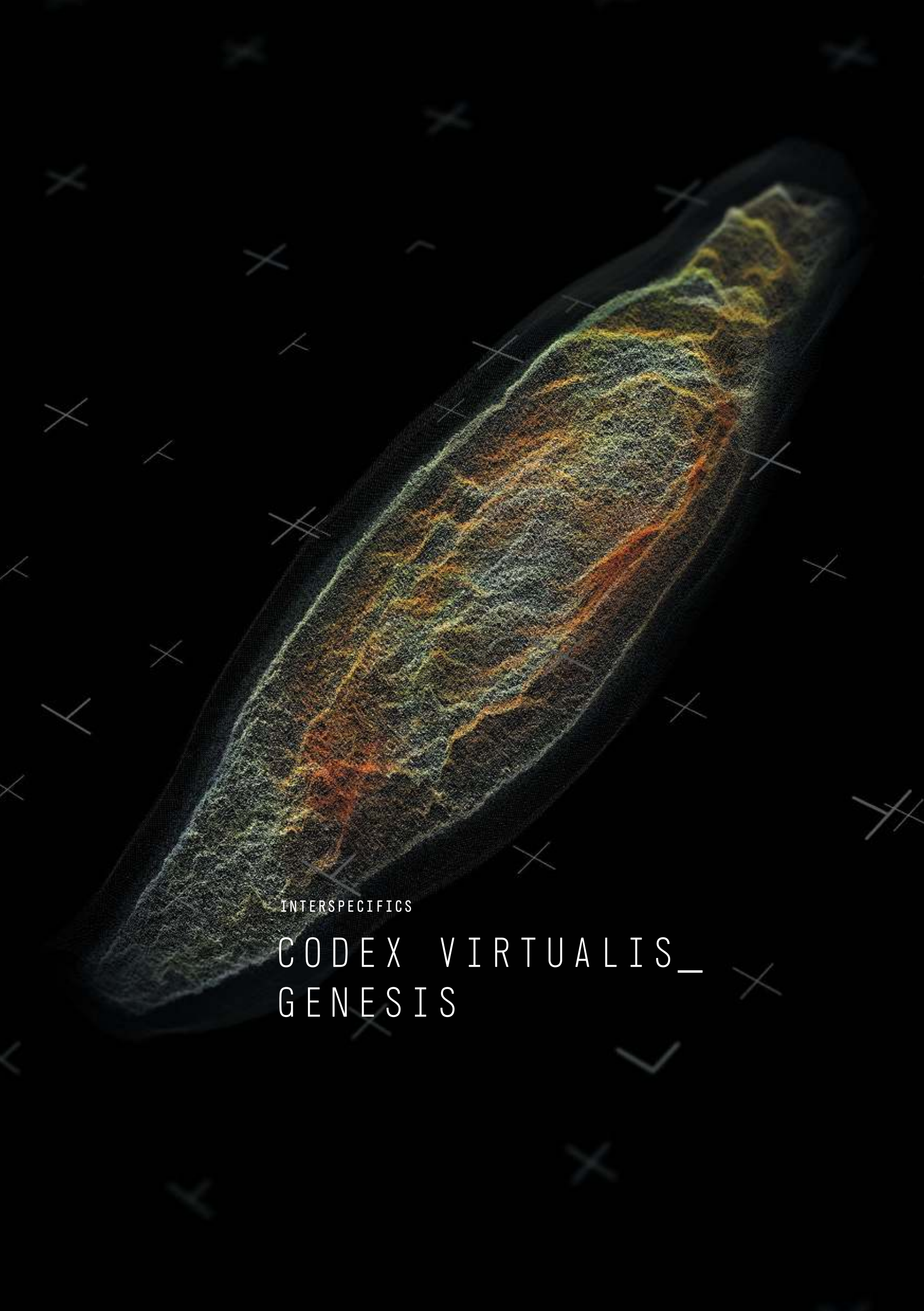


INTERSPECIFICS

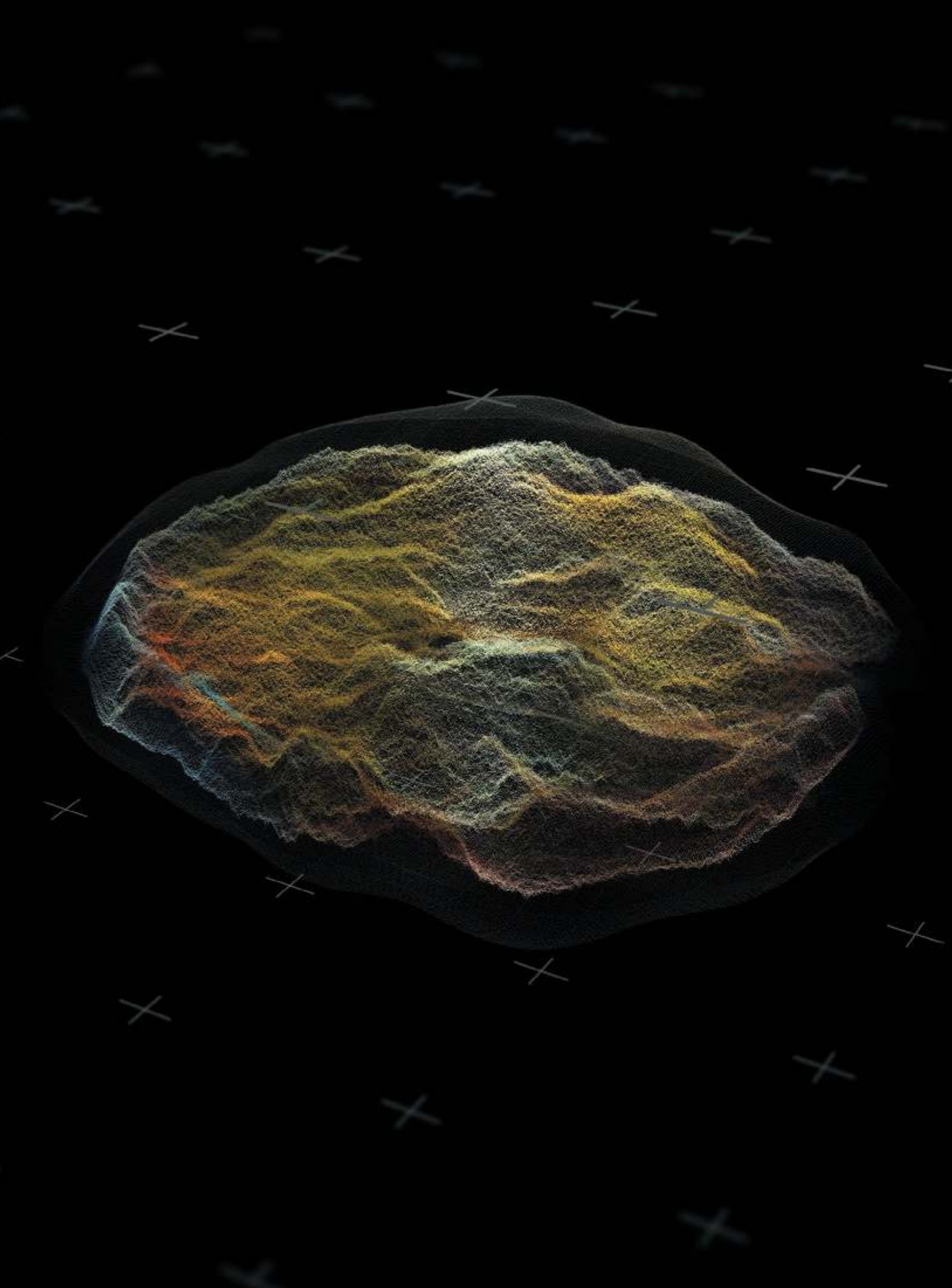
CODEX VIRTUALIS_ GENESIS

INDEX

/INTRODUCTION

Codex Virtualis is an AI-art-science research framework oriented towards the image synthesis and evolution of an open-ended taxonomic collection of new-to-nature speculative life forms. An aesthetic journey through an ecosystem of neural networks and algorithms that reflects on the role form and association account for changes in the natural world.

The project, designed to be delivered in four phases, begins with Codex Virtualis_Genesis: the origin, initial classification, and multidimensional representation of these entities. Continues with Codex Virtualis _ Habitat, establishing a relationship with a meta-environment by exposure to simulated inputs. Later, in Codex Virtualis _ Emergence, intra-activity is ensued between living biological samples to try and transfer features in real-time. To finally test the resilience of one of these organisms and see it living virtually in Codex Virtualis _Life. A long-scope research strategy and distinctive feature of previous projects.



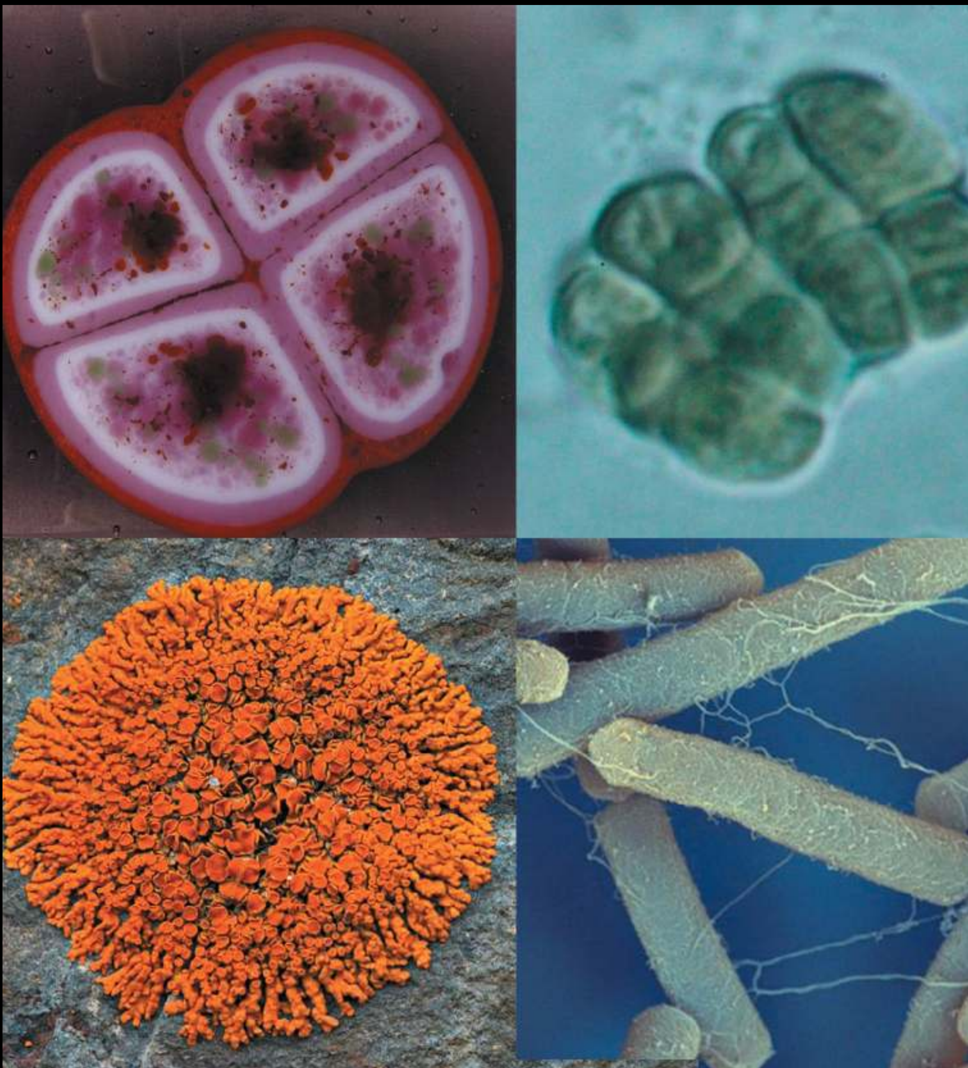
/ INTRODUCTION

Codex Virtualis is rooted in a field of analogies that symbolically compares genetic expression with probabilistic data distribution, transfer learning with genetic recombination, and horizontal gene transfer with style transfer to materialize a generative morphogenesis source in a virtual environment. The two main inputs fed into and orchestrated by our artificial generative system are microscopy and cellular automata images. A dynamic feature transfer between biotics Naro and Agua datasets, and Bert Chan's 2019 automaton project Lenia. In this sense, within the core of this project lies the exploration of a life and life-simulation morphological interplay. A space from which a meta-deep biosphere emerges within the technosphere.

