

**Plant Biotechnology:
A Proposal for Economic Leadership**

Placing Virginia at the Center of a 21st Century Worldwide Industry



By

David Sebring and Dr. Gary Evans

An Economic Development Initiative
by the Thomas Jefferson Institute for Public Policy

Thomas Jefferson Institute for Public Policy

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This Economic Development White Paper, “ Plant Biotechnology: A Proposal for Economic Leadership” does not necessarily reflect the views of the Thomas Jefferson Institute for Public Policy nor its Board of Directors. Nothing in this study should be construed as an attempt to hinder or aid any legislation.

Foreword

The enclosed Economic Development White Paper was prepared by two experts who understand the direction our economy will take during the next step in the "technology revolution." The ideas are exciting and may be a key to making Virginia a center of economic growth in the 21st century.

David Sebring, Senior Marketing Manager for IBM's Global Government Industry, a huge division larger than Microsoft, wrote this paper at the urging of Thomas Jefferson Institute for Public Policy. It encapsulates the ideas Mr. Sebring expressed in a series of discussions with the Institute's Chairman, Michael Thompson.

Dr. Gary Evans is the Director of the Natural Resources Institute at the United States Department of Agriculture. He is among the world's top experts in plant biotechnology and sees the concept in this White Paper as an opportunity to have the U.S. remain the leader in this terribly important field whose potential is only now beginning to be fully recognized.

Although this White Paper is not focused on Virginia, it is clear that the ideas expressed in it can become the catalyst to develop a worldwide center for plant biotechnology here in our state. That is why we are bringing this concept to the attention of the academic, government and private sectors of our economy. Only through a partnership of those sectors can the ideas in this paper become reality.

Virginia is ideally located to be the hub of this worldwide center for plant biotechnology. Our research universities are primed to capitalize on this concept. Working with the private sector and the government, these world-renowned institutions can develop this industry here in Virginia.

The Center for Economic Development is one of five "centers of activity" in the Thomas Jefferson Institute's organizational structure. It is interested in bringing creative ideas to public discussion that will enhance free enterprise, promote limited government and, at the same time, encourage the international competitiveness of our state.

This Economic White Paper does not necessarily reflect the opinions of the Thomas Jefferson Institute for Public Policy or its Board of Directors. However, the concepts are brought to the attention of our leaders in business, academia and government in order that actions can be taken to make sure Virginia takes advantage of the ideas expressed by Mr. Sebring and Dr. Evans.

Lawrence Framme and John Alderson
Co-Chairs, Center for Economic Development
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Plant Biotechnology: A Proposal for Economic Leadership

White Paper

by

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Introduction

The economic potential created by advances in plant biotechnology will produce a dramatic growth engine for regions that lead in academics and research tied to entrepreneurial ventures. Today, this emerging field is underfunded and largely ignored. This paper discusses four assertions that form the basis of a proposal for regional economic development built upon leadership in this promising new technology. These assertions are:

- 1) Biotechnology will be the primary engine that drives the global economy in the 21st century.
- 2) Distributed global teams will be the future of innovation.
- 3) Progress in biotechnology and distributed collaboration create demanding new dependencies on information and communication technologies.
- 4) These changes will create new regional economic winners and losers.

This is a proposal to establish a public/private partnership to address these assertions and the shared needs of several communities of interest to accomplish the following objectives:

- to create a center of expertise for plant science research distributed across several institutions,
- to create nonproprietary assets essential for benchmarking progress and commercializing this research,
- to develop necessary information technologies to enable progress in this emerging field, and
- to begin economic development based upon establishing leadership and creating value.

This white paper does not necessarily represent direction in IBM or in the U.S. Department of Agriculture (USDA). It is an attempt to assess interest of key regions and universities and within USDA and IBM. It is provided to solicit comments that will be used to improve the ideas proposed in this paper. It is also intended to be a catalyst that will lead to collaborations creating the new regional economic leaders for this important emerging field.

Please forward comments to Dave Sebring or Dr. Gary Evans at the e-mail addresses above.

