Genomics Revolution Uncloaked

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Introduction

Living systems are supported and sustained by their genomes, through the action of the transcriptome, proteome, metabolome and ionome, the four basic biochemical pillars of functional genomics. These pillars represent the sum of all the expressed genes, proteins, metabolites and elements within an organism. The dynamic response and interaction of these biochemical "omes" defines how a living system functions, and the study of genomics is presently one of the biggest challenges in the life sciences. These complex interactions will be dramatically illustrated using a large 3D interactive exhibit. The objective of the exhibit is to enhance the visitor's conceptual framework regarding modern plant genomic science, with the exhibit being targeted at visitors from kindergarten through older adult. Information will be developed and delivered in age appropriate ways for each age level with a target outcome of enhanced education through orientation and interactive involvement with the subject matter. In "*Genomics Revolution Uncloaked*" participants will be guided through a visually stimulating and interactive environment designed to illuminate the core principles underlying the integration of the various disciplines that make up genomics. As these principles are revealed to the participant, strong and lasting connections will be forged between genomics and key areas of human society including agriculture, human health and the environment. These connections will remove genomics from the shadows and reveal the beauty, complexity and interconnectivity of the genomics revolution and the world we live in.

Proposal Aims

This proposal focuses on enhancing and expanding the on-going development of the *cellular voyager* (Fig 1); the core component of the "*Genomics Revolution Uncloaked*" exhibit. The majority of the design, development and building of the exhibit, as described, is being supported by a grant from the NSF 2010 program (IBN 0419695). Funds from the ASPB Education Foundation would be used to incorporate interactive computer graphic animation (Fig 1 C & D) into this exhibit, providing a dynamic and visually appealing "portal" through which visitors associate and learn about plant functional genomics. The ASPB Education Foundation award will leverage funds previously obtained from the NSF, and be used towards the implementation of computer-based, interactive software, that will simulate a plant cell undergoing abiotic and biotic stresses, and allow the visitor to control the fate of such cells by reacting

to the changing conditions. Much like other simulation gaming architecture programs, the interactive *cellular voyager* software will allow the user to navigate the intra- and extra-cellular environment to identify regions that are being afflicted by the corresponding stress stimulus. This design will utilize the Cellscape Explorer™ technology developed by Dr. Jeremy Friedberg from Vive Technologies Inc (http://www.vivetechnologies.com/). Dr. Friedberg has a doctorate degree in molecular genetics and plant biotechnology. This expertise will be essential for the development of the interactive, simulated scenarios (see letter of support). Additionally, the program will incorporate simple, yet effective, genomic, transcriptomic, metabolomic and ionomic profile panels that will allow the user to monitor the cellular changes that occur during the different scenarios. By learning how to interpret these profiles while navigating through the cell, the visitor will learn about functional genomics in a graphic and fun manner. The gaming architecture platform of cellular models is an effective way to attract and educate visitors of all ages. Funds from the ASPB Education Foundation will also ne used to support the additions of special effects into the exhibit, to allow for the dramatic illustration of concepts presented in the virtual world to be mirrored in the physical exhibit. The enhancement of the *cellular voyager* through these interactive elements will educate in a stimulating and dynamic way, so that the visitor will form a long-term connection between plants and their impact on human society. Ultimately, this will spark greater interest in plant science in general and plant functional genomics as it relates to agriculture, human health and environmental preservation.

Detailed Exhibit Walk Through

As the participant approaches the *Genomics Revolution Uncloaked* they will encounter an array of stimulating images prepared by artists whose visual representation of genomics and its relationship to human society will be displayed. This circular display will serve to both define the boundary of the exhibit and provide the participants' imagination with new and exciting images. On exiting the "genomics gallery" towards the center of the exhibit, the participant will get their first clear view of the *cellular voyager* (Fig 1 A & B), which lies at the heart of the exhibit. The *cellular voyager* is a 3-D representation of a living plant cell. On entering the *cellular voyager* the participant will be immersed in a complex and ever changing environment of images, light, color and motion, representing the complexity inherent in genomics. Within the cell, a network of microtubules will form a complex grid to support

