EMERGING STRATEGIES "UNDER THE BAY" IN AR/XR

Lisa Moren, Dr. Tsvetan Bachvaroff
University of Maryland Baltimore County (UMBC), Institute of Marine and Environmental Technology (IMET),
University of Maryland Center for Environmental Science (UMCES) Baltimore, Maryland
lmoren@umbc.edu, bachvarofft@umces.edu

Figure 1. *"Under the Bay"* augmented reality (still) by Lisa Moren with Dr. Tsvetan Bachvaroff. Scene 03 \\ Chalky Faeries, 2022. Image shows a cropped Bay Nettle jellyfish with coccolithophores (the microbes responsible for all the chalk in the world). The app allows the user to click and drag on the microbe to draw in chalk. Courtesy of the artist.

Abstract

"Under the Bay" is an augmented reality project where a user can point their cell phone at the water—or anywhere in the world — like a microscope and reveal invisibilities under the Chesapeake Bay. A series of animated stories between humans and non-humans emerge when they do. Images, sounds, and stories are affected by live data streamed in from sensors located in the largest estuary in North America. Sensors in the Chesapeake Bay relay live pH, oxygen, temperature, etc. (figure 10). Similar to the water itself, color, speed, audio fluctuate with the water and marine life, making *"Under the Bay"* a data-driven narrative with eight scenes that tell a story of a world beneath the marine surface, and the exciting but frail health of estuaries and oceans worldwide.

The two projects discussed here, *"Under the Bay"* (2022) and *"What is the Shape of Water?"* (2020), are part of Lisa Moren's series of cross-species artworks aimed at diminishing human-centered exceptionalism. The collaborations began in 2019 when Lisa was the inaugural Artist-in-Resident at the Institute for Marine and Environmental Technology (IMET). There, she met researcher and marine biologist, Dr. Tsvetan Bachvaroff (Tsetso) and the two immediately shared a like-minded vision to develop a project that exemplified phenomenal exceptionalisms in micro-organisms.

Dr. Tsvetan Bachvaroff directed the live organisms, science and data analysis for the augmented reality project. Stories are written and told by Lisa, who produced and art directed the animation and AR scenes. The original sound score is by electronic composer Dan Deacon. Dr. Marc Olano led the software engineering and development by John Boutsikas, for the AR app in IOS and Google Play.

Keywords

Augmented Reality, AR, bio-art, data-driven narrative, emergent strategies, Tao Te Ching, water, symbiosis, dinoflagellates, Chesapeake Bay, estuary, marine biology, performance, microbes, media art, podcast, experimental narrative, bio-architecture, Lynn Margulis, Ted Nelson, Jane Bennett, Theodor Schwenk, data-driven music, philosophy.

Introduction

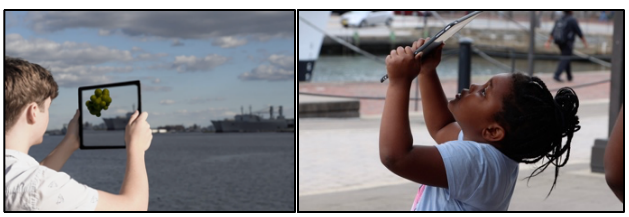

Figure 2. *"Under the Bay*" AR by Moren/Bachvaroff. Left: demonstration of AR in Fells Point, Baltimore; right: Beta testing of AR on Pier V, Baltimore's harbor. Courtesy of the artist.

In our collaborative work, we borrow the idea of "emergent strategies" to consider strategies in nature (also physics) that describe phenomena driving new emerging forms. Inspired by Octavia Butler, and Adrian Maree Brown who coined the term *"Emergent Strategy",*[1] as *"a framework for resistance that is rooted in the miracles of nature, decentralized, collective leadership, and personal, relational, organizational, and movement-wide transformation."*[2] We focused our strategies based in part on Brown's idea that anomalous strategies in nature can be a model for the benefit of human communities, from species longevity to social change. Lisa's second influence was participating in a Taoist meditation group where she studied and meditated on the Tao Te Ching.[3] These meditations blended with her observations of nature, primarily starling bird murmurations described in Scene 05. The connections between emergent strategies, organic differentiation, and a Taoist social order became the basis of this art and science collaboration.