Background

History will record the late 20th century as a time exiting the Industrial Age and entering the Information Age. There is little doubt that today it is information and communication technologies that create the greatest value and cause the most change. These technologies are credited with creating a new level of prosperity, enabling globalization, and generally changing the way we work, educate, the way we are entertained, the medical care that we receive, and the way governments serve their constituencies. The world is in the midst of an information and technological revolution that is transforming every aspect of our lives.

In the emerging information-based global economy, value is shifting from manufactured commodities to information. Data will be the new raw material and the technologies to manage these data and extract knowledge will be the tools of the new industrial base. But information and communication technologies are only the tools. It is the application of these tools to the 21st century industries that will create value and drive economies. *The key question for the future high-growth regions is: where must we focus today to lead those areas that will be the most highly valued in the 21st century, and how must we proceed to become the magnet for economic activity?*

This white paper is based upon four assertions that describe the new economic environment:

First: Biotechnology will be the primary engine that drives the global economy in the 21st century

Economists and technologists are starting to observe that in the 21st century it will be biotechnology that overtakes information technology as the primary driver of the new economy.

Biotechnology can be divided into animal science and plant science. Research focus has been on animal science with some breakthroughs but many false starts and unfulfilled promises. This is no different from any budding industry. Animal science, especially the application of human genome research, will become a key economic driver.

The side of biotechnology that is largely ignored, however, is plant biology – yet plant science may hold the potential of even greater economic impact than animal science. This promising field concentrates on genomic technology, the science of identifying genes of plants, their functions, altering or combining these genes to perform differently, and understanding variables affecting the improved plant's performance. Advances in this science will produce better foods: higher yielding, more nutritious, drought-tolerant, chemical- and blight-resistant crops. Research is just beginning to expand this science beyond food: to seek ways to alter plants to produce better fabrics, to grow pharmaceuticals, polymers and commodity chemicals.

Today, genetically altered plants include fifteen percent of the US corn harvest, thirty percent of the soybean crop, more than half of the production of cotton, and many root and vegetable crops. Success of the first generation of genetically engineered crops is creating an accelerated demand. Analysts predict that genetically reengineered food crops will be worth \$7 billion by 2005. The impact to process and medical industries could be even greater – growing materials directly such as vaccines and even plastics. This area is just beginning to catch the attention of entrepreneurs and venture capitalists, but they find few opportunities to invest. Few companies

focus on plant science, and no region is emerging yet as the magnet for research or commercialization.

Second: *Distributed global teams will be the future of Innovation*

There is a fundamental change occurring in the way corporations work. Industry is moving from a time of the implied lifelong contract between an employer and employee to a time when domain experts are transient. Skilled employees will become independent consulting enterprises of one. Innovation in the future will be accomplished by bringing together experts in needed fields. These specialists will come together with temporary loyalties from many different locations around the world for the duration of a project. They will work together intimately without leaving home and perhaps without ever meeting face-to-face. They will come from universities, business, governments, and as individual consultants—all globally dispersed. Because of the expertise quickly brought together to focus on a problem, it will be hard in this environment for an internally focused enterprise to compete effectively.

The relationship between companies is changing as well. Companies are starting to focus on what they do best, outsource peripheral activities, and seek alliances to acquire needed expertise in other areas. The institutions that embrace collaboration to leverage respective expertise will be advantaged in this new economy.

This trend will equally affect economic regions that depend upon local institutions for growth. Public/private partnerships including the university, industry, governments, and individual consultants will be important in developing a region's comparative advantage with advanced technologies. The success of a region may depend in part on research from multiple regions working together. Given the limited available funding in plant biotechnology, advances that strengthen the collaborative capability through high speed information exchange will provide competitive advantage by exploiting the collective expertise of dispersed plant biotechnology scientists.

Third: *Progress in biotechnology and distributed collaboration create demanding new dependencies on information and communication technologies*

Advances required to support economic development from plant biotechnology and collaborative research require advances in the information and communication technologies to enable this progress. Critical areas are:

Collaboration The I/T industry provides useful collaborative environments for handling text and pictures, but these systems break down when collaboration requires complex data types. Current information technology tools do not present complex virtual environments well, especially the virtual office that would be required for technical collaboration described above. This is especially important for advances in biotechnology where information is predominately visual.

