

(Re)imagining human-yeasts relations via art-science collaboration

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Abstract

More-than-human beings are largely de-animated in Western cultures and perceived of as the backdrop for human activities. In particular, with modern modes of production and consumption, customers often have no idea how specific products have been created and which more-than-human beings have been involved in manufacturing specific consumables. As a partial response to this problematic disconnect, this text presents the art book, *Yeasts as We Do Not Know Them*, as a means to learn about human-yeast interactions and the ways these fungal microbes are used to manufacture different products and substances. The book, therefore, (re)imagines yeasts as omnipresent, diverse, and symbiotic. Conceiving of symbiosis as a set of interspecies relations, including mutualistic, pathogenic, and commensal ones, the project, *Yeasts as We Do Not Know Them*, as this article argues, maps diverse interspecies interactions and, by doing so, provides recourse for navigating material systems, thereby invoking trans-corporeal ethics.

Keywords

Human-Yeast Relations; Art-Science Collaboration; Transdisciplinary Research; Symbiosis; Mutualism; Climate Change.

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Introduction

Contemporary modern production and consumption practices are based on the general compartmentalization of economy, culture, and nature.¹ That is, despite ecological concerns, diverse forms of life are largely de-animated and instrumentalized in Western cultures.² While consumption and waste production levels in many regions are incredibly high despite myriad alarming environmental issues, customers are often unaware of the sources of specific products and from which living and non-living materials they are made. In response to such circumstances, scholars from diverse disciplines tackle the problematics of climate change, with a rising number of researchers emphasizing the role of art in developing ecological sensibilities, aesthetics, and imaginaries.^{3, 4} Such views derive from the assumption that climate change issues arise from and influence diverse aspects of human and nonhuman lives and cannot be tackled merely within the environmental sciences and adjacent fields. Rather, as researchers in environmental humanities Astrida Niemanis, Cecilia Åsberg, and Johan Hedrén have pointed out, “any policy or action aimed at ameliorating environmental problems must take into account human desire, motivation, and values; a deep understanding of the environment cannot be divorced from human imagination, culture, and institutional and social practices.”⁵ In other words, dealing with climate crises cannot be limited merely to environmental sciences. Instead, in order to face immense challenges, significant changes are needed within distinct yet deeply interconnected economic, industrial, cultural, social, institutional, political, conceptual, visual, and other realms. Hence, instead of compartmentalization, environmental humanities require transdisciplinary methodologies and practices.

For these reasons, art book, *Yeasts as We Do Not Know Them*, which is the focus of this paper, rejects compartmentalization and instead takes the concepts of symbiosis and trans-corporeality as a starting point, mapping out some of the yeast interspecies relations. Created by the authors of this article, *Yeasts as We Do Not Know Them* depicts human-yeast interactions as diverse, omnipresent, and symbiotic. We use the concept of symbiosis to describe human-yeast relations as sometimes mutualistic, sometimes commensal, and sometimes even pathogenic. Trans-corporeality, according to American literary scholar Stacy Alaimo, is a mode of thinking that regards beings and entities as porous and materially and discursively interrelated.⁶ By presenting ways in which yeasts are interconnected with diverse life forms and are involved in the industrial production of food, medicine, chemicals, and cosmetics, the book invites the audiences to learn about human-yeast material interchanges and to consider the repercussions of these interchanges. In mapping some of the actual interspecies interactions, our project, as we argue in this text, invokes trans-corporeal ethics.

In order to develop this argument, we begin by discussing symbiosis and trans-corporeality as guiding concepts in the project. Further, we elaborate on the connection of the art book to these concepts via two main threads. First, we trace yeasts across scales on the level of bodies and in the production of various products and consumables. Second, we emphasize the importance of transdisciplinarity in creating this artistic publication.

Symbiosis and trans-corporeality

Nowadays, most biologists define biological symbiosis as a close (in direct contact) relationship between individuals of two species, either with positive, negative, or neutral outcomes.⁷ According to this definition, parasitism, mutualism, and commensalism are all symbiotic relations. While several generations of scientists have widely debated this notion of symbiosis, currently, the understanding of symbiosis as interspecies relationships of both mutualist and non-mutualist character is, for the most part, accepted and widely circulated via undergraduate biology books.