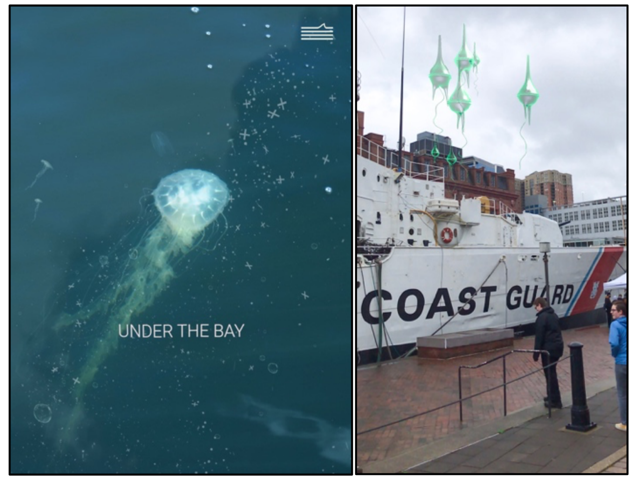

Figure 3. *"Under the Bay*" AR by Moren/Bachvaroff. Left: Still from splash screen with user interface (UI); right: still from AR Scene 02 \\ Water Moving Around My Fingers at Pier V, Baltimore. Courtesy of the Artist.

Emergent Strategies

Evolution and the Darwinian idea of natural selection has been combined with genome inheritance from two parents into what is now called the 'modern synthesis'. While this synthesis has excellent explanatory power, some observations are not a perfect fit to describe evolution. For example, photosynthesis is scattered across multiple kingdoms, but the process of photosynthesis is unlikely to be invented multiple times. The solution to this paradox was provided by Lynn Margulis in 1967 who proposed that eukaryote microbes are a combination of two cells from different lineages (species), one contributing the nucleus and the second contributing the organelles that intake oxygen and exhale carbon dioxide, the foundation for breath itself. mitochondrion as a 'cell within a cell'[4]. Mitochondria are the She proposed that the cell with a nucleus engulfed the cell with mitochondria to exhibit a new complexity of features. The first scene in our project

[1] Brown, Adrienne Maree. *Emergent Strategy: Shaping Change, Changing Worlds.* Edinburgh: AK Press, 2017.

[2] Ritchie, Andrea. *Invisible No More: Police Violence Against Black Women and Women of Color*. Beacon Press; Reprint edition, 2017)

[3] Lao-Tzu; translated by Stephen Addiss and Stanley Lombardo; introduction by Burton Watson*. "Tao Te Ching"*. Boulder: Hackert Publishing Company, 1993.

[4] Margulis, Lynn. "On the origin of mitosing cells". *Journal of Theoretical Biology*, vol. 14, no. 3, 1967, pp. 225–274.

Scene 01 \\ Origin Stories, describes that before Margulis, any scientific reference to a symbiosis hypothesis was taboo. To accept symbiosis science had to imagine a scenario analogous to a species swallowing a giraffe's eye to successfully acquire desired longer eyelashes, but then, they pass those eyelashes onto their offspring. However, once the idea of symbiosis was accepted, Sarah Gibbs then extended this observation to include photosynthesis in chloroplasts — again a cell within a cell — which can ultimately be traced back to a cyanobacteria, just as mitochondria can be traced to eubacteria[5]. Therefore, an individual can be shaped by two evolutionary processes. The first is the familiar and dominant expression of parental genes via vertical descent with modification (Fig. 4). The second represents the less familiar or exceptional cases of horizontal gene transfer either from endosymbiosis, or as an independent gene transfer event.