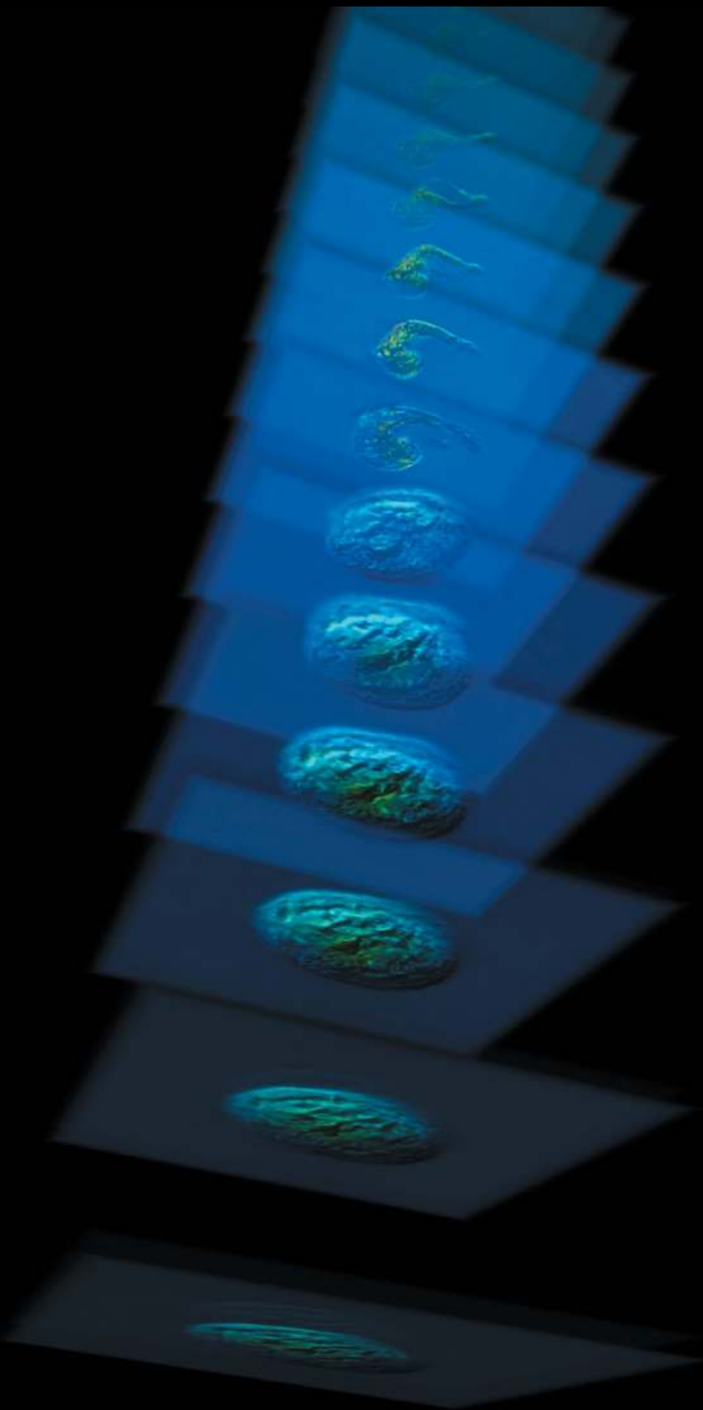
The symbiotic narrative of evolution is for Codex Virtualis a conceptual ground to speculate on different levels of fusion and metamorphosis. In the first level, a selection of resilient model organisms: Chroococcidiopsis, Deinococcus radiodurans, Bacillus subtilis, and Xanthoria Elegans, constitute the initial line of kinship from which a series of morphological symbioses will take place. The cooperative nature of an algorithmic ecosystem in the second level and the human-machine intentionality enactment is the third level of symbiotic relationships embedded in this project.

Therefore, Codex Virtualis can be understood as a readymade of technology and theoretical frameworks that seek to sharpen our perception of the creative function in machine terms, and questions conventional definitions of life, experimenting with algorithmic behaviors that progressively become novel lifeforms in themselves.

The project joins a cultural and artistic contemporary praxis inquiring around the concept of life through codices that recount ancestral cosmogonies, mechanical representations, computational simulations, and mechanisms of life. Building an epistemic bridge between microbiological knowledge and the artificial intelligence connectivism approach, Codex Virtualis imagines ways of living together, of deep interspecific relations that may enhance our possibilities of survival.



Model Organisms_



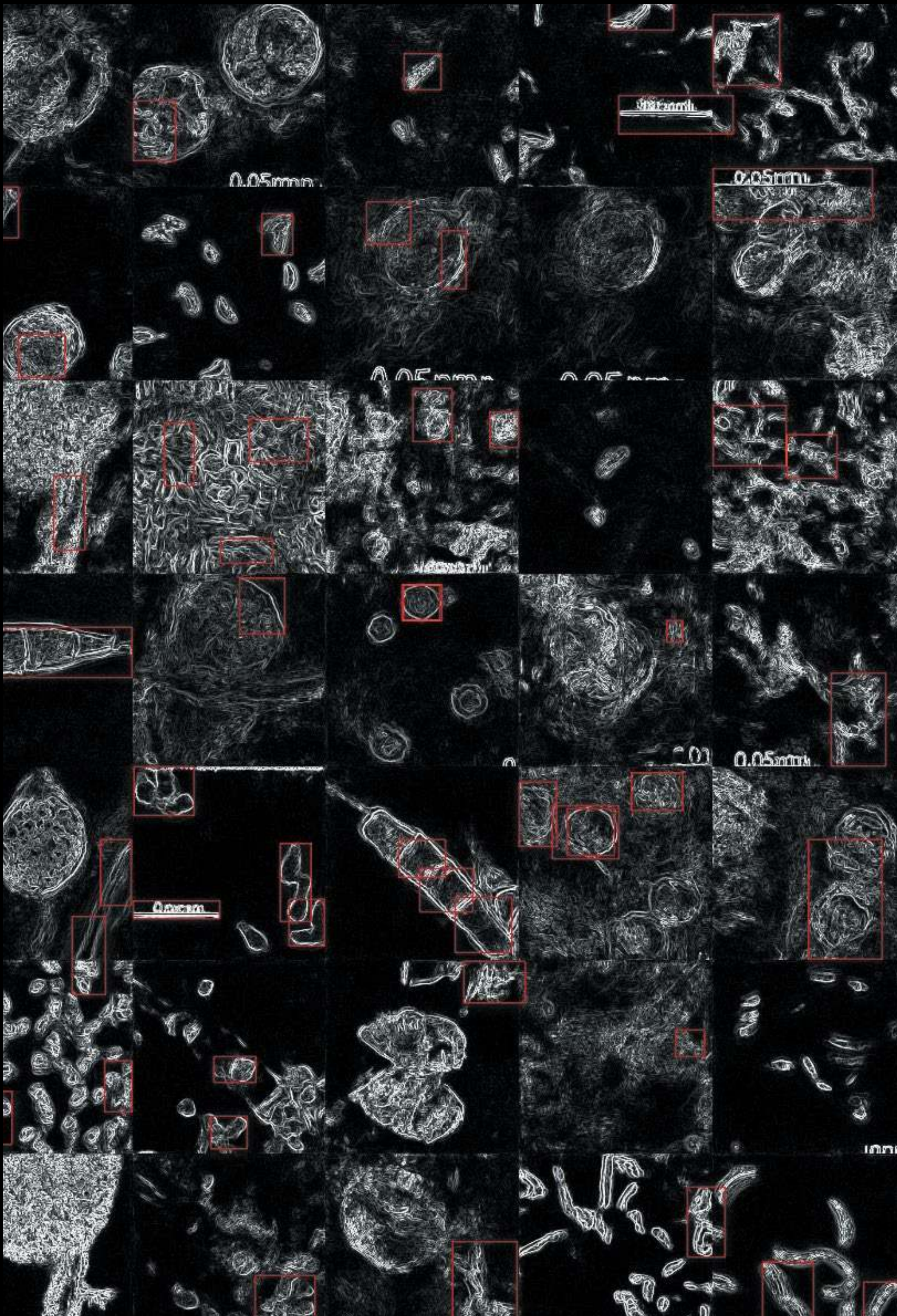
/CODEX VIRTUALIS_ GENESIS

In a broader metaphorical sense, the AI generative models used in the workflow of our multi-layered computational ecosystem become analogous to the role of evolution within biology. In this process, a change in the gene pool of a population (genotype expression) can produce a continuous stream of novel organisms (phenotype selection). Similarly, by using in silico evolutionary architectures, we explore different algorithmic recipes under which the biological concepts of variation, heredity, fusion, and cooperation can aesthetically manifest themselves and lead to de novo hybrid morphological profiles.

One of the fundamental processes adopted within our system is the mixed training of our generative adversarial networks (StyleGAN2). In this task, two qualitatively different datasets merge by adopting domain adaptation machine learning strategies, leading to the emergence of new visual samples. These bimodal architectures allow us to explicitly represent an information transfer between domains, analogous to the horizontal gene transfer mechanisms in biology. The latter being an increasingly acknowledged relevant source of evolutionary novelty due to genome acquisition, mutualistic interactions, and synergy between organisms.

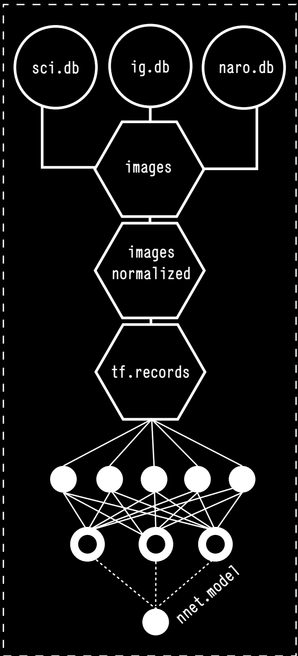
Often in artificial genetic modeling, symbiotic evolution is described by genetic fusion operators within a genotype representation level. However, in our GAN architectures, coevolution is implemented via a game-theoretical phenotype level approach, in which information exchange, deception and imitation constitute a primordial set of inner interactions that lead to a divergent, continuously evolving, collection of visual forms incited by the generative and discriminative network interplay. In addition, we embed in the last stage of our system a perceptive layer, which has the role of directing the exploration within the latent space of our network by some visual attribute metrics extracted by computer vision algorithms. We interpret this exploration as navigating through an abstract fitness landscape where the variation along a morphology-related parameter results in specific morphotypes.