One of the most prominent and well-studied examples of mutualistic symbiosis is the two-species association with lichens, which was first described in the 19th century. Lichens display a win-win relationship with filamentous fungi and either cyanobacteria or microalgae. The fungi species benefit from photosynthesis products such as simple

sugars produced by cyanobacteria or microalgae. In turn, the latter grow, embedded in a mycelium structure, which protects them from dehydration and environmental stress. Another well-studied example of mutually beneficial relationships between two distinct species is the cooperation between mycorrhizal fungi and plants. In their interactions, plants fix carbon from the air through photosynthesis and provide the fungi with simple sugars. In response, the fungi help the plants extract minerals from the soil.

The notion of symbiosis is closely connected with symbiogenesis or endosymbiotic evolutionary theory. This theory explains the origin of more complex cells—eukaryotic cells—which constitute the bodies of animals, plants, and fungi.⁸ Endosymbiosis describes the relationship between two species where one organism lives inside the cell/cells (either for unicellular or multicellular organisms) of another. The theory suggests that, between 2500 and 1800 million years ago, a bigger cell engulfed a prokaryotic one (bacteria) and, instead of processing it as food, integrated the prokaryote into itself. In the process of incorporating the prokaryote, the bigger cell gained the ability to generate energy thanks to prokaryotic mitochondria and perform photosynthesis thanks to prokaryotic chloroplasts. Thus, instead of consuming the prokaryote, the host cell negotiated a functional relationship of symbiosis. Present-day examples of endosymbiosis include paramecium *Paramecia bursaria*, commonly known as infusoria, a single-celled freshwater being covered in cilia. *Paramecia bursaria* harbors several hundred single-celled green algae *Chlorella spp.* cells in the cytoplasm that perform photosynthesis for simple sugar production.⁹

In recent years, with the development of ecological thought, ecoart, bioart, and environmental humanities, the concepts of symbiogenesis and symbiosis have traveled far beyond biological sciences. As the discourses concerning climate crises and mass species extinctions alarmingly stress the catastrophic devastation facilitated by climatic disasters, artists and scholars in the humanities broadly employ the notions of symbiogenesis and symbiosis in their respective work. They increasingly emphasize interrelations and cooperation between diverse life forms as opposed to individualistic perspectives and conceiving of bodies as separate from the environment.

Perhaps one of the most prominent examples of engaging with symbiogenesis theory in the humanities is the work of technoscience scholar Donna Haraway. Drawing on the biological concept of endosymbiosis, Haraway has highlighted the interconnectedness of diverse organisms and entities.¹⁰ Instead of considering living beings as bounded “self-organizing individual units,” the author stresses their “multispecies becoming-with” and their constant mutual co-influences on each other.^{11, 12} Haraway regards such interrelations and interdependent sensibilities as crucial for establishing more ecologically-minded practices of living on a damaged planet.

Practitioners and academics in the visual arts also refer widely to the concepts of symbiosis and symbiogenesis to emphasize the constant interrelations between living beings. As artist and writer Claire Pentecost puts it, multiple contemporary artists create “symbiotic art”; that is, they expose the interrelations between diverse life forms and, in this way, help us to recognize “a world of relations” and our dependencies on manifold living beings.¹³ When talking about creative projects developed using microorganisms, artist Ken Rinaldo emphasizes their “symbiotic aesthetics” as the means to draw the attention of broader audiences to the complexity of natural living systems and their impact on environmental health.¹⁴ Overall, numerous researchers in the visual arts and (post)humanities engage with the concepts of symbiogenesis and symbiosis as making-with instead of considering bodies and entities bounded.¹⁵

Similarly, Stacy Alaimo regards bodies not as contained but rather as trans-corporeal, that is, porous, not existing as preceding entities but constantly co-influencing each other.¹⁶ As Alaimo argues, such a relational consideration of beings and entities requires a different kind of ethics—a trans-corporeal ethics. Indeed, trans-corporeal ethics arises from the obligations to “inquire about all of the substances that surround us, those for which we may be somewhat responsible, those that may harm us, those that may harm others, and those that we suspect we do not know enough about.”¹⁷ As the author posits further,

this approach to ethics “calls us to somehow find ways of navigating through the simultaneously material, economic, and cultural systems that are so harmful to the living world and yet so difficult to contest or transform.”¹⁸ In other words, considering things, bodies, and entities as porous and permanently affected by their symbionts and co-existing materialities requires understanding the material interchanges across beings and entities and, if possible, lessening the impact of harming interchanges.