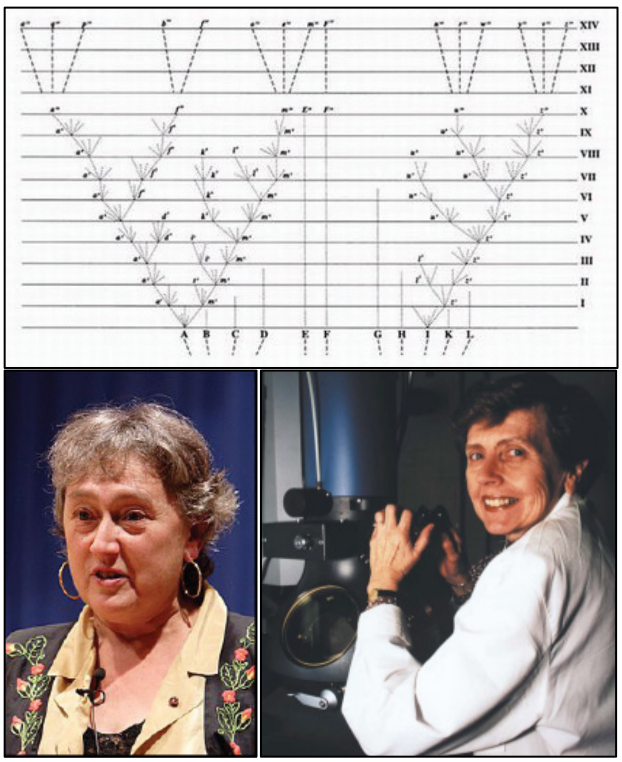

Figure 4. Above: Darwin's original descent with modification figure from the 'Origin of Species'. Lower left: Lynn Margulis, https://en.wikipedia.org/wiki/Lynn_Margulis#/media/File:Lynn_Margulis.jpg; right: Sarah Gibbs, Gibbs, S *Annu. Rev. Plant Biol. 2006. 57:1–17.*

The dinoflagellates are eukaryote micro-organisms the ancestors to both plants and animals. They are a perfect case study to demonstrate both horizontal gene transfer and the global importance of smaller eukaryotes in our planet. In current synoptic statements of global marine eukaryotic primary production (or photosynthesis) dinoflagellates are typically listed side by side with diatoms as the top two major groups producing most of the world's oxygen, including the contributions from the Amazon rainforest. This is underscored by modern sequencing which places dinoflagellates as second in abundance to animals and first in diversity in marine oceanic surveys. Dinoflagellates also include a wide array of life strategies such as built-in harpoons used to capture prey[6]. Other strategies include a symbiotic photosynthetic lifestyle as the algae found in coral reefs, internal and external types of parasitism, heterotrophy (those who consume food for energy), and mixotrophy. This new ecology term, mixotrophy, is used to describe the role of many photosynthetic dinoflagellates, which can simultaneously be both 'autotrophs' (i.e., are photosynthetic) and consumers of prey or heterotrophs[7].

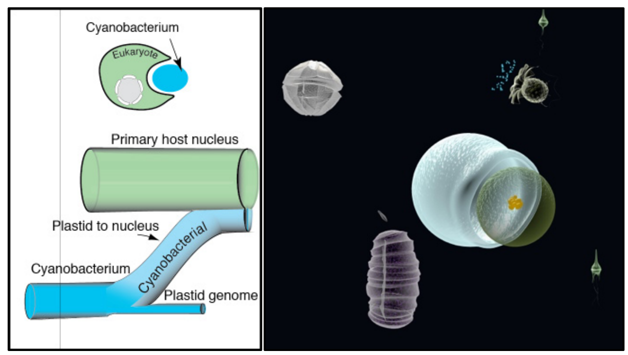

Figure 5. Left: Gene Flow Symbiosis chart by Tsvetan Bachvaroff, right: *"Under the Bay"* AR by Moren/Bachvaroff. Still from Scene 01 \\ Origin Stories showing symbiosis. Courtesy of the scientist and artist.

Mixotrophy and diversity in the ocean combined with the concept of symbiosis represented by Gibbs and Margulis provides the narrative for symbiosis. For example, the feeding of *Dinophysis* on ciliates demonstrates how the chloroplast could be consumed intact from prey by injecting a built-in "straw-like method" to acquire, or suck, chloroplasts from its prey. [8] The list of such events — here only cases where dinoflagellates have acquired photosynthesis — includes roughly nine different described events where dinoflagellates contain chloroplasts apparently borrowed or gained from

[5] Gibbs, Sarah P. "The chloroplasts of *euglena* may have evolved from symbiotic green algae." *Canadian Journal of Botany*, vol. 56, no. 22, 1978, pp. 2883–2889.

[6] *Polikrokos* harpooning prey https://www.youtube.com/watch?v=BddN1LE1YZQ

[7] Photosynthetic *Fragilidium* consuming a large *Ceratium*

[8] Note the *Dinophysis* sucking the chloroplast from it's prey using a built-in 'straw-like' method. https://www.youtube.com/watch?v=cq3SBoCHPP4&t=3s

essentially every available eukaryotic lineage. And this list does not include dinoflagellates with elaborate structural features that contain cyanobacteria as external symbiotes in a sort of 'garden' (figure 7).