Image Management The I/T industry currently manages image data as pictures very well, but it does not do a good a job treating images as datasets packed full of variables with information on how these variables relate or how they behave. Other advances in digital image management are also required. Scientific observation relies upon faithful representation of the original object.

Precise color preserved in the remote digital image, for example, is essential for an effective collaborative tool for plant biology research.

Information Discovery On-line analytical processing and data mining tools focus on text and record data, yet scientists tell us that 80% to 90% of human insight is contained in image data. This field must progress to discovering patterns and relationships between variables contained in images and variables represented in text, tables, records, and graphs.

Geographic Information Systems (GIS) These are decision-support technologies that utilize the core spatial nature of data allowing users to capture spatial information and to work with data in sophisticated ways. GIS is an essential information discovery tool for recording data about variables and understanding relative performance of altered plants under various conditions.

Fourth: These changes will create new regional economic winners and losers

It is the responsibility of governments to provide and maintain an environment in which commerce can flourish, where regional economies can grow, and constituents can prosper. Deliberate or not, all governments provide this environment with infrastructure, education, policy, tax, legislation, initiatives, and with the university. There are numerous examples throughout the nation and around the world of how the productivity of an economy and the affluence of its citizens vary dramatically depending upon how skillfully this environment is maintained.

But the factors affecting regional growth have changed. This emerging global economy has created an environment in which consumers will shop electronically across borders, where companies will move production to the most cost effective facilities, will move research to the centers of expertise, will appeal to the most lucrative markets, and will make these tradeoffs to maximize profits without regard to regions or borders. Economic regions no longer find themselves competing for industry only against neighboring jurisdictions. Governments compete globally to attract companies into their regions while the same companies are becoming non-regional —often non-national. And in this Information Age where value is shifting from commodities to concepts and distributed knowledge, the producers of these commodities are no longer the primary engine of growth.

Competition for regional growth is not directed effectively to this new economic reality. Emphasis is on promoting a region to outside companies seeking to relocate factories or warehouses. Emphasis is still on regional competition and bidding by providing incentives —and then to provide additional incentives to retain companies already established in a region. While this approach may be attractive to companies that profit by relocating, it adds no value to the economy. Many regions are finding that their efforts do not improve the quality of local employment, the affluence of their citizens, or their relationship with companies already established in the region.

It is important to consider what we are really trying to accomplish with economic development policy. Is economic development about regional competition to host factories, or is it about creating comparative advantage in the global economy? Should we fashion policy targeted to a shrinking Industrial Age manufacturing base, or should we target the expanding Information Age high technology ventures? Or should we target the “next big thing”?

Just as businesses use advances in information technology to gain small incremental improvements to compete more effectively, regions must shift focus to the new economic realities and fine-tune government processes and policy to optimize this environment.

- Advanced-technology infrastructure with wired application-specific industrial parks is important and often governments will become the anchor tenant justifying the initial investment.
- The meaning of "workforce training" must shift from graduating employable skills in local industry to lifelong learning continually updating skills for a changing workplace.
- University-centric public/private partnerships and technology transfer are essential to maintain regional comparative advantage.
- Policy for long-term growth must recognize the importance of creating companies in the emerging industries rather than displacing maturing companies in declining industries.

Areas of the country that flourish because of advances in the computer industry generally have one thing in common: leading companies were created and grew in these regions. They understand that long-term growth and prosperity are functions of investment in creative new ideas. They understand that, in order to grow a high-technology economic base, it is essential to attract the entrepreneur with the bright idea and the determination to create something of value, and then to provide an incubator environment that will nurture and grow this venture into a successful company.