Finally, using 16s and 18s ribosomal RNA sequences from model organisms and language model GPT-NEO, we generated DNA sequences to create hybrids between the biotic and the generative DNA segments.

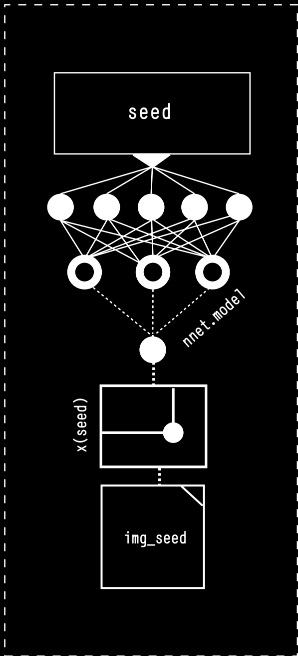


/ TECHNOLOGY ROADMAP

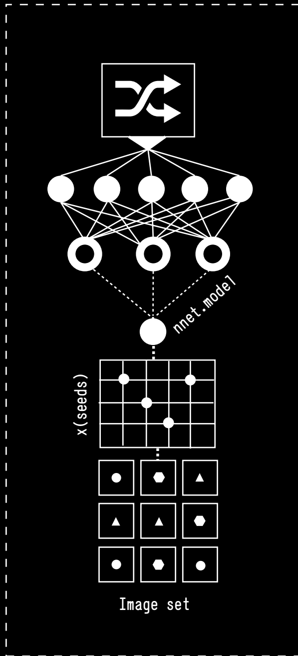
1. NETWORK TRAINING



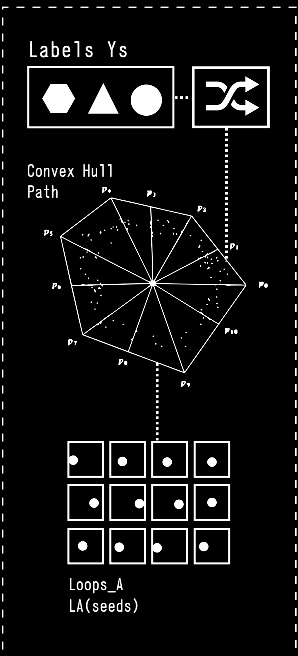
2A. IMAGE SAMPLING



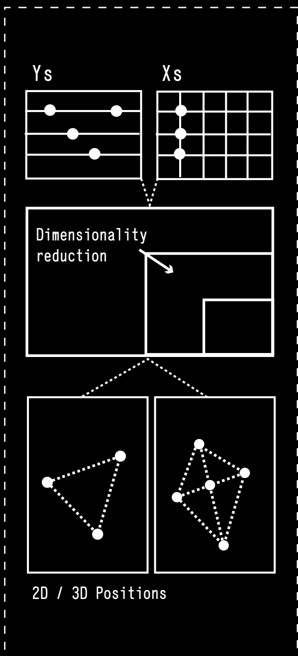
2B. IMAGE SAMPLING SET



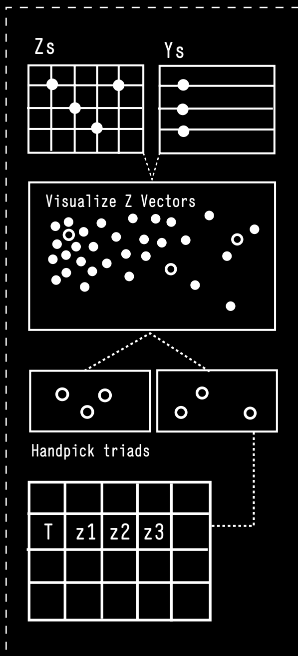
6. CLASS-A CYCLES



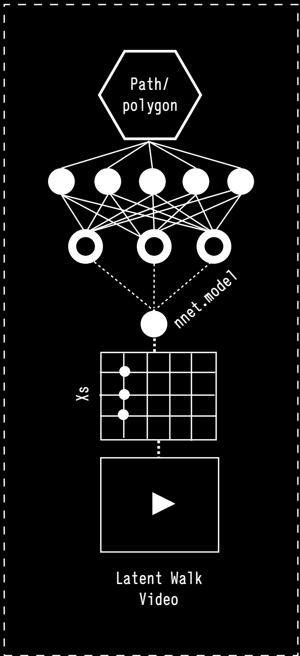
7. DIMENSIONALITY REDUCTION



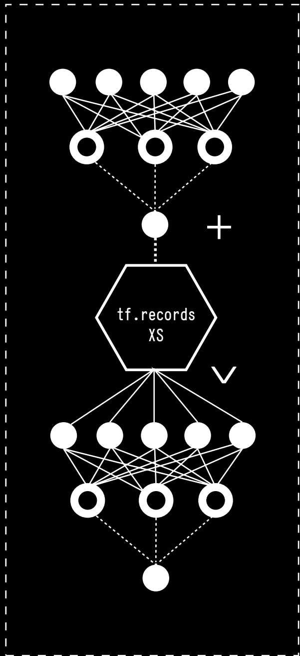
8. NODES SELECTION



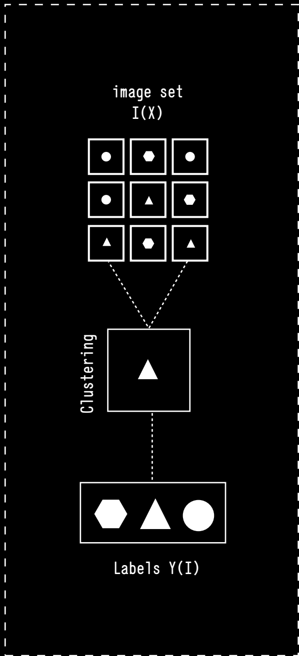
3. LATENT SPACE EXPLORATION



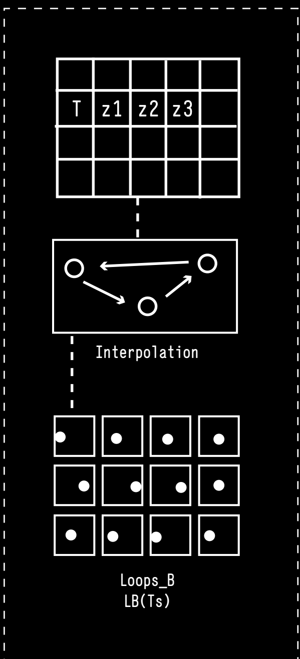
4. TRANSFER LEARNING



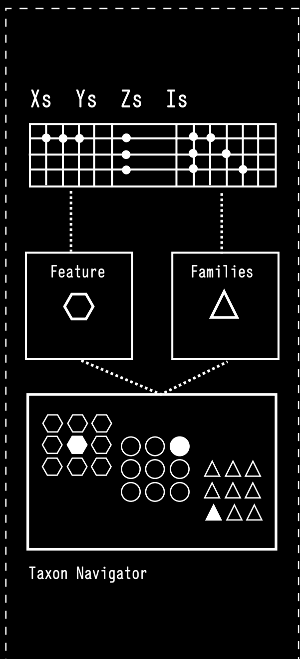
5. CLUSTERING/SELF-LABEL



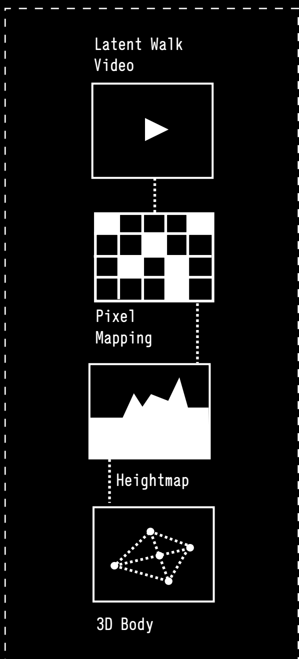
9. CLASS-B CYCLES

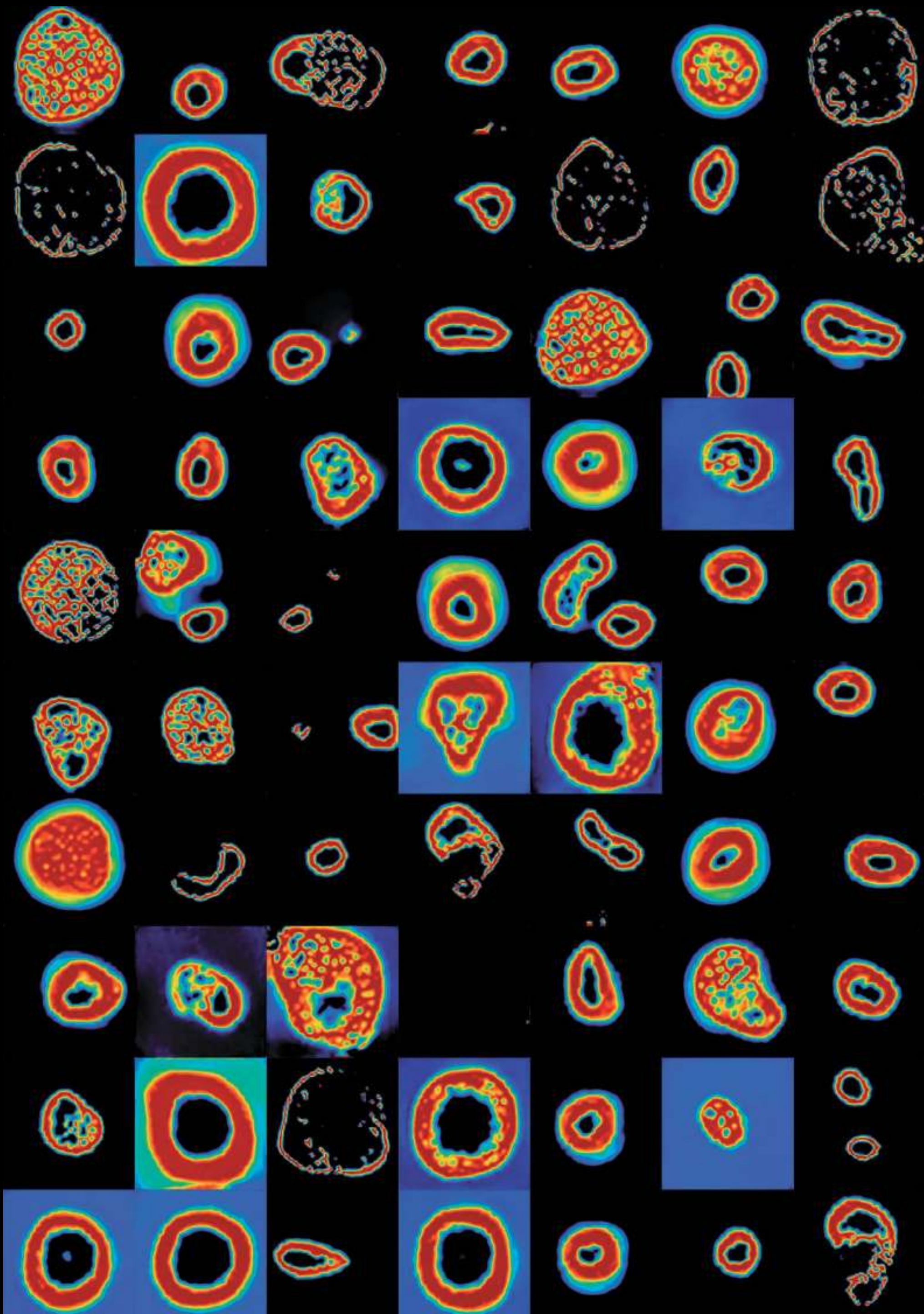


10. TAXONOMIC NAVIGATION

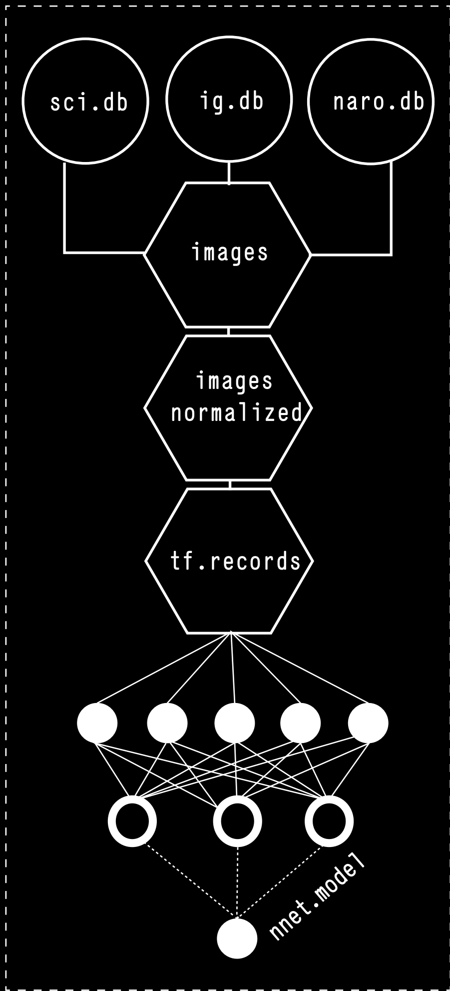