The evidence for horizontal acquisition of traits as in symbiosis is to describe a dominant or vertical inheritance pattern. This tree of relationships can be based on gene sequences or features such as overall cell structure to establish relationships and provide some relative distance between the organisms. The tree is then tested against a model to provide an overall or 'organismal' set of relationships well-supported by the data. Then that tree is contrasted with genes or features that are not congruent with it, to test for acquisition of traits or genes. For example, in the *Dinophysoid* dinoflagellates including (Figure 6) the overall rigid cell structure is composed of 16 or 17 armored plates found in this combination only within the group. This clear evidence that individuals within the group are more closely related to each other than other dinoflagellates has been strongly supported by trees from DNA sequencing. However, within the group there are a series of different types of photosynthesis and symbioses, including the 'gardening' *Ornithocercus*, the 'heterotrophic' *Dinophysis*, and at least two other types of internal symbionts within the group. *Ornithorcercus* will host cyanobacteria in its physical bird cage-like shape, a strategy that not only stores nutrients for on-going consumption, but the chains of cyanobacteria itself reproduces creating a "fruit-on-the-vine-like garden" (Figure 7). These traits are then counted as either independent or shared events of symbiosis across the dinophysoid dinoflagellates. Overall, the approach is to construct an overall or organismal phylogeny and then trace the movement of symbiotes across the lineage.

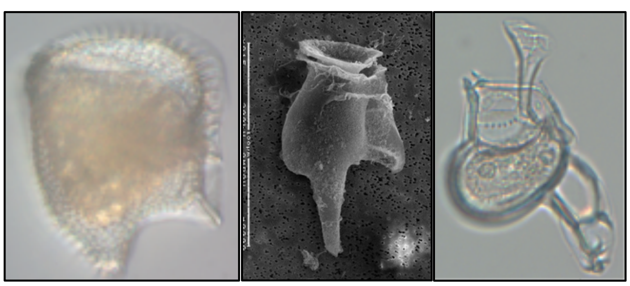

Figure 6. Four genera of dinophysoid dinoflagellates. Left to Right: *Phalachroma, Dinophysis* SEM*, Histioneis* each with distinct symbionts*.* Three genera contain intracellular photosynthetic organelles or symbionts. Courtesy of the scientist.

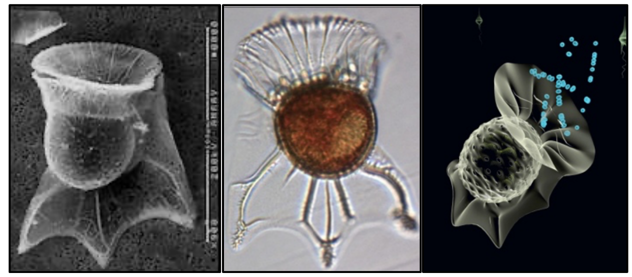

Figure 7. Left to Right: *Ornithocercus* SEM, *Ornithocercus* with visible cyanobacteria, *"Under the Bay*" AR (still) by Moren/Bachvaroff. Courtesy of the scientist and the artist.

The variety of these genetic survival strategies are mostly found only in microbes. Using these strategies for hundreds of millions of years, have allowed dinoflagellates to diversify into more than twenty thousand species that will clearly outlive humans. Therefore, diverse reproductive, energy consumption, and other strategies assisted the dinoflagellates in obtaining longevity that humans can only dream of. For example, the dinoflagellate ceratium can both cell divide and mate for optimum reproduction benefits. In Scene 01 of *"Under the Bay,"* the viewer will see images of the ceratium having only one trailing flagellum (a propeller-type tail). However, an identical ceratium — of the same species that was spawned from cell division — has two flagella because they had two parents that mated (figure 3).

Other strategies we named included organic differentiation in the structure of the cell walls of the dinoflagellates. These complex forms, such as Voronoi patterns use less matter to produce structures that are lighter in weight than any objects human engineering could produce based on Cartesian principles in manufacturing. Differentiation can be exemplified in the exoskeleton of a crab or lobster but most visible in the repeating hexagon pattern of a turtle shell, where the shapes repeat, but not perfectly. It's in that imperfection, crookedness, or wobble, that creates more strength with less matter. Dinoflagellates, diatoms, and other microbes also have this efficient design principle of differentiation. Scene 04 \\ Crooked Shelters (figure 8) describes how differentiation influenced the largest 21st-century algorithmically designed and digitally fabricated architectural form in Seville, Spain, the Metropol Parasol.[9] The aerial view of Metropol Parasol appears as a mushroom blooming throughout the grided city. It's designed using algorithms and curves, distinct from the past five centuries where modern architecture progressed by using grids with more material that's more dense such as steel. Another architectural example is in Stuttgart, Germany where one of the algorithmic pavilion's based on

