Open Ocean • Here be Dragons 2018

Micronauts Report

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Project Goals

Microbes are the foundation upon which life on Earth depends: they set the boundaries of habitability for all plants and animals and create half of the oxygen we breathe. Ocean-dwelling microbes regulate the global climate and could hold the secrets to the origin of life. Put simply, we wouldn't be here without microbes, yet most people don't realize how pervasive and important they are.

The Micronauts project sought to overcome this concerning knowledge gap by building an emotional bridge. Microscopic creatures are, by definition, hidden from view, and the challenge of seeing them and perceiving their importance prevents emotional involvement and investment. This is a major problem, as a failure to understand and connect with this hidden operating system of our planet leaves us unlikely to protect it and vulnerable to its collapse. Our sustainable use of food, power, and material resources, as well as the maintenance of thriving ecosystems, depends, in many ways, on building a deeper appreciation for microbial communities.

Approach

To achieve our goal of building an emotional connection between visitors and the microorganisms that sustain our planet, we created an immersive experience around cutting-edge scientific discoveries, inviting visitors – “Micronauts” – on a journey into the dynamic world of ocean microbes. The exhibit, which was deployed at the MIT Media Lab for the All Hands On Deck meeting, consisted of four primary elements. Relevant materials are appended to this report.

1 - Interactive Projection

The centerpiece of the exhibit was a 3m x 6m floor space illuminated from above by two overlapping, co-registered projectors, which allowed for the compensation of visitors' shadows. A background image from a scanning electron micrograph of a grain of sand was projected. As visitors walked onto the projection, a thermal camera captured their location and sent that information to a computerized program. This program used ecologically relevant metabolic reactions and feedback processes to simulate members of the microbial community at Sippewissett marsh on Cape Cod, Massachusetts. A visitor's location was modeled as a source of sunlight, prompting phototrophic microbes to grow and, later, predator organisms to bloom in response. Both organisms died off at a set rate as the "sunlight" moved away, to ensure a dynamic range of the microbial population within the projected area. This immersive projection offered visitors a dynamic view of the microbial world through an interactive lens.

2 - Electron microscopy

To one side of the projection, an electron microscopy gallery showcased high-quality prints of some of Sippewissett's microbial denizens. These images were collected during several sessions on Harvard

University's scanning electron microscopes (SEM). The textures, patterns, and surroundings of individual organisms imbued them with a sense of personality, and the portrait-style composition and presentation offered a grandeur rarely conferred upon microorganisms. On the floor of the SEM gallery were three large, colorized images, adding a more artistic, psychedelic glimpse into the marsh's mysterious inhabitants.

3 - Informational posters

Two informational posters bookended the exhibit. At the “entrance” near the SEM gallery, one poster evocatively contextualized the Sippewissett marsh and welcomed visitors into the microbial world, previewing the microbial interaction featured in the projection. At the other end of the exhibit, a more detailed poster explained the “guts” of the projection experience. The symbiotic metabolisms and the growth model were highlighted: the photosynthetic *Chromatiaceae* gains energy from light and provides sugars to *Achromatium*, which generates inorganic carbon to help sustain its phototrophic partner. This symbiosis was placed into context of marine microbiology and the essential services that microbial communities provide.

4 - Paintings

Four large-format paintings encapsulated the exhibit, offering an impressionistic sense of what field work at Sippewissett feels like. In contrast to the more clinical SEM portraits, these paintings offered a more familiar entry point to the exhibit, featuring organic shapes and colors.