visual components representing the vacuole, mitochondria, golgi vesicles and the endoplasmic reticulum. On the outside of *cellular voyager* interactive modular pods (Fig 1 B) will allow the participant to stimulate the cell into responding to pathogens, salinity and arsenic, through a computer generated virtual environment (Fig 1 C – D). Funding from the ASPB Education Foundation will be used to develop these interactive computer environments. Each module houses a single participant, "the cellular commander", who once inside directs the activity within *cellular voyager*. Three interactive scenarios are available to demonstrate the complex yet integrated response of the cell to various external and internal stimuli. These genomic scenarios have been designed to highlight the important connections between plant functional genomics as it relates to agriculture, human health and the environment. The scenarios are triggered by the participant in each separate modular pod and will involve the following:

- Fungal pathogen attack and the flavonoid response.
- Sodium chloride stress and the SOS pathway response.
- Arsenic stress and the arsenate reduction and transport response.

In each of these modules the *cellular commanders* will learn about the integrative cellular response to these stimuli. With the aid of genomic, transcriptomic, metabolomic and ionomic profiles the *cellular commanders* will be guided through a set of responses to each stress. This interaction will enable the visitors to understand the complex and integrated set of events that are required to sustain life in the *cellular voyager* under several simulated conditions. In the "fungal pathogen attack and flavonoid response" module the *cellular voyager* will guide the participants and on-lookers through plant cellular responses to stresses imposed by fungi, and learn how compounds such as flavonoids are used to combat human maladies related to cancer and heart disease. The connection between agriculture and plant functional genomics will be represented in the "sodium chloride stress and the SOS pathway response" module where the visitors see how plants react to salinity stress, a major agronomic problem due to current irrigation practices, and illustrate the complexity and elegance of the Salt-Overly-Sensitive (SOS) signal transduction pathway as it pertains to the regulation of ion homeostasis and salt tolerance. The module denoted "arsenic stress and the arsenate reduction and transport response" is designed to exemplify how specific metal

tolerant plant species deal with toxic environmental pollutants like arsenic by activating cellular reductive and transport processes targeted to detoxify and circumvent lethality. The Education Foundation supported virtual cellular environment (Fig 1 C & D) will provide a portal for the visitor to access computer generated representations of each scenario. In each module the visitor will learn about how these stresses, and the plants' response to them, can impact agriculture, human health and the environment. The pods are physically connected to the *cellular voyager* (Fig 1 A & B), and certain activities inside the virtual environment or within the *cellular voyager*, that impact the themes of agriculture, human health and the environment, initiate various special effects to highlight these interconnections. Agriculture is connected to the *cellular voyager* through a 3-D representation of corn, soybean, tomato and cotton plants. Human Health is connected through a child holding hands with her grandparents, representing how genomics can impact our health throughout our life. The environment is connected through a polluted river, representing how genomics can help improve our stewardship of the environment. The physical connection of all 3 focus areas is representative of the interconnectedness of these vital components in modern human society.

Possible Venues to Host the Exhibit

Genomics Revolution Uncloaked is a traveling exhibit designed to meet the needs of science center, science museum and botanical garden venues throughout the country. The exhibit is a 1,000 sq.ft. modular, highly interactive presentation that offers many resources for school groups, youth programs and lifelong learning opportunities. The Indiana State Museum, Fort Wayne's Science Central, Imagination Station of Lafayette, Evansville Museum of Art and Science, and Purdue University's Bindley Bioscience Center at Discovery Park are currently being considered as possible venues.

Budget

Computer equipment	$10,000
Software Development	$10,000
Special Effects Equipment	$10,000

Budget Justification

Three desktop computers with high definition 19" flat screens and enhanced graphic cards and ball-track input devices will be required to run the cellular simulations at each of the three "modules". Dr Jeremy Friedberg, vive Technologies Inc., has agreed to incorporate our cellular simulations, for $10,000, into his interactive cellular environment, for use in the "Genomics Revolution Uncloaked" exhibit. To integrate the virtual simulations with the physical "cellular voyager" special effects involving lights, sound, color, motion, 3-D objects and 3-D graphics will be incorporated at an additional cost of $10,000. Such effects will be implemented by John Bricker, Senior Exhibit Designer, Purdue University.