[9] https://www.setasdesevilla.com/

differentiation in nature was so strong and lightweight, it blew away.[10]

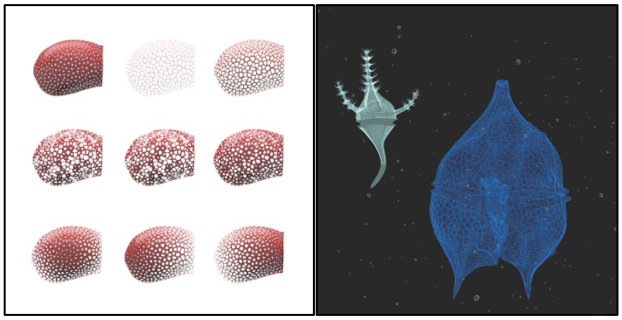

Figure 8. *"Under the Bay"* AR by Moren/Bachvaroff. Left: Work in progress; right: still from Scene 04 \\ Crooked Shelters. Courtesy of the artist.

Water Projects

In our first attempt to create a public project for an open house at IMET, we created an artwork demonstrating the microbial strategy of making light through the bioluminescence of the dinoflagellate (*Pyrocystis*). Eventually, the public display was set up as a ceiling tank hooked up to a Max/MSP, Arduino, and AV system for the Light City Festival in Baltimore's Inner Harbor. The system worked with a voice-activated trigger so that when a participant spoke into a microphone, for example, *"What is the Shape of Water?"* the millions of microscopic organisms in the ceiling tank answered the question in turbulent shapes of blue bioluminescence. Originally, this was influenced by the mesmerizing organic order and differentiation in the murmuration patterns of starling birds[11]. However, Tsetso's colleague, Dr. Al Place who studies the motion behavior of dinoflagellates, says that the flocking of the dinoflagellates will unlikely look as organized as the starlings. Instead, the water agitation produced turbulent patterns more akin to the wobble, the crookedness or what philosopher Jane Bennett calls *murmuring messiness*.[12]

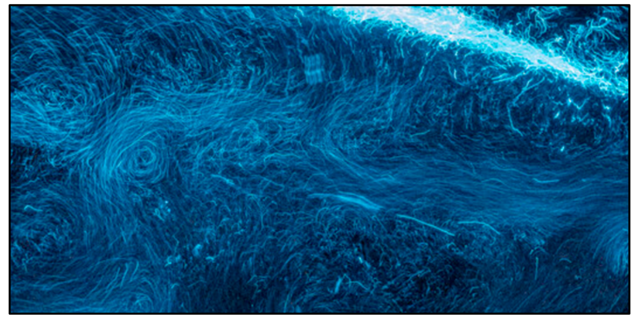

Figure 9. *"What is the Shape of Water?"* Photograph (detail), Moren/ Bachvaroff. 16x16", 2019. Courtesy of the artist.

"What is the Shape of Water?" began as a somewhat expedient strategy of displaying bioluminescence in an art project that took over a year to fully realize. It was an unrealistic approach to create art installations for the more than two dozen strategies we identified for potential exhibition. We instead turned to story-telling and produced an augmented reality (AR) project with eight scenes, approximately 10 minutes per scene. Lisa took the strategies we identified for the project and built narratives that meandered through purposefully fragmented topics related to microbes, water, Taoist meditation, architecture, monuments, and politics. The fragmented writing overlaps between scenes, with the intention for the phrases and topics to move like the ocean wave crests and advances forward before its forces crash and envelop the smaller waves, or text.

The AR project became *"Under the Bay"* and it's trailer[13] illustrates the animation, narrator, and incoming data. For the data, we worked with the Maryland Department of Natural Resources (MD DNR) to siphon data from sensors already installed in the largest estuary in North America, the Chesapeake Bay. In total 36 parameters stream into the project from six locations in the Bay. Locations are from the Delaware border to Washington DC, the Eastern Shore of Maryland, and Baltimore City (figure 10). The parameters pH, temperature, oxygen, salt, chlorophyll, and turbidity (clarity) are updated every 15 minutes. These parameters then affect the animation's color, speed, and scale, along with the narration and music composition. For instance, when the oxygen levels in the Bay are of good quality, the narrator's voice sounds normal. However, when the water is anoxic, with little or no oxygen, the voice becomes choppy, fragmented, as if choking. In this way, the story, images, and sounds change from day to night and season to season for an ongoing collaborative narrative

[10] https://www.itke.uni-stuttgart.de/research/icd-itke-research-pavilions/

[11] https://www.youtube.com/watch?v=LAQwEWqg0ug

[12] Bennett, Jane, and Connolly, William. "The Crumpled Handkerchief." *Time and History in Deleuze and Serres*, Bloomsbury, London, UK, 2013. Pp. 155.