11. 3D MODELLING (SOFTSHELL)





3.1 NETWORK TRAINING



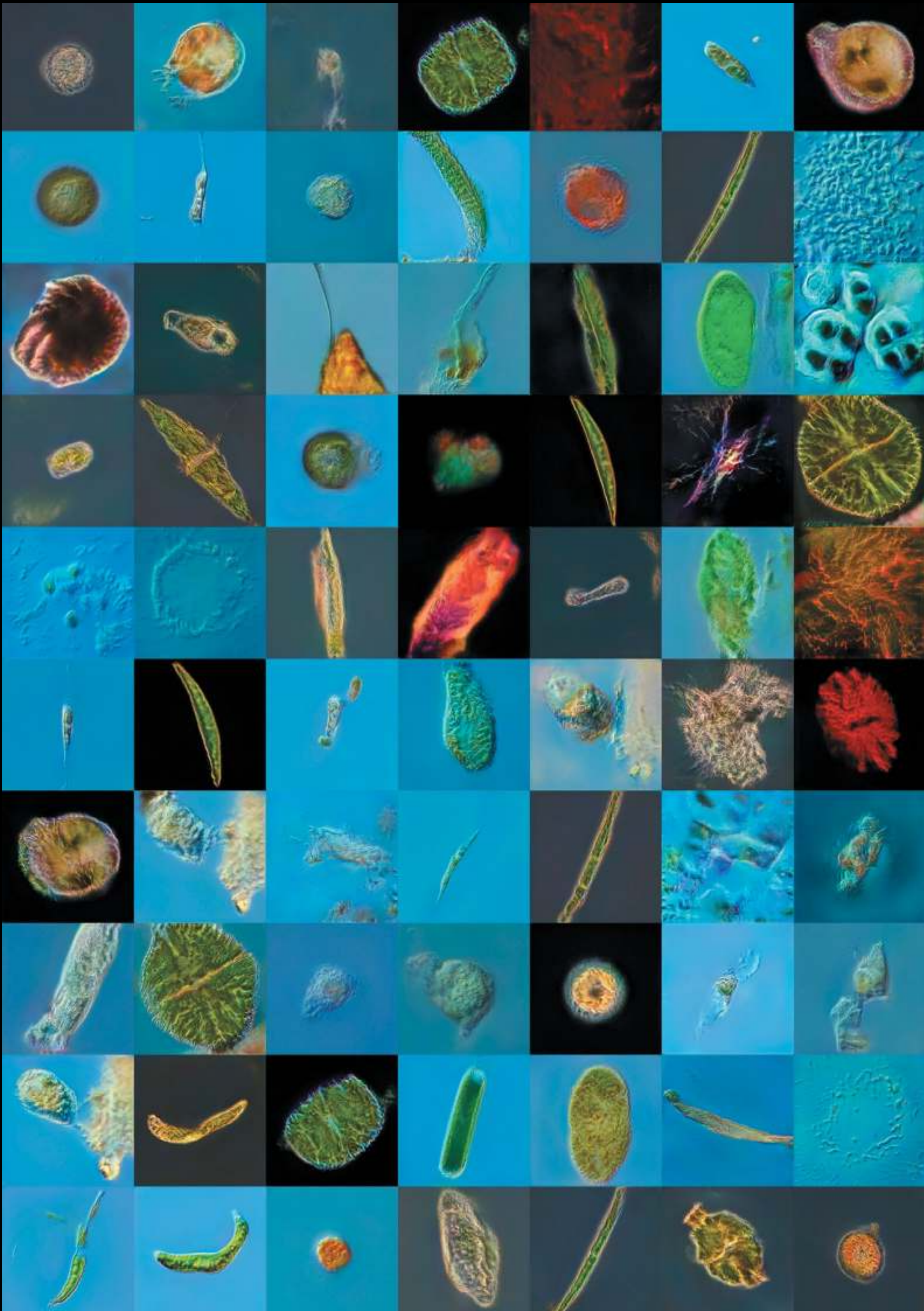
We iteratively calculate the connection weights between neurons by continuous exposure to real-life images to find the optimal values that produce non-existent though statistically accurate samples. Next, a base StyleGan2 model is trained on the following microorganism data sets:

AGUA: 1,300 crowdsourced image collection.

NARO: 1,200 images from the NARO genebank public collection.

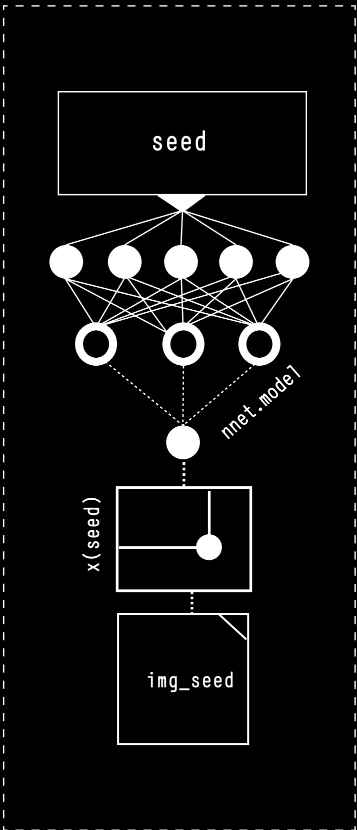
LENIA: 1,500 image collection from continuous cellular automata Lenia.

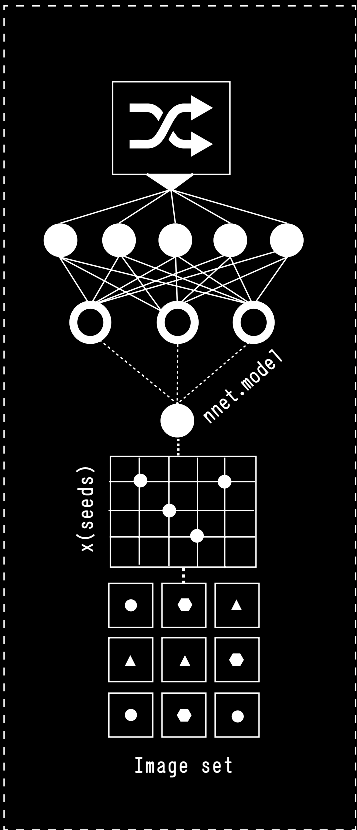
MODEL ORGANISMS: extreme condition resilient organism collection inspired by astrobiology research.

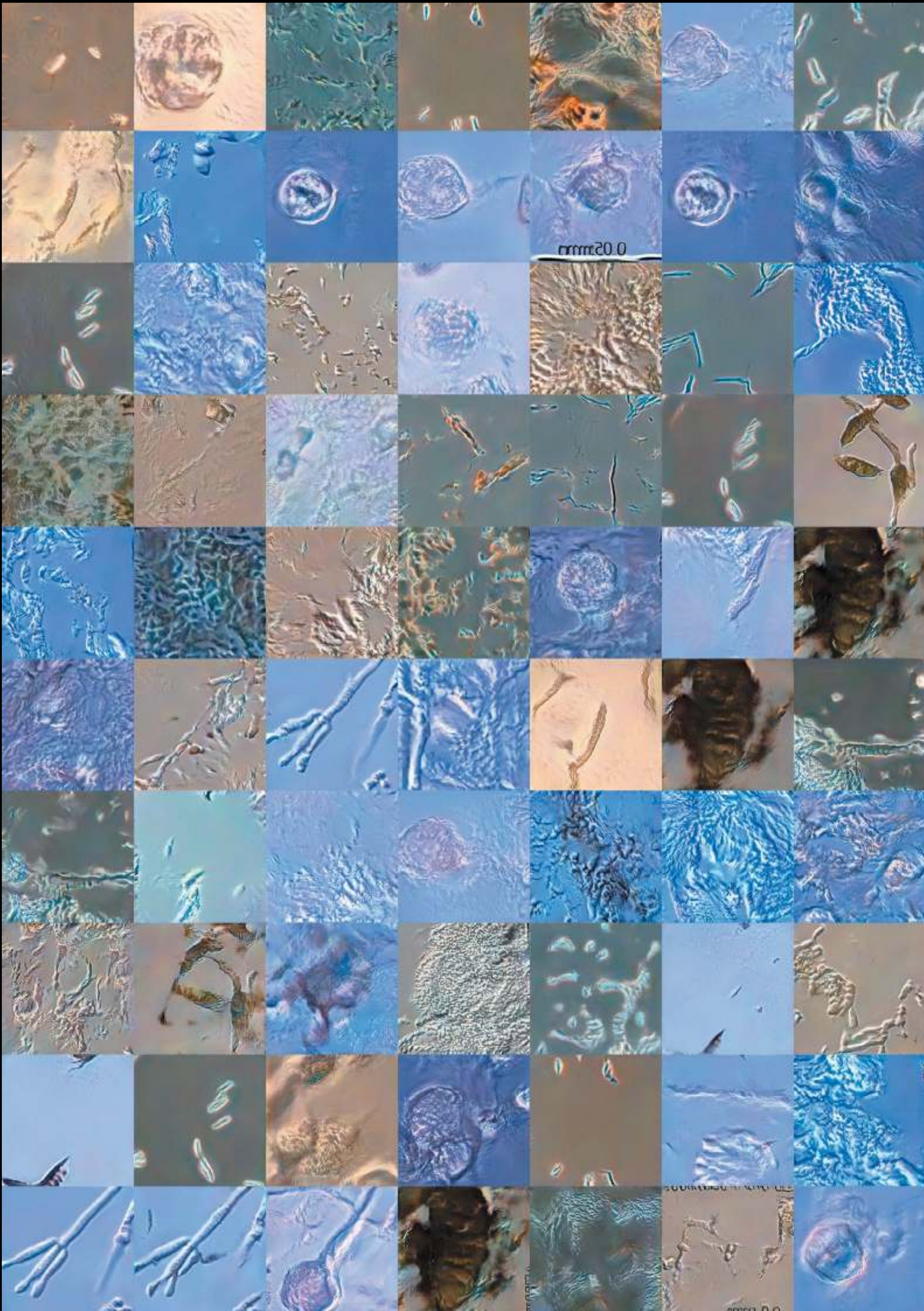


3.2 IMAGE SAMPLING

We select points from the n-dimensional space of the network to infer and generate a corresponding image. This action is repeated to group samples with similar spatial distribution features.