Informed by these conceptualizations of symbiosis, symbiogenesis, and trans-corporeality, *Yeasts as We Do Not Know Them* engages with them on various levels: 1. the symbiotic natures of the yeasts co-habiting with and within other living beings; 2. in more metaphorical terms, human-yeast “symbiotic” relations in the production of various products and consumables and, finally, 3. the interdisciplinary “symbiotic” collaboration between a biotechnological engineer, designer, and art researcher aimed at creating the project. Depicting human-yeast relations as symbiotic, the book aims to map material interchanges across scales and species in the spirit of trans-corporeality, thereby demonstrating how yeasts interact with humans across multiple scales.

Mapping yeasts across scales

Yeasts—unicellular organisms that belong to the Fungi kingdom—play a vital role in the Earth’s biosphere. While scientists have described around 100,000 fungi, they estimate that there are 1.5 million different species of fungi in total, in which only around 1 percent might be yeasts. As of now, researchers have described around 1,500 yeast species and found that these microbial fungi exist in every single habitat and ecosystem: from terrestrial to aquatic ones and from tropical ecosystems to more extreme niches such as Antarctica, where the fungi present specific adaptations to diverse environmental factors and ecosystem dynamics. Yeasts play an essential role in those habitats, being involved in, among other processes, the decomposition and recycling of living and non-living matter. At the same time, some of them are related to diseases in plants, animals, and even tiny protists such as paramecium, widely known as ameba.

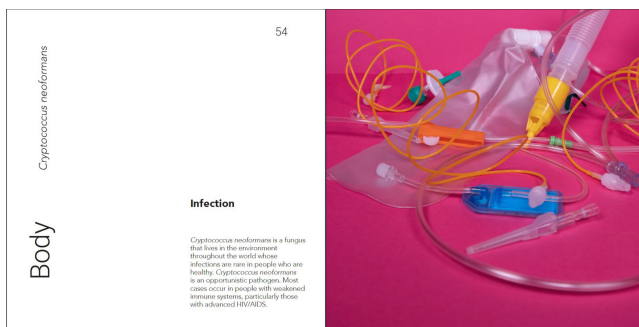


Figure 1. Page 54 and 55 of the book, *Yeasts As We Do Not Know Them*, related to *Cryptococcus neoformans* infection, 2022. ©Eva Direito, Patrícia Moreira, Olga Timurgalieva.

Single-celled yeasts require magnification to be visible to the naked eye if not grouped in colonies. In response to their general invisibility to humans, the book, *Yeasts as We Do Not Know Them*, helps to imagine their omnipresence and diversity. It conceives of bodies and entities as *microbial*, presenting material entanglements between yeasts and humans and several examples of yeast relations with plants, animals, and other microbes.¹⁹ For instance, *Candida albicans* and *Candida auris* are widely known for being related to human and animal infections. *Cryptococcus neoformans* and *Exophiala dermatitidis* are less known to a broader audience but related to invasive infections (Figure 1). So-called “wild” yeasts live in every environmental biome of the planet, including oceans, the stratosphere, glacial ice, bodies of animals, plants, fungi, algae, and microorganisms. Although not necessarily depicting the tiny fungal cells, the publication locates schematically yeasts’ symbiotic relations, including commensal, opportunistic, and pathogenic ones.

Additionally, the printed collection displays various examples of human-

yeast interactions involved in the manufacturing of numerous consumables. The immense and diverse metabolic powers within yeasts and their presence in all habitats and regions have led humans in various geographical locations to unknowingly use yeasts in fermentation to produce beer, bread, kombucha, soy sauce, and other food and beverages (Figure 2). These practices have been passed down from generation to generation through millennia. In contemporary societies, however, such ancestral uses of biotechnology have been significantly optimized, while the fundamentals of producing some of the most common drinks and snacks remain the same. *Yeasts as We Do Not Know Them* features several historical records of the use of yeast and numerous contemporary examples.



Figure 2. Production of rice liquor (mijiu) and Guangxi snake liquor (shejiu), illustrated in the fourth volume herbal, *Shiwu bencao* (Materia dietetica), 1368-1644. ©Wellcome Collection.

In recent centuries, scientific developments in biotechnology have permitted scientists to expand the metabolic toolkit of yeasts further and apply them in the manufacture of complex products such as pharmaceutical compounds, biofuels, cosmetics, and other chemicals, as well as bioremediation solutions. Additionally, yeasts are widely used in pharmaceutical research and experiments to produce a host of chemical substances and mixtures. *Yeasts as We Do Not Know Them* provides numerous examples of such products.

Although the book maps interspecies yeast relations across the scales of micro- and macroscopic bodies and the diverse ways in which yeasts are used in the production of numerous consumables, we do not intend to collect all the instances of human-yeast interactions with all the known microbial fungi. Instead, the art book functions as an invitation to learn more about some of these microbes and their interspecies material interchanges.