[13] "Under the Bay" trailer by Lisa Moren with Tsvetan Bachvaroff, 2022. https://vimeo.com/796868197

with the Bay water. The unpredictable variability of the incoming data becomes an authentic wobble created by the environment.

Figure 10. *"Under the Bay"* AR Moren/Bachvaroff. UI showing locations in the Chesapeake Bay where sensors allow water parameters to stream into the project. Courtesy of the artist.

Listening to the Water

The project propaganda claimed the ambition of cross-species communication specifically "*What if we could hear what the water is saying?*" To address skeptics to these claims, we're borrowing from water physicist Theodor Schwenk, as we do in the AR project, but also Jane Bennett[14], who references Graham Harmon, Bruno Latour, and Michel Serres's *The Birth of Physics*.[15]

If we look at water as an object, we can argue that water is the largest object in the world. On the one hand, the ocean contains essential elements, H2O, saline, and other matter on the periodic chart. We know that water and gravity work together to form currents like pipes that braid in distinct patterns and that these flowing pipes separate into differing physical data such as speed and temperature. These differences become visible when encountering an obstacle, like a rock in a river, where we observe differentiation in the water shapes bulging around the rock. Similarly, in the ocean, large and *"long waves travel faster than short waves"* and overlap until the larger ones envelop the smaller ones, and the waves repeat the pattern endlessly.[16] But unlike early CGI waves, the real ocean's patterns are not perfect or predictable waves, their equilibrium billows, and exhales asymmetrically, and it's in that asymmetry that they wobble. Or, what Bennett calls, they produce a *vibratory noise*, where the force of repetition starts to create a *murmuration of messiness*, a surge, an *"irregular bombardment of circumstances,"* especially when new physical elements act as an obstacle such as a rock. Here, the current billows and exposes its diverse temperatures, causing what Serres names a *"cauldron of turbulence that thickens into lumps of phenomena, and the bubbling swirl keeps those shapes upright… while the wobble produces variances of noise.*"[17] A shape derives from the swirl that is both form and vibratory. To Serres, he calls this vibratory noise *"the fluctuating ado that is the strange substance of any discrete, differentiated shape,…* (where) *the multiplicity of the possible rustles in the midst of the forms that emerge from it… It is restless matter…*(a) *percolation.*"[18] While much of this noise dies like seedlings that don't spawn, the intermingling currents and swirls, etc., that overlap with force create forms that emerge from it.

While we do not think of water as having agency, free will, or decision-making abilities or even that its elements are alive, in complex natural events, water does cause a multitude of events to happen, and is therefore an actant. One of the most significant events that water enacts is sustaining and creating new life, but also emerging shapes, and unique forms. In this way, water will begin by initiating an abundance of events, such as a vortex or a whirlpool effect. Any time these elements react or affect one another, there is the potential for something to emerge, including new life.

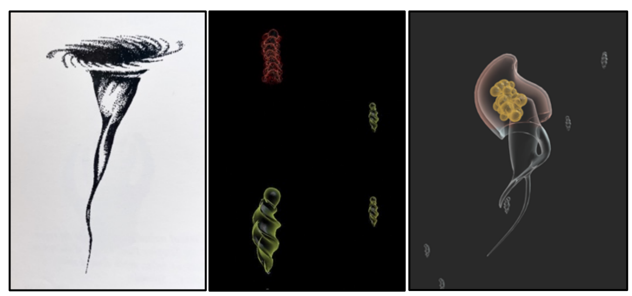

Figure 11. Left: Vortex funnel drawing by Theodor Schwenk,*"Sensitive Chaos: The Creation of Flowing Forms in Water and Air"* 1967, pp 44; center and right: *"Under the Bay"* AR by Moren/Bachvaroff. Stills of microbes expressing the negative spiraling shape of the vortex. Courtesy of the artist.

In Scene 02 \\ Water Moving Around My Fingers, the microbes reflect Schwenks organisms that take on the negative space of the vortex shape traveling in a reverse

[14] Ibid, Bennett, Connolly.
[15] Serres, Michael. *The Birth of Physics*. Rowman & Littlefield International, Ltd., 2018.

