgenic approach to imparting resistance in alfalfa.

- **Cell and Developmental Biology.** Researchers at the Noble Foundation and OSU apply an array of advanced experimental approaches to understand the complex biological processes underlying cellular function and plant development. As but one example, researchers are assessing how plants respond to environmental signals, including identifying the cellular and molecular mechanisms by which plants sense changes in their

environment and how this information is translated into a developmental or growth response.

- **Plant Breeding.** Researchers at the Noble Foundation are developing new varieties of high performance forage grasses, forage legumes, small grains, and bioenergy crops using traditional breeding, selection, hybridization, and advanced molecular techniques. Likewise, researchers at OSU are using such techniques to develop a broader range of crops, including, in part, hulless barley, canola, wheat, Bermuda grass and bioenergy crops particularly suited for climates and soil types across the southern Great Plains.
- **Plant Transformation.** Oklahoma researchers are developing safe, reliable and efficient plant regeneration and genetic transformation systems to generate novel plant material – based on crop – by direct introduction of agronomically signficant genes into targeted crops.

- Aviation/Aerospace

Oklahoma is one of the top six global hubs for aerospace maintenance, repair and overhaul services, with the aerospace industry directly responsible for 72,535 Oklahoma jobs in the 1st quarter of 2006, or 4.3% of the state's total employment. Indirect and induced employment figures added another 43,237 jobs, bringing the total job level to 115,772 positions for that time period, representing a payroll of nearly $5 billion.

Statewide direct and indirect gross output from Oklahoma's commercial aviation industry was estimated at $12.4 billion in 2004, accounting for just over 10% of Oklahoma's industrial output. With wages within the industry typically above the state average wage of $15.13 an hour, the aerospace industry is a strong economic driver for the state's economy. This is an extremely important statistic for Oklahoma, since the state ranks only 37th in the nation in per capita income and 14% of the population lives below the poverty level.

Aviation/aerospace is synonymous with Oklahoma and Oklahoma's legends: luminaries such as Will Rogers, Wiley Post, Clyde Cessna, Tom Braniff, Tom Stafford, Shannon Lucid, Gordon Cooper and others. It is also an industry that is grounded in innovation and technology. The underpinnings for **aviation/aerospace** training and education are science, math, and multi-disciplinary engineering. Existing and potential applications include nanotechnology and other advanced materials, and composites. One paragon of globally-significant technological achievement is the new Boeing 787 Dreamliner, significant sections which are being produced and manufactured in Tulsa. The aircraft is over 50% carbon-fiber composite materials. This new technology, along with

existing challenges such as corrosion and fatigue which are pervasive throughout the U.S. fleet of aging aircraft, spawns vast new opportunities for research that are irrefutably strategic; they are derivatives of Oklahoma's largest industry that, along with energy and agriculture, have the richest legacy upon which to build. Additional research strengths in Oklahoma may be found in structural health monitoring of aircraft using state-of-the-art sensors and imaging technology for non-invasive and non-destructive inspections; advanced coatings for extended engine life, and environmental and fuel efficiency research such as "synfuels" being produced in Tulsa. In aggregate, air transport composite maintenance, repair and overhaul (MRO) demand is expected to more than double by 2014. The composites MRO market is currently about one fifth of the production market at $7.3 billion and is projected to grow to $30 billion by 2026. Information obtained from: Aerostrategy Management Consulting, Ann Arbor, Michigan and Amersham, UK. Aviation/aerospace is also extremely important for the career opportunities it presents for young people to remain in Oklahoma. These jobs, as an average, are twice the state's per-capita income and are tied to an industry that is global with a trajectory that trends upward – both civil/commercial and military – as far as the mind's eye can see. Its future is bright, indeed, and that can only augur well for Oklahoma and its young – especially the best and brightest, if today's leaders make wise decisions and utilize our resources strategically and with the highest probability of success.

S&T Plan Goals

The recognition of the critical role research and development plays in global economic competitiveness has been highlighted in recent publications such as "Rising Above the Gathering Storm." This reality has in turn been recognized by congress and federal support for research and development is increasing, as authorized by the "America Competes" legislation enacted in August 2007. This provides an unprecedented opportunity for states such as Oklahoma to leverage their research and development investments.

To take full advantage of this opportunity and to enhance educational and economic opportunities for all of its citizens, our overriding strategic priority is to fully fund the $1 billion dollar EDGE Endowment within three years.

With the resources that would be provided by the fully funded EDGE endowment, the goals of Oklahoma's Science and Technology Strategic Plan are:

1. To graduate from NSF EPSCoR-eligibility within five years after full funding of the EDGE Endowment. This would require doubling of NSF funding in constant dollars from its current statewide level of approximately $18 million per year (FY 2006 data).

2. To improve the national rankings of Oklahoma's comprehensive research universities to the top 100 within five years of full funding of the EDGE Endowment and to the top 75 within 10 years. OSU is currently ranked #121 and OU-Norman is #128. Placement within the top 75 research universities would require doubling in constant dollars the current level of research expenditures of approximately $100 million per year at OSU and OU (FY 2004 data).

OKLAHOMA SCIENCE AND TECHNOLOGY PLAN TASK FORCE

Mr. Steve Biggers	Deputy Director	Oklahoma Center for the Advancement of Science & Technology
Dr. Kelvin K. Droegemeier	Associate Vice President for Research Regents' Professor of Meteorology & Weathernews Chair	University of Oklahoma
Mr. John Frick	Partner	Chisholm Private Capital Partners, LC
Dr. Sheryl Hale	Innovative Initiatives & Services	Oklahoma Department of Career & Technology Education
The Honorable Mike Jackson	Oklahoma House of Representatives	The Great State of Oklahoma
The Honorable Charlie Joyner	Oklahoma House of Representatives	The Great State of Oklahoma
Mr. Ken Lackey	Chairman & CEO	The Nordam Group
Mr. Hershel Lamirand	Executive Director	Oklahoma Health Center Foundation
Mr. Dan Luton	Associate Director	Oklahoma Center for the Advancement of Science & Technology
Dr. Stephen McKeever	Vice President for Research & Technology Transfer	Oklahoma State University
Ms. Deidre Myers	Division Director, Research & Economic Analysis	Oklahoma Department of Commerce
Dr. Stephen M. Prescott	President	Oklahoma Medical Research Foundation
Mr. Steve Rhines	Vice President, General Counsel and Director of Public Affairs	The Samuel Roberts Noble Foundation, Inc.
Dr. Paul G. Risser	Chair & Chief Operating Officer, University Research Cabinet	University of Oklahoma

Dr. Allen R. Soltow	Vice President of Research	University of Tulsa
Mr. Warren Thomas	Partner	Acorn Growth Companies
Dr. Joseph Waner	Vice President for Research	The University of Oklahoma Health Sciences Center
Dr. Richard Wansley	Vice President for Sponsored Programs, Research, & Institutional Advancement	OSU-Center for Health Sciences
Dr. Frank Waxman	Director, Oklahoma INBRE & EPSCoR	Oklahoma State Regents for Higher Education
Dr. James Wicksted	Head, Department of Physics	Oklahoma State University