And long-term growth is a function of the application. If the Industrial Age companies no longer offer the growth that we seek, then what about information technology? In this rapidly evolving time where the pace of change is accelerating, value is shifting and the focus that created Silicon Valley and the Route 128 corridor decades ago is probably not the right focus to create the future leading regional economies. The expression "Silicon Dominion," for example, might even connote the wrong emphasis at a time when value is shifting so rapidly from commodities to concepts. It is especially the wrong focus with the realization that all of the information and communications technologies are only tools. It is the new application, the "next big thing," which exploits these tools that will drive economies in the next millennium.

Proposal

This is a proposal to establish a distributed public/private partnership to leverage the most promising research already underway, to create nonproprietary assets, and to make these assets available to attract and assist the entrepreneur in creating leading-edge companies in the region. A private nonprofit arm would be necessary, over time, for licensing, managing intellectual property issues, and to manage technology transfer. This proposal has the following elements:

1) *Distributed Public/Private Collaboration*

A collaboration between regions anchored by higher educational research institutions, federal government research labs, and industry will create a research-based distributed center of expertise on plant biotechnology. The collaboration would create two assets that would be made available for further research by the participants and would support regional entrepreneurial ventures. Creation of these assets will provide necessary focus required for progress.

2) *Leverage Existing Assets*

Several assets exist within the U.S. Department of Agriculture research organizations that can provide part of the scientific base for a digital infrastructure for plant biotechnology collaboration.

- The Germ Plasm Resource Information Network (GRIN) is an online catalog of all germplasm acquisitions maintained in the US national germplasm collection, housed in the plant germplasm repositories throughout the country. This collection is commonly used by plant breeders, geneticists and biotechnologists.
- The USDA Plant Genome program, managed by Agricultural Research Service, is developing the libraries of plant genome data for future plant breeding and genetic engineering.
- The *National List of Scientific Plant Names* is an essential database developed more than 25 years ago by USDA and Smithsonian and subsequently updated through the Flora of North America project. This database provides a scientific code to define the scientific genus, species, subspecies, cultivars and varieties throughout the US. Progress in genetic reengineering will create the need for further updates.

Plant biotechnology research programs in USDA are focused in Agricultural Research Service (ARS) at the Plant Germplasm Research Center. Crop breeding programs to develop new, more productive lines for wheat, barley, soybeans, corn, rice and several fruit and vegetable crops are also conducted within ARS. Most of the conventional crop breeding records are maintained within GRIN. This is further augmented by data from the state agricultural research stations throughout the U.S. where regionally specific crops are developed.

3) *A Digital Botanical Master Library*

A comprehensive digital library of digitized images of plants (leaves, stems and flowers) under various conditions that affect performance, (nitrogen deficiency, acidic soil, drought, insects, blights, pollutants, etc.) with technology to search by image content (shapes, texture, colors) that is suitable for scientific research and commercial exploitation could become an international asset

4) *A Geographic Environmental Framework*

A digital, geographic framework creating a geospatial record of plant conditions and productivity, and the surrounding time-dependent environment: soil composition and moisture content, acid rain, effluent entering rivers, blights, etc. with technology to discover patterns and relationships of the variables represented in the geocoded digital image could become a national asset. This framework must be common across regions and data must be maintained in common formats that allow sophisticated automated information-discovery analysis.

5) *The Entrepreneurial Incubator*

A regional, university-centric, nonprofit organization would be established to support the startup venture and to attract growing companies expanding into this field. This support would include

an intermediary role to attract venture capital. Venture capital is crucial to the creation of an entrepreneurial incubator. Startup efforts that are funded by venture capital have a higher probability of success. This is not just because of funding and the qualifying process. It is also because of a discipline imposed and assistance provided, sometimes required, from the venture capitalist. A program to provide intermediary services would help the venture capitalist and also the would-be entrepreneur. An intermediary role would also consider whether we are helping the would-be entrepreneur enough; consider, for example, how many bright ideas are lost because the individual does not understand, or will not tolerate, the discipline of a business plan? Or if we dismiss a promising idea too quickly because the business case is based upon a "build it and they will come" mentality? Ideally, this intermediary would work closely with the university in providing services to new ventures.