[16] Schwenk, Theodor. *"Sensitive Chaos: The Creation of Flowing Forms in Water and Air"*. Sussex: Rudolf Steiner Press, 1996. Pp 33.

[17] Ibid, Bennett, Connolly. Pp 157.
[18] Ibid, Bennett, Connolly. Pp 157.

corkscrew spiraling up (figure 11).[19] Therefore, when we say we can hear what the water is saying? It's not that the water, as pure physical compounds, produces a will or agency that desires to be heard. However, water's natural environment has reactions, interactions, and relationships with other phenomena and other physical materials where unique consequences emerge as shapes, forms, beings, and blooms. Moreover, if we consider the incoming parameters of the Bay water as a kind of alphabet — to use a human metaphor — the data does arrange itself to describe a story of the Bay water's emerging behaviors and forms. This communication is so hard for humans to understand, especially to predict — that when the data reflects the formation of an algae bloom, it's often too late to hear the water telling us *we are out of balance.* Perhaps the data acts like a Google knowledge engine, an algorithm anticipating the user's thoughts when typing a partial phrase into the search bar and displaying our presumed burning questions. However, in this case, the data anticipates the thoughts of the Bay water. This concept is so significant that the scores of MD DNR sensors we use to siphon data are funded solely to predict the emergence of algae blooms in the Chesapeake Bay. *"Under the Bay"* observes how the Bay ebbs and flows over time to create an emerging narrative driven by what the water is enacting as an emergence. We call this murmuration messiness*,* listening to what the water is saying.

Conclusion

Once we name this process of emergence, we can apply it to the other scenes in the AR project, addressing issues of differentiation and emergence not only in nature but also in creative ideas, forms, art, music, architecture, monuments, and also politics, protests (we discuss emerging protests including BLM, the beheaded Columbus statue ending up in the Bay, or the #metoo flocking of women in a bloom of pink hats — figure 12). This bring Brown's term *emerging strategies* full circle where strategies in nature can be a model for social change. Again, our stories meander through these topics and phrases, like waves undulating and enveloping other waves leaning on influences from the Tao Te Ching as much as science.

Figure 12. *"Under the Bay"* AR by Moren/Bachvaroff. Left: Scene 08 \\ Turnover [I Can't Breathe] (still); right: Scene 07 \\ Vaccine Blooms with Pink Hats (still). Courtesy of the artist.

"Under the Bay" will be exhibited at the Peale Museum, in Baltimore, Dec 14 to Feb 1, 2024, for *"Chamber of Wonders*", with a public panel on Jan 18. While *"Under the Bay*" is freely available to download,[17] the XR installation will include iPads interacting with paintings, drawings, and assemblages for a unique museum experience. *"What is the Shape of Water?"* and related works will also be on display.

"Under the Bay" Scenes 01-08 include: Origin Stories \\ Water Moving Around My Fingers \\ Chalky Faeries \\ Crooked Shelters \\ Lava Lamps in the Sky \\ Instrumental \\ Vaccine Blooms with Pink Hats \\ Turnover [I Can't Breathe]

Left to right: *"Under the Bay"* AR by Moren/Bachvaroff, 2022: Apple IOS; Google Play. *"Under the Bay"* (podcast), 2022: Spotify, Google Podcasts and Apple Podcasts.

Bibliography

Bennett, Jane, and Connolly, William. "The Crumpled Handkerchief." *Time and History in Deleuze and Serres*, Bloomsbury, London, UK, 2013.

---

[19] Ibid, Schwenk. Pp 44.

[20] An eight-episode podcast version of *"Under the Bay*" is available on Spotify, Google, and Apple podcasts.
Links to podcasts and more information can be found on the project website : http://lisamoren.com/underthebay.

[17] Download the AR from Apple IOS or Google Play:
https://apps.apple.com/app/id1641553491

https://play.google.com/store/apps/details?id=com.lisamoren.underthebay&pli=1

Brown, Adrienne Maree. *Emergent Strategy: Shaping Change, Changing Worlds.* Edinburgh: AK Press, 2017.

Fishel, Stefanie R. *The Microbial State: Global Thriving and the Body Politic*. University of Minnesota Press, 2017.

Gibbs, Sarah P. "The chloroplasts of *euglena* may have evolved from symbiotic green algae." *Canadian Journal of Botany*, vol. 56, no. 22, 1978, pp. 2883–2889.