Accomplishments

To the best of our knowledge, the Micronauts journey was the first production of its kind, using innovative techniques and rigorous science to link the intellectual profundity of the microbial world with the emotional resonance of an embodied, interactive experience. Key achievements include the following:

- The primary accomplishment was bringing several disparate pieces together in the face of the challenges discussed below to create a coherent project and collaborative team atmosphere. By bringing art and science into conversation with each other, we believe the resulting exhibit resonated with a wide audience and activated multiple dimensions of each visitor's intellectual experience.
- The SEM images exposed new and previously unseen portions of the microbial world. Visualizing a range of diatom and bacterial species in their native habitats – and particularly the interaction between organisms – provided new knowledge of the Sippewissett microbiome. These results will be used as supporting evidence for other, quantitative treatments of this microbial community.
- The interactive model represents the first step of a microbial community ecosystem model. Starting with two organisms interacting in a relatively simplified way, we can cross-reference the model's results with other observations to work toward a more mechanistic understanding of the complex system. This line of

investigation coheres well with a broader effort in marine microbiology to link structure with function and develop a predictive sense of how these massively multipartite communities operate.

- We found that the interactive experience is particularly appealing to children. This kind of work could be extended as an educational tool, to help parents and educators in explaining the invisible world to kids and teenagers.

Challenges

Building the Micronauts exhibit was challenging; obstacles can be summarized as follows:

- Developing a coherent vision: From the outset, team members had somewhat varying ideas of what the ultimate product would be. Ambitious plans engendered a lot of excitement, but the infeasibility of realizing them soon became clear. Logistical and time pressures ultimately demanded that decisions be made, offering helpful direction and corralling our plans.
- Site uncertainty: Clarifying precisely where the exhibit would be, and what infrastructural support would be provided, was a substantial obstacle that delayed the production phase of our exhibit by several months. Final approval of the site – which was needed before we could sketch out and develop the narrative of the visitor’s experience – came less than two weeks before the exhibit’s debut, forcing us to simplify some of the initial ideas..

- Time & resource limitation: The resources and flexibility provided to make the Micronauts project happen were generous, and we are very appreciative of the opportunity to create and share our vision of the marine microbial world with a larger audience. However, because of pre-existing commitments and other pressures, Micronauts was largely a side project. Within that context, we believe the effort was a galvanizing success.

Next Steps

Given the work that went into Micronauts and the new discoveries and artistic works it enabled, we are excited to pursue future, related projects. The seed funding provided through Here Be Dragons has made this possible. Specifically, we are exploring the following opportunities:

- The Harvard Museum of Natural History has expressed interest in adapting a Micronauts-based exhibit. The core of the exhibit would be the interactive projection, and informational placards surrounding the floor space would provide additional scientific context. We are also in talks with 'Museu do Amanhã', in Rio de Janeiro, and the Children's Museum, in Boston.
- The computational model developed for the Micronauts exhibit represents the first step of a broader network of interactions among the complex community at Sippewissett. As we acquire additional supporting data, the model will be iteratively validated, providing an illuminating perspective on functional properties of the constituent organisms.
- An online interactive simulator, where visitors can control resources available and watch how the organisms respond, would help to expand this project and communicate how the microbial life cycles happen and are affected by changes of the natural environment. This could be extended to a VR experience inspired by the *Fantastic Voyage* book and movie.
- Beyond the award: The friendships and collaborations established during this project continue to grow and expand. As a group we keep in touch for social events, discuss future projects and collaborations.

The Team

Teamwork was essential in bringing Micronauts to fruition. Despite the challenges noted above, all team members graciously and enthusiastically donated their time and expertise while negotiating a number of competing priorities. Contributions are highlighted below:

Mark Adams: Large-format paintings, “Micronauts” iconography.

Benjamin Bray: Initial projection analysis.

Keith Ellenbogen: SEM photography and prints.

Raquel Fornasaro: Installation development, SEM colorization.

Jeffrey Marlow: SEM photography, informational posters.

Craig McLean: Informational posters, interactive projection coding.

Caroline Rozendo: Interactive projection design and coding, electronics prototyping.

L-R: Raquel Fornasaro, Craig McLean, Mark Adams, Jeff Marlow, Caroline Rozendo, Keith Ellenbogen

Thank you

On behalf of the group, we would all like to thank the MIT Media Lab Open Oceans Initiative and National Geographic Society for this award. It was just the kind of free thinking interdisciplinary art, science and technology project that sparks new ideas and creative expression around the appreciation and conservation of the ocean. Micronauts was funded by the National Geographic Society.