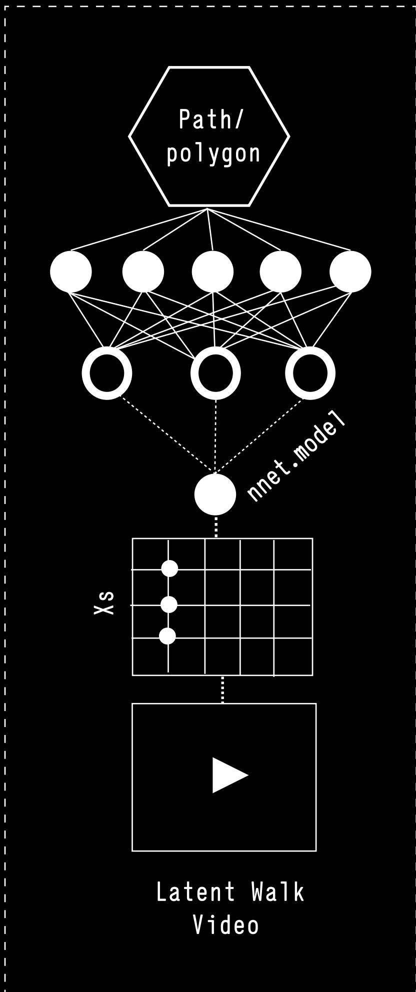






3.3 LATENT SPACE EXPLORATION

Latent—or hidden—space refers to the abstract dimension containing the attribute values of an image. It cannot be interpreted directly but encodes meaningful representational data. In order to identify relationships between image attributes and the latent space region that generates them, a compression and clustering phase is set to identify structural similarities and trajectories that produce interesting visual patterns.

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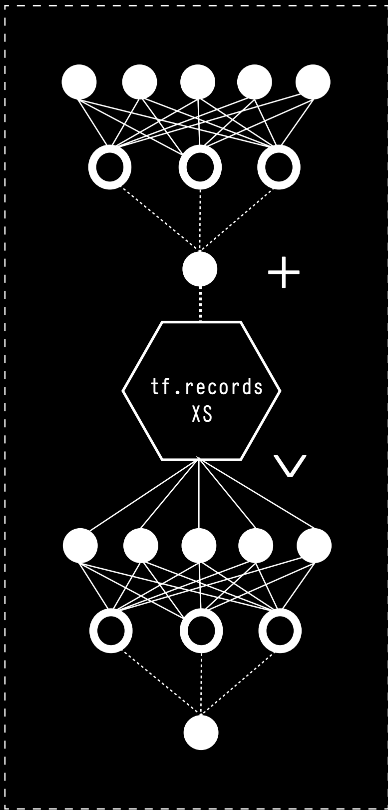
2169-3442-3184
3763-1235-0132
2468-0182-1394
1199-0484-3122
0028-0516-0839
0782-0484-3785

3.4 TRANSFER LEARNING

To transfer visual elements from one image collection to another, we implement a transfer learning technique that replaces all images at an advanced phase in training with a new set of images. This technique pushes the model to transfer features from dataset A to dataset B, creating variation in visual components while maintaining attributes belonging to both datasets, a process analogous to genetic recombination in biology.

The following base/target combinations are used to create mutated families of organisms descended from the original organisms in dataset A + traits in dataset B:



[A] AGUA + NARO

[B] AGUA + BS *(Bacillus subtilis)*

[C] AGUA + CH *(Chroococcidiopsis)*

[D] AGUA + DR *(Deinococcus radiodurans)*

[E] AGUA + XE *(Xanthoria elegans)*

[F] AGUA + LENIA *(algorithmic organisms datasets)*


3119-0484-3410
1572-1607-3275
2588-0484-0132
3254-3442-3124
3763-3286-2907
1199-1607-1598
3867-1501-0839
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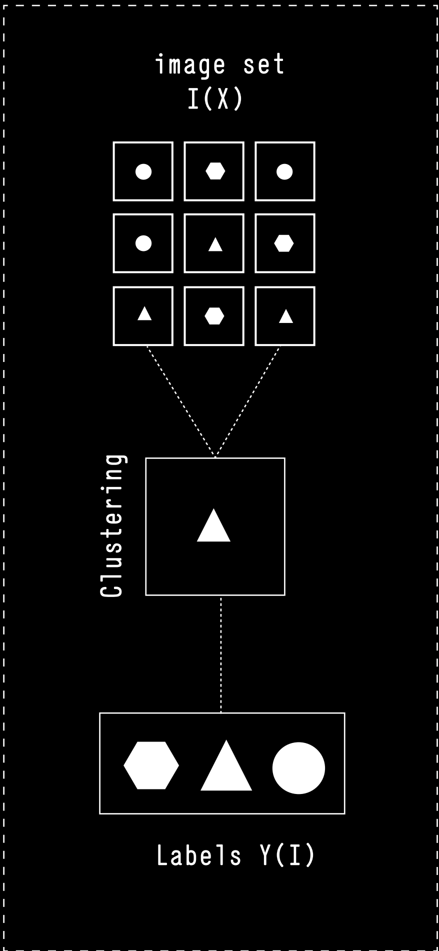
2169-3442-3184
3763-1235-0132
2468-0182-1394
1199-0484-3122
0028-0516-0839
0782-0484-3785

3.5 CLUSTERING / SELF-LABELLING

We perform image sampling to generate the corresponding set of images for this training stage. As mentioned above, every set of hybrid organisms create new visual-attribute to latent-space-coordinate relationships.Groups of similar images are identified using K-means and Agglomerative Clustering so as to find out how these relationships may work. This clustering step assigns each hybrid organism family a group id or label, and organisms in the same group share visual characteristics of shape, color, and texture. The latter makes it easier to identify latent space vector points that could conform to a neighborhood, in other words, a region in space where a configuration of similar visual features is maintained, and to which to generate cycles that exhibit uniform behavior.

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1107-3931-2929
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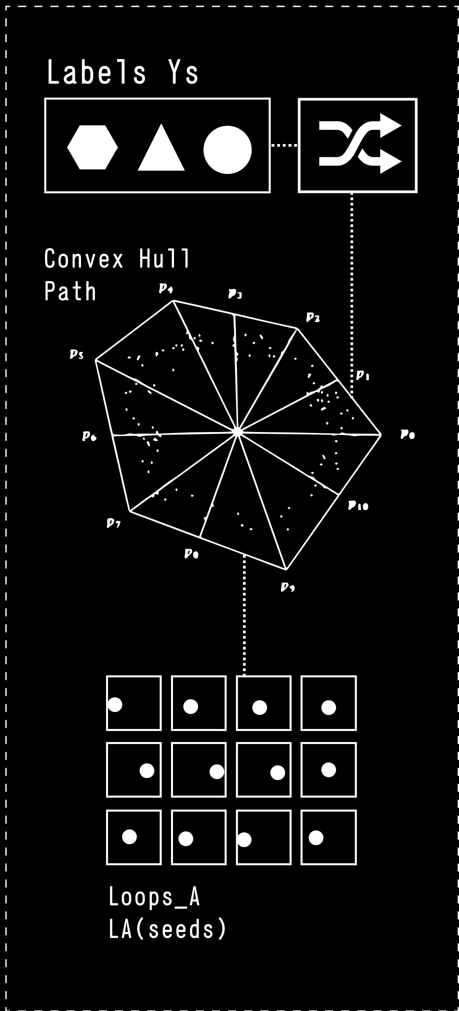
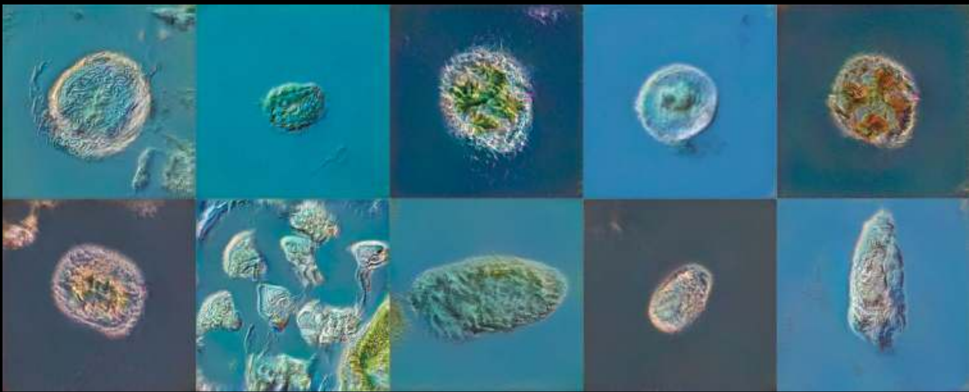
2169-3442-3184
3763-1235-0132
2468-0182-1394
1199-0484-3122
0028-0516-0839
0782-0484-3785

3.6 CLASS-A CYCLES

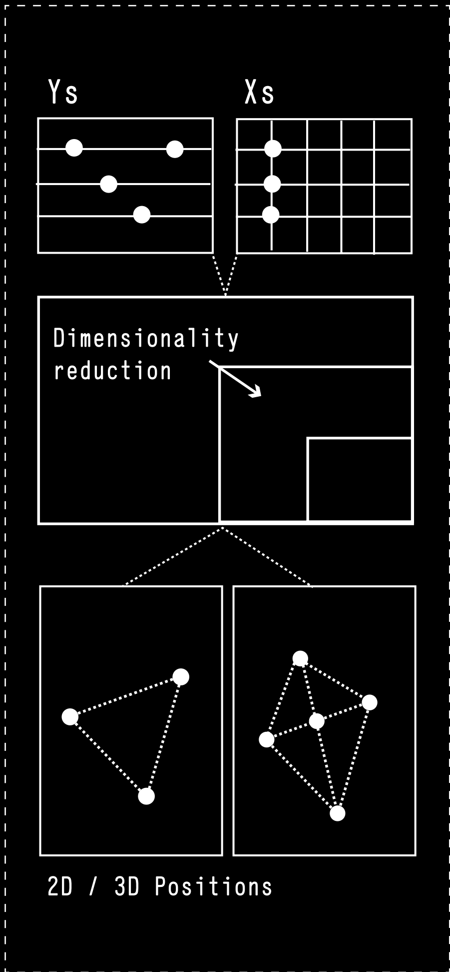
A cycle refers to a video where a newly generated organism shows an organized, uniform, and continuous behavior. These sequences are produced by traversing the trajectory of a given set of points in the latent space, interpolating the intermediate ones, and inferring a frame for each of them. Class-A cycles are generated automatically by selecting an ordered cluster subset—which represents a family—, sampling a point within each individual cluster's convex hull and tracing the trajectory between them.