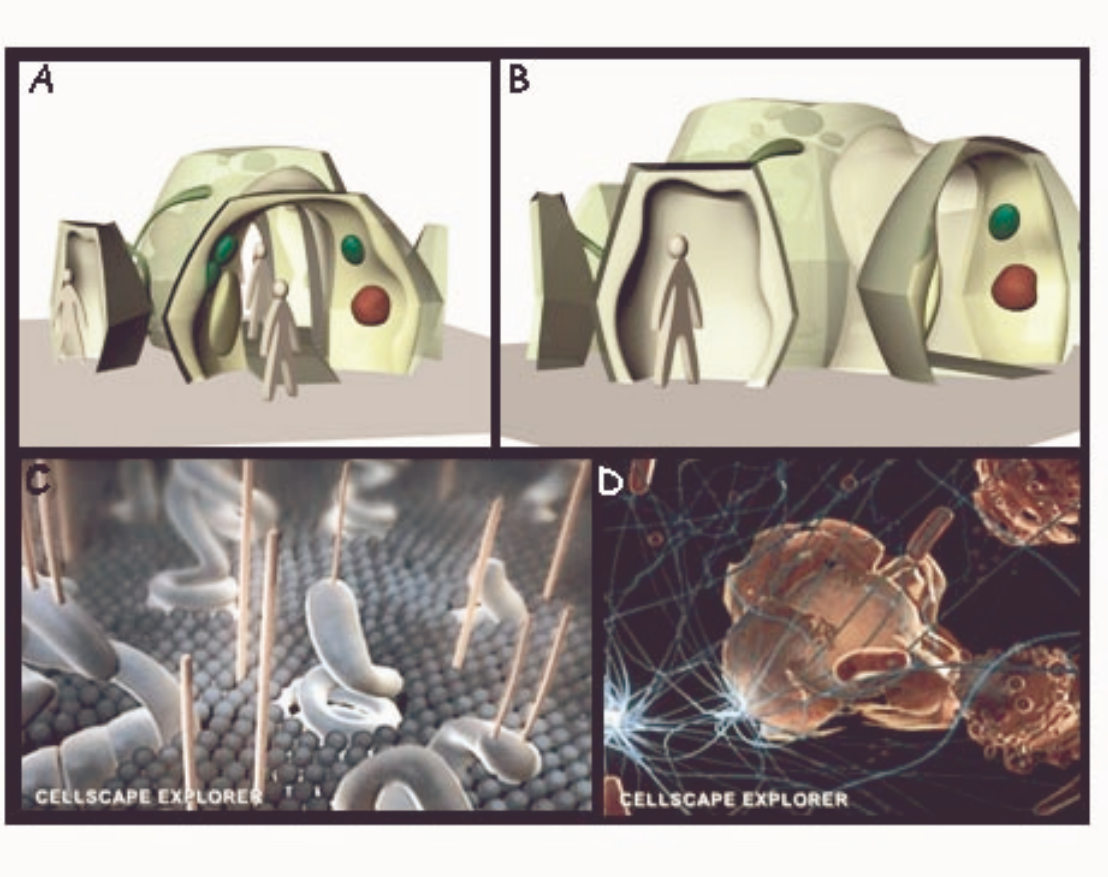

Figure 1. 3-Dimensional Graphical Representation of the *Cellular Voyager*
Graphical perspective views of the entrance to the Cellular Voyager (**A**), and one of the 4 attached information panels (**B**). Examples of the graphical animation to be incorporated into the Cellular Voyager on computers housed in the attached panels, including the plasma membrane (C) and interior of a cell (D).

vive Technologies Inc.
virtual in vivo education

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June 7, 2005

Dear Dr. Salt

I am writing to you to indicate vive Technologies' desire to collaborate with you in adapting our software for use in the "Genomics Revolution Uncloaked" exhibit and acting as a consultant for the simulation and learning objectives of plant functional genomics and agriculture, human health and the environment. Our software is currently being designed as a simulated interactive cellular environment based using computer gaming technology, which allows a user to experience the inner workings of a cell. Although we have not completed development of our software platform, we look forward to your contributions during development to incorporate your required cellular learning objectives, thereby adding to the learning content of your exhibit.

Sincerely,

Jeremy Friedberg

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