The Value Proposition

An Integrated System for Plant Biotechnology

With the dispersal of current plant biotechnology research across 50 state land-grant universities, multiple agricultural research stations and more than 100 Agricultural Research Service research locations the availability of an integrated system providing common access to leading research offers significant potential to the university seeking critical mass for its own program and as a national asset that would serve entrepreneurs and companies seeking to commercialize promising new ideas.

Integration of the assets described above would be structured, as in the following electronic commerce example, such that a wide population has the incentive to provide real-time data that would be captured and maintained in the digital geographic framework. In the electronic commerce example, the remote digitized queries for diagnosis and prescription of stressed plants would provide valuable data on existence and progression of plant disease as well as the influence of environmental factors. The system would become a valuable source of information about plant performance and the factors affecting this performance. This integrated system would grow to be the premier source of aggregated data for selected topics.

Exploitation of the Assets

This proposal describes unique nonproprietary assets that could become a significant international resource. Commercial exploitation could be based upon the following:

A Research Tool This system could support collaborative plant science research allowing scientists in remote locations to simultaneously view and discuss precise plant conditions. Data mining and on-line analytical processing tools would discover patterns and subtle relationships that could shape investigations.

Electronic Commerce A digital library system would have economic value today connected to storefronts transmitting images of a farmer's or homeowner's diseased leaf, for example, for remote automated pattern recognition, diagnosis and prescription. This capability returns value to a nursery, garden supply, or department store in attracting customers. It returns value to the

manufacturers of the chemicals prescribed, and it returns value to the customer who conveniently gets correct advice.

Agriculture New beneficial uses of reengineered crops such as tobacco would have a significant impact in states like Virginia. All regions will benefit with crops reengineered to flourish under a variety of adverse conditions. Agricultural information/alerts to co-ops would provide valuable information to farmers or even facilitate remote management of crops, especially important in emerging economies.

Environment Use of prescriptive farming practices and prescriptive homeowner practices would minimize unnecessary chemicals added to the environment. This system would also help alleviate a persistent problem of environmental pollution from essential industries.

Regional Comparative Advantage University research, expertise, and credibility in biotechnology would grow over time providing a regional skill base that would attract biotechnology industry initiatives. As local services grow, industry clusters would follow surrounding these centers of expertise.

Entrepreneurial Incubator The real potential for economic development is in establishing the environment to attract and assist entrepreneurs. This includes university research and support, infrastructure and business assistance, and the availability of venture capital.

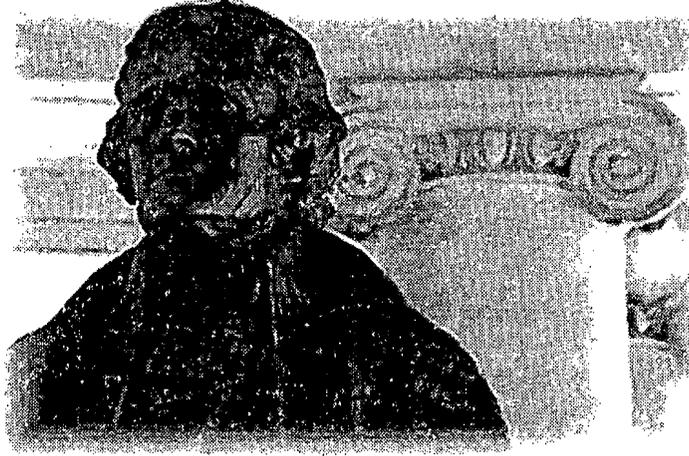
A Plan for Action

This white paper is intended to solicit interest from key universities, colleges, regions, USDA and IBM. It will be circulated to these groups with follow-up discussions to identify interest and suggestions to improve the concepts and make the proposal more targeted to the needs of the participants.

The second step will be a workshop planned for October to discuss objectives, requirements, technologies, organization, and to create a plan to proceed – given sufficient interest.

Please provide comments and suggestions to

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“... a wise and frugal government, which shall restrain men from injuring one another, shall leave them otherwise free to regulate their own pursuits of industry and improvement, and shall not take from the mouth of labor the bread it has earned. This is the sum of good government, and this is necessary to close the circle of our felicities.”

Thomas Jefferson

1801