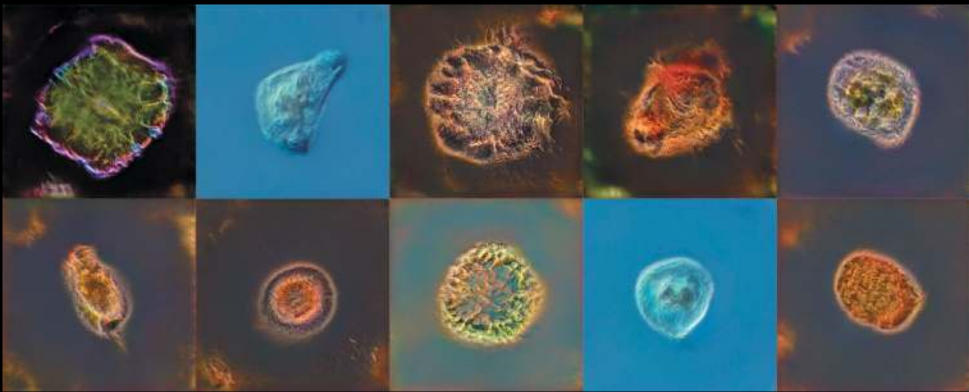




3.7 DIMENSIONALITY-REDUCTION VISUALIZATION

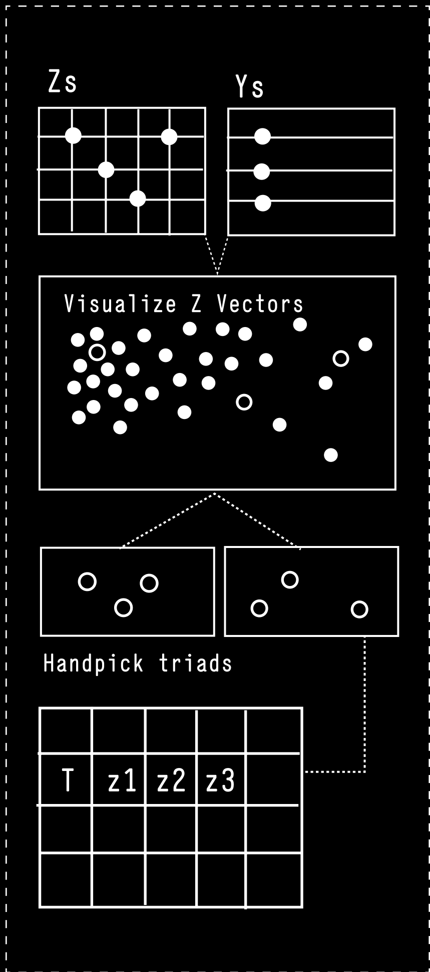
Moving through points in latent space allows the appearance of the resulting images to be modified. However, it is difficult to visualize and interpret their location and displacement direction in this abstract geometric dimension. To facilitate this exploration and identify regions of interest, we project the vectors of the sampled organisms into a lower-dimensional resolution. The resulting 2D and 3D visualizations show the corresponding points for every image and allow a selection of the target transition's direction to form another class of cycles.





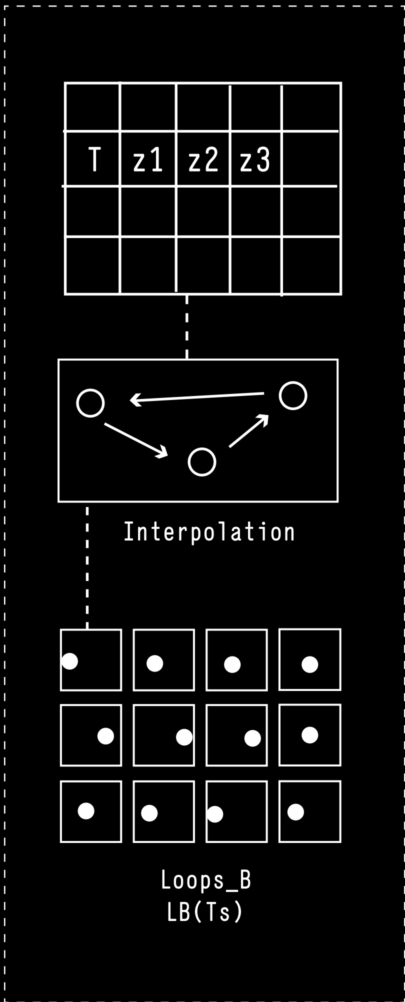
3.8 NODE SELECTION

After visualizing points in the latent space, we manually select groups of points to visit through in an interpolation path to generate class-B cycles. The purpose of this manual choice is to find the most suitable individuals that will constitute our genetic pool to form a new generation.



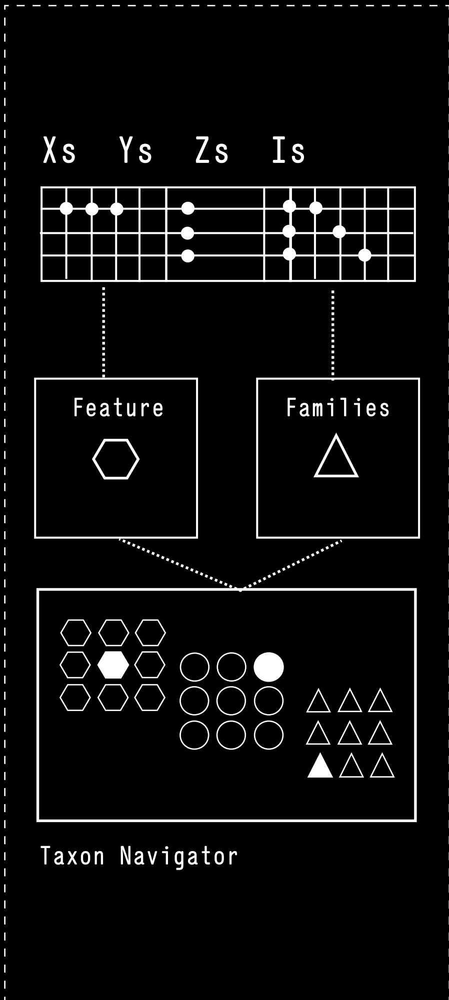
3.9 CLASS-B CYCLES

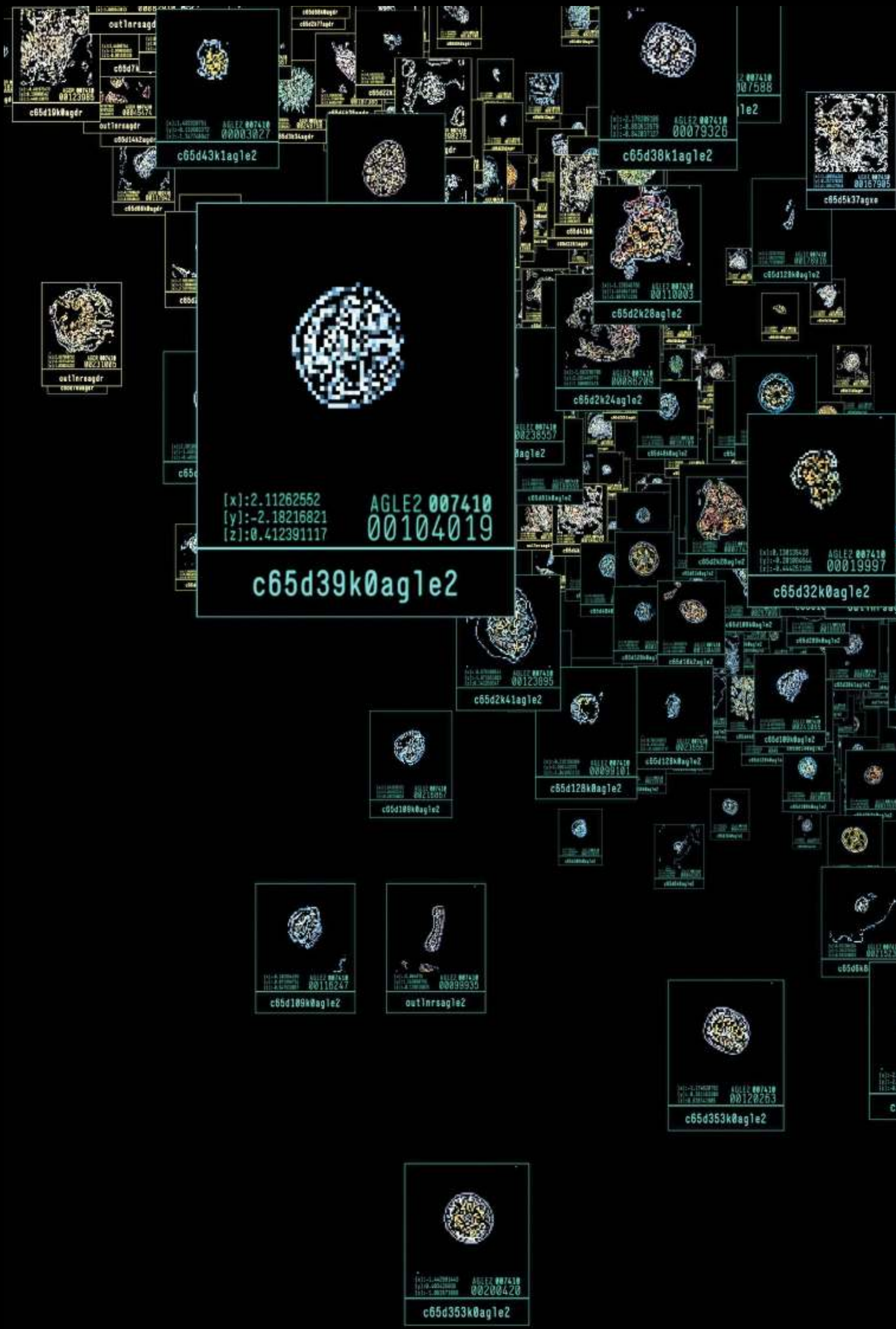
Class-B cycles contain transitions between latent space points manually selected through the low-dimensional visualizations.Selecting for organized, uniform and continuous behavior, the manual selection criterion acts as a fitness function, allowing to merge features of organisms and targeted mutations.



3.10 TAXONOMIC NAVIGATION

The agglomerative clustering in phase 4 allows us to build a hierarchy of similarity between groups or neighborhoods. By adding this hierarchical organization to a 3D visualization—where each node is an organism connected to others in the same group by proximity—we obtain a form of taxonomic division of the population for each family.