Kahn, Douglas. *"Energies in the Arts"*. Cambridge and London: MIT Press, 2019, pp. 2–46.

Lao-Tzu; translated by Stephen Addiss and Stanley Lombardo; introduction by Burton Watson*. "Tao Te Ching"*. Boulder: Hackert Publishing Company, 1993.

Sagan, Lynn. "On the origin of mitosing cells." *Journal of Theoretical Biology*, vol. 14, no. 3, 1967, pp. 225–274, https://doi.org/10.1016/0022-5193(67)90079-3.

Schwenk, Theodor. *"Sensitive Chaos: The Creation of Flowing Forms in Water and Air"*. Sussex: Rudolf Steiner Press, 1996.

Spuybroek, Lars. *Sympathy of Things: Ruskin and the Ecology of Design*. Bloomsbury Academic, 2016.

Acknowledgements

This project is generously supported by the Saul Zaentz Innovation Fund at Johns Hopkins University and the R.W. Deutsch Foundation. This project originated during an artist-in-residence supported by the Institute of Marine and Environmental Technology (IMET), the Center for Innovation, Research, and Creativity in the Arts at the University of Maryland, Baltimore County (UMBC). We're grateful for the support from Maryland Department of Natural Resources; John Boutsikas for his API and AR development, Danielle McPhatter and Harvestworks DigitalMedia Art Center, the IRC and CAHSS, and Antoine Cayrol of Atlas V Immersive Experiences in AR, XR, VR.

Production Team

Lisa Moren, Co-Principal Investigator, Producer, Art Director, Writer and Narrator; Dr Tsvetan Bachvaroff, Co-Principal Investigator, Marine Biologist, Researcher and Data Anaylsis; Dan Deacon, Electronic Composer; Dr. Marc Olano, Co-Principal Investigator, Lead Programmer; John Boutsikas, Programmer and Developer; Austin Samson Modeler and Animator; William Forrest, Modeler, Animator, UI and Technical Artist; Woody Lissauer, Voiceover Engineer and Male Narrator 1; Ruskin Nohe-Moren, Male Narrator 2; Aliyah Baruchin Copy Editor and Fact Checker.

Author's Biography

Lisa Moren is a multi-disciplinary artist who works with emerging media, bio-matter, public space, AR and works-on-paper. She has exhibited her work at the Chelsea Art Museum, Creative Time, Drawing Center (New York), Cranbrook Art Museum (Michigan) and Ars Electronica (Austria), Akademie der Kunste (Germany), uShaka Museum (South Africa), and the Artists Research Network (Australia). She received the National Endowment for the Arts award, is a Fulbright Scholar; a multi-year recipient of the Maryland State Arts Council and CEC Artslink International, is a R.W. Deutsche Award recipient and a Saul Zaentz Innovation Fellow in Film and Media at Johns Hopkins University.

Her writing has appeared in Performance Research; Visible Language; Inter Arts Actuel; New Media Caucus for *"Algorithmic Pollution: Artists working with Dataveillance and Societies of Control"* and *"CYBER IN|SECURITY"*; and her books on *"Intermedia"*; and Issues in Contemporary Theory for *"Command Z: Artists Working with Phenomena and Technology."* Lisa Moren is a Professor of Visual Art at the University of Maryland Baltimore County (UMBC); is an Affiliate Faculty at the Imaging Research Center (IRC) UMBC; and taught at FAMU and AVU in Prague; and the University of California San Diego (UCSD).

Dr. Tsvetan Bachvaroff's research is focused on dinoflagellate evolution with special emphasis on the parasitic dinoflagellates, using large scale sequencing and phylogenetic methods to describe the evolutionary history of different types of genes in dinoflagellates. He uses DNA sequence analysis from data collection, assembly, annotation and phylogeny; has received numerous academic awards, including the William Trager Award from the Journal of Eukaryotic Microbiology, International Society of Protistologists, culture independent methods such as single cell PCR, sequencing, and sequence analysis; Establishing dinoflagellate cultures. He received the Marsho award, Mid-Atlantic Section of the American Society for Plant Biology, University of Maryland College Park, and the Chemistry Prize, Trinity School, New York.

Tsvetan Bachvaroff received his B.A. degree from Johns Hopkins University and Ph.D. from the University of Maryland College Park. He was a Post-doctoral Fellow at the Center of Marine Biotechnology and subsequently with the Smithsonian Institution. He is an Associate Research Professor for the Institute of Marine and Environmental Technology (IMET) at The University System of Maryland.