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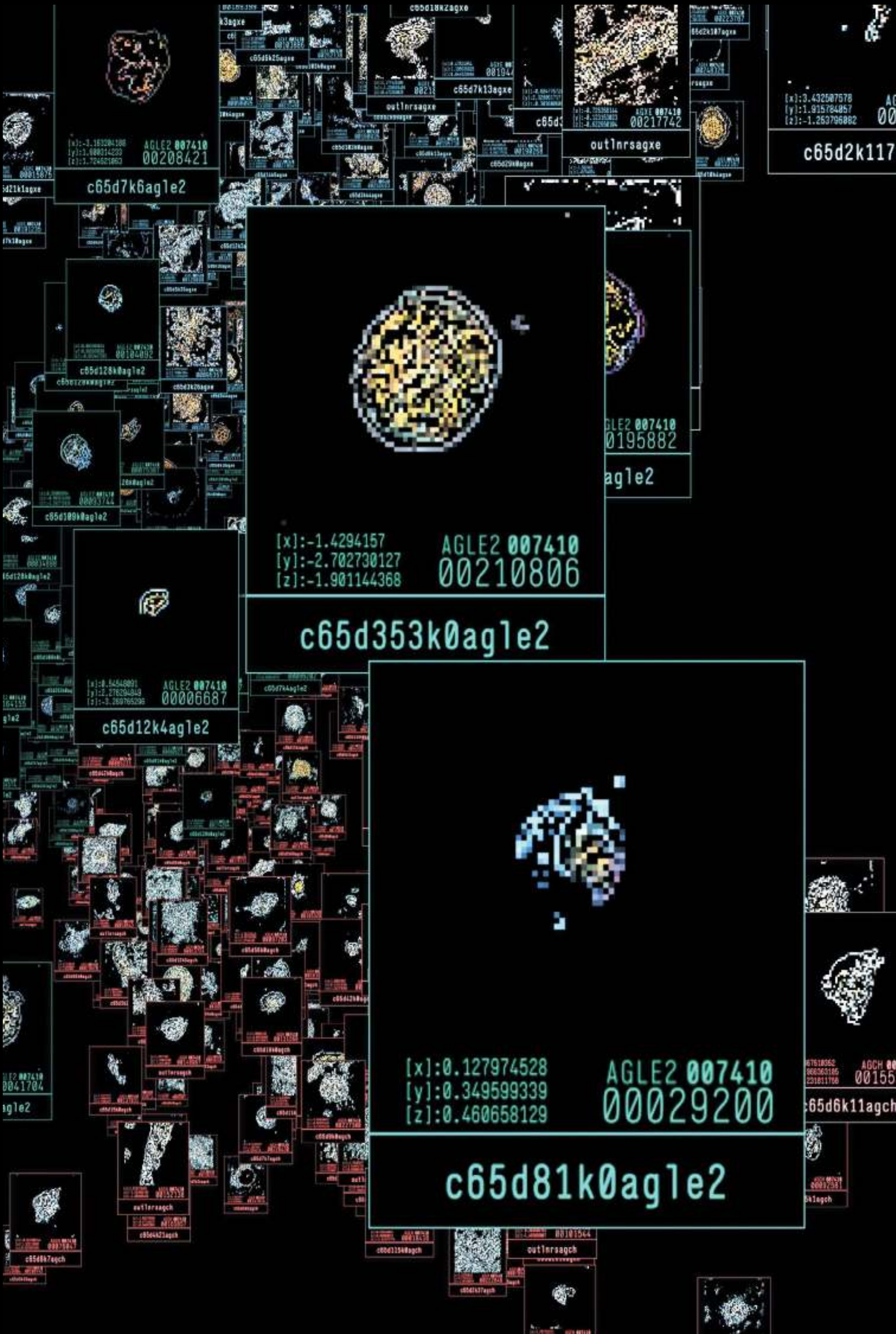
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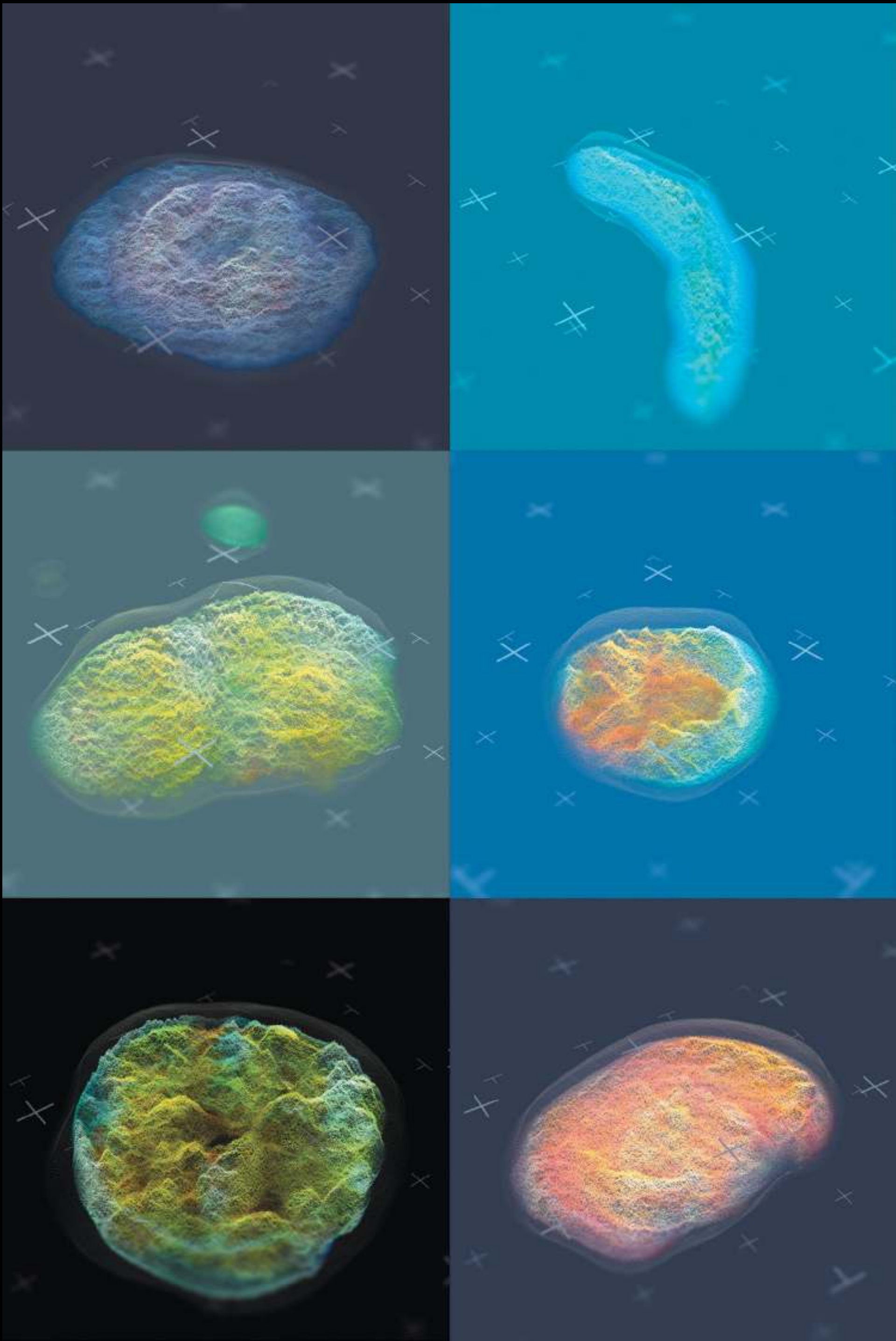
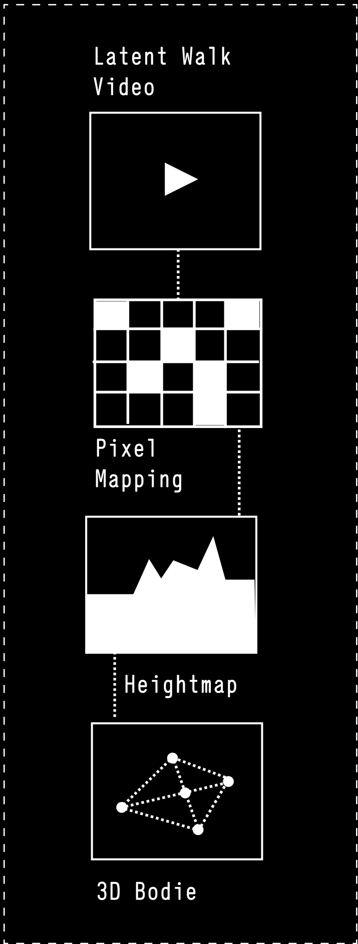
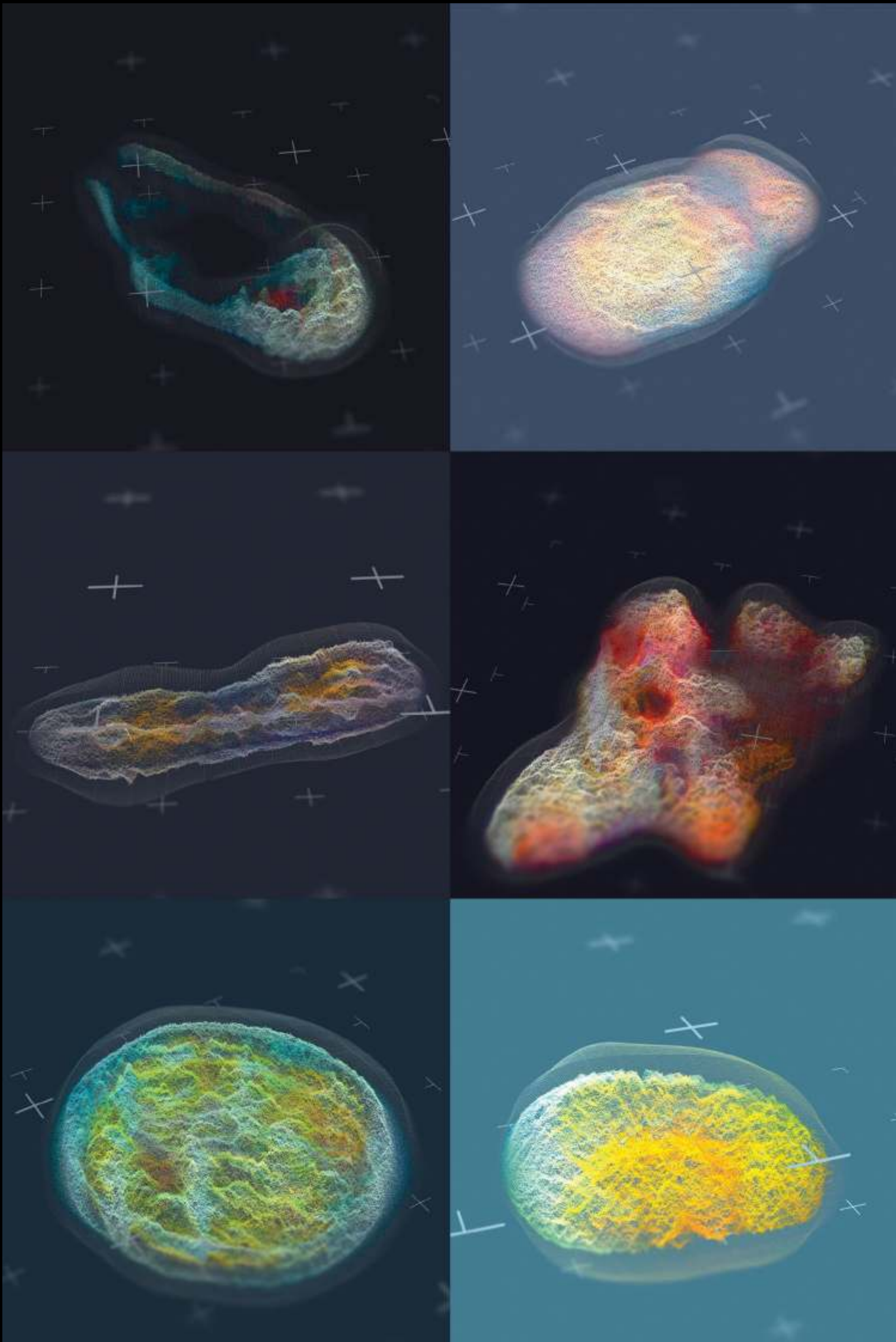


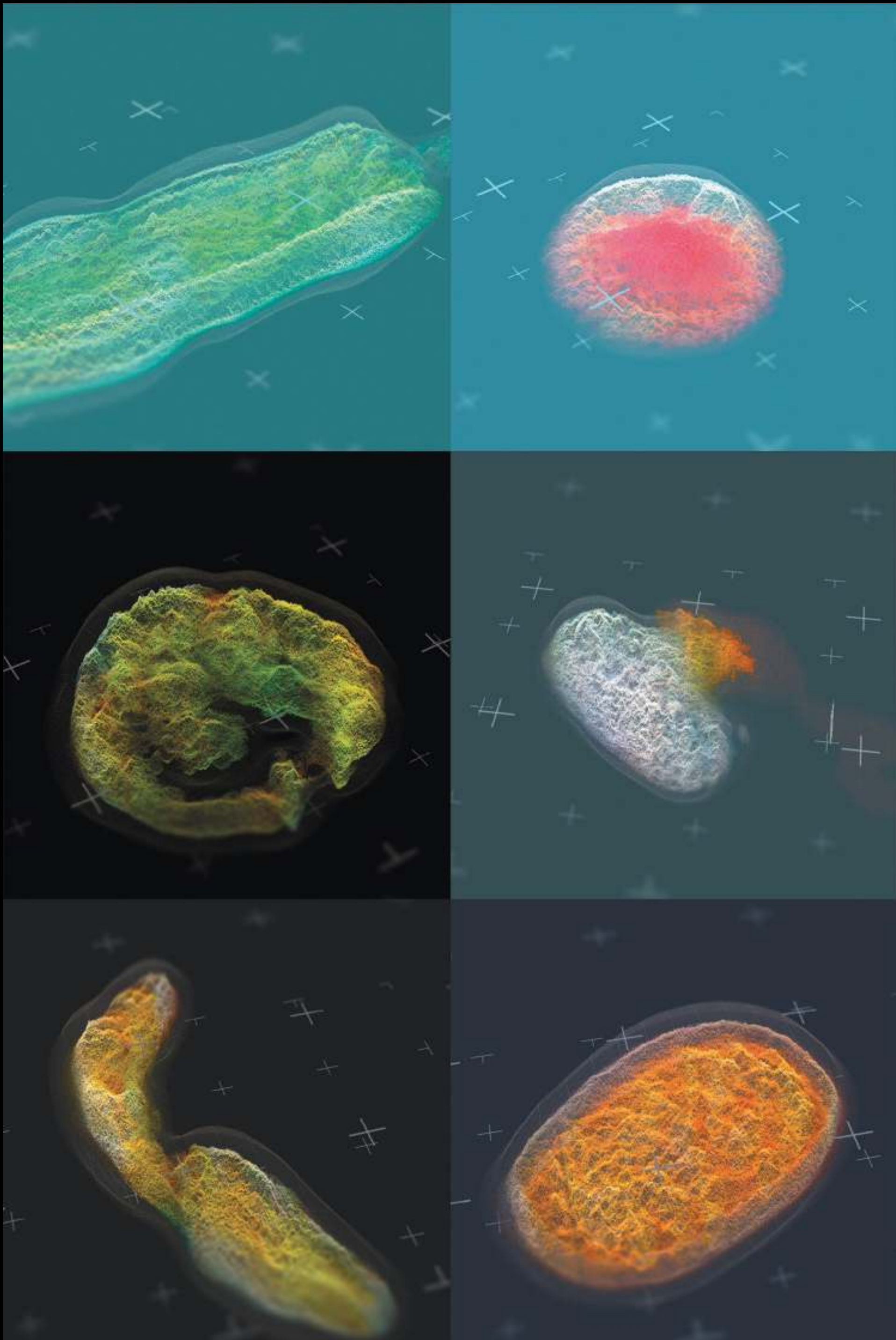
3.11 3D MODELLING

We model a three-dimensional outer membrane body by drawing points in a 3D environment using videos as procedural textures.To this end, we map the x/y position, draw two equidistant points to the base plane in opposite directions, and use the video as a heightmap of positive and negative values. Having an opposite plane gives the generated body a spherical shape.

This process solves the need to abandon the two-dimensional space of the StyleGAN2 results and—in future phases—will allow the organism to receive environmental inputs and respond via reshaping its softshell.







/CREDITS

INTERSPECIFICS /

Leslie García
Paloma López
Emmanuel Anguiano
Felipe Rebolledo
Alfredo Lozano
Maro Pebo
Carles Tardío
Nickole Klinckwort

[PARTNERS]

Ars Electronica Futurelab /

European Artificial Intelligence Lab /

SETI Institute /

Co-founded by the Creative European Program of the European Union /

[CONTACT]

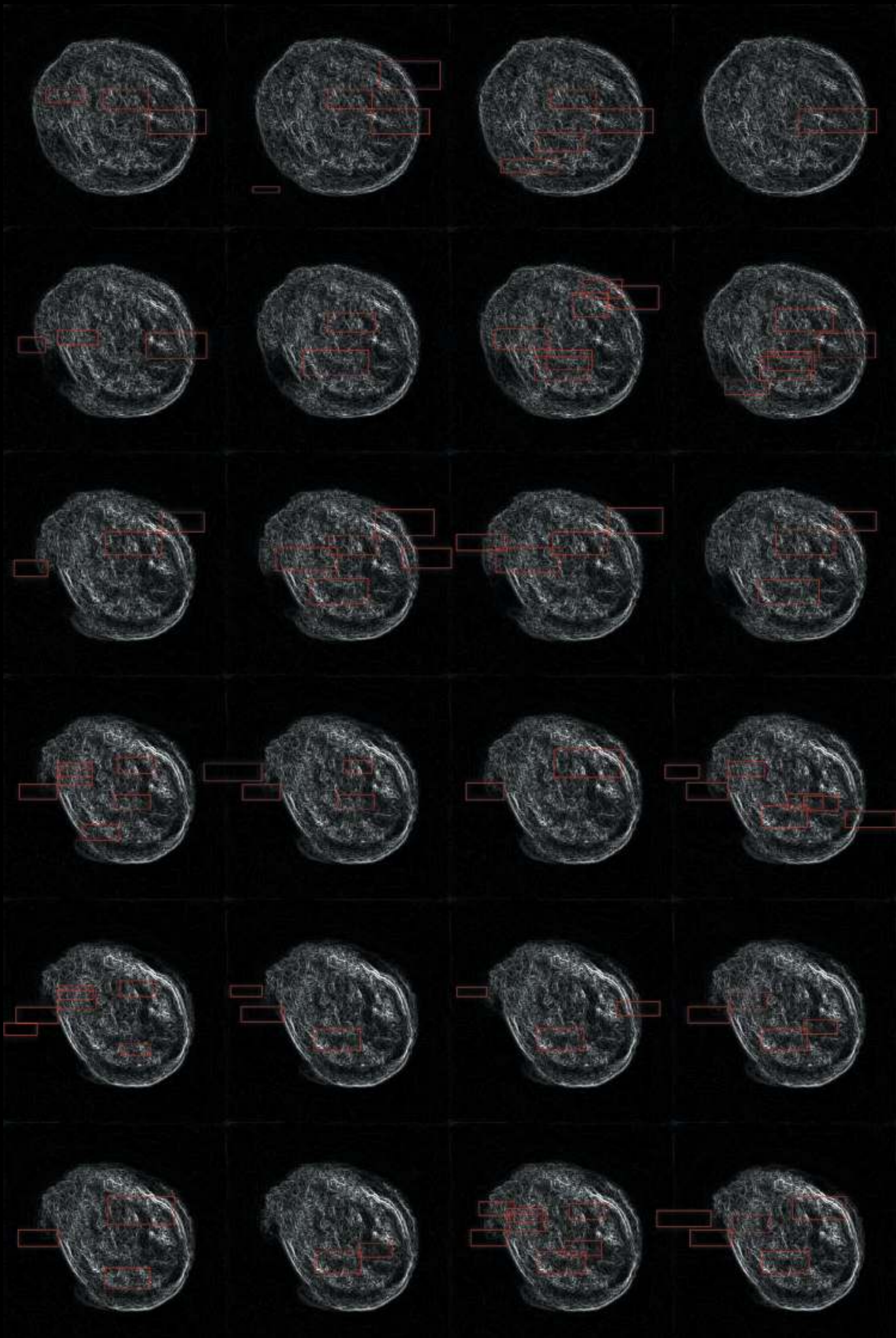
MAIL /
hello@int-lab.cc

interspecifics.cc
int-lab.cc/codex

Codex Virtualis_ Genesis was created during the SETI X AI @ Ars Electronica Futurelab 2021 artist residency.

The SETI x AI residency is part of the AI Lab (European ARTificial Intelligence Lab). It offers international artists working in AI a chance to win a residency at a scientific partner institution and the Futurelab of Ars Electronica.Based in Linz, Ars Electronica is a globally unique platform for art, technology, and society that has been analyzing and commenting on the digital revolution since 1979. The focus is always on current developments and possible future scenarios and how they will change people's lives.

The SETI Institute Artist In Residence (Air) Program connects contemporary artists with SETI Institute researchers and facilitates an exchange of ideas to catalyze new perspectives, insights, and modes of comprehension.Founded in 1984, the SETI Institute is a non-profit, multi-disciplinary research and education organization whose mission is to explore, understand, and explain the origin and nature of life in the universe and the evolution of intelligence.



INTERSPECIFICS

Independent artistic research bureau founded in Mexico City in 2013. We have focused our research on the use of sound and A.I., to explore patterns emerging from biosignals and the morphology of different living organisms as a potential form of non-human communication. With this aim, we have developed a collection of experimental research and education tools we call Ontological Machines. Our work is deeply shaped by the Latin American context where precarity enables creative action and ancient technologies meet cutting-edge forms of production. Our current lines of research are shifting towards exploring the hard problem of consciousness and the close relationship between mind and matter, where magic appears to be fundamental. Sound remains our interface to the universe.

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