We do not regard this project as a mere celebration of human-yeast entanglements. We rather seek to encourage the readers to consider the impact of these interrelations and whether or not they can be harmful in some way. As geographer and sociologist Bram Büscher has pointed out, some aspects of human-nonhuman interactions involved in consumables production might harm ecological systems or be associated with social inequalities. For this reason, such manufacturing practices need to be revised or even “unmade,” argues the author.^{20, 21} *Yeasts as We Do Not Know Them* displays various examples of yeast applications and, by doing so, invites the viewers to contemplate which of the human-yeast relations might need to be remade or unmade. In this way, the project invokes trans-corporeal ethics.

Transdisciplinary synergies

The idea of *Yeasts as We Do Not Know Them* has grown from a transdisciplinary course called “Gender and Sustainability—Introducing Feminist Environmental Humanities” offered by the KTH Royal Institute of Technology and Linköping University. This course gathered artists,

scientists, architects, anthropologists, philosophers, and researchers in literary studies, art criticism, ecology, sustainability, and feminist and gender studies. Course participants discussed numerous complex challenges of the global ecological crises. They studied some of the theoretical instruments and methodologies that can be applied in dealing with global environmental issues.

In the spirit of the course, *Yeasts as We Do Not Know Them*, functions as a form of trans-disciplinary practice-oriented inquiry. More specifically, the book was developed by a biotechnologist Patrícia Moreira, a designer Eva Direito, and a researcher in bioart and environmental humanities Olga Timurgalieva. The cross-pollination between the three disciplines has allowed us to gather crucial information about the microorganisms and their application in biotechnological research and industrial production (microbiology), establish a conceptual framework to engage with interspecies relations creatively (bioart and environmental humanities), and, most importantly, to develop and apply the visual means with which to communicate our ideas (design). Combining this diverse disciplinary knowledge permitted us to learn about human-yeast ecologies as complex interspecies relations and translate what we learned into an artistic project.

As a product of transdisciplinary collaboration, *Yeasts as We Do Not Know Them* became a material embodiment of “symbiotic” relations between art and science. The book’s visuals and content reflect the interplay between the disciplines and the typical clichés associated with them. The project alludes visually to the style of a modern encyclopedia and simultaneously to a catalog of products for sale. As the primary reference for developing the images and graphics for our collection, we looked at the book, *Pig 05049* (2007), which was created by artist Christien Meindertsma and designed by Julie Joliat.

Pig 05049 compiles dozens of everyday consumables produced from a single source—a pig numbered 05049.²² The collection of consumables is divided into chapters, each devoted to a specific body part or bodily substance of the pig from which the products were made such as blood, skin, bones, fat, and so forth. Each product page features a photo illustration, a brief description, and an icon that refers to a type of consumable. Icons and chapters structure the book, thus referring to indexing conventions and highly organized scientific knowledge. At the same time, non-scientific symbols, icons, and names of body parts and substances, as well as the cover alluding to swine skin with the identification tag reveal the playful character of the book.

In a similar vein, *Yeasts as We Do Not Know Them* is quasi-encyclopedic and simultaneously calls to mind the glossy magazines aimed at advertising products and services. The publication comprises almost seventy pages presenting human-yeast interrelations (in its current prototype version; we aim to extend the book to 150 pages). Divided into six sections (research, body, drinks, food, industrial, and material), the printed collection provides scientific names of yeast species and brief descriptions of the way yeasts are used in a specific product or research area or are related to human bodies. Additionally, the pages with the excerpts from historical records (as mentioned above) provide insight into the past and show how yeasts were used in previous centuries (Figure 2). Thus, the book offers a wealth of factual information and some historical references.

At the same time, however, the accompanying photographs are not meant to illustrate yeasts, yeast-related diseases, and biotechnologies scientifically; instead, the visuals are playful (Figure 3, 4). With their colorful backgrounds and brightness, they depict objects connected with specific microbial fungi and the products and services produced with the involvement of these organisms. The making of such images was inspired by the work of photographers Colin Ross and Suzanne Saroff, who created bright still lifes with ambiguous spatial atmospheres and optical illusions. The photographers created these illusions with the help of water or a magnifying glass, which helped to distort light and alter shadows.^{23, 24} Borrowing some of these visual effects, the images in *Yeasts as We Do Not Know Them* attract the readers’ attention and invite them to think about the objects presented in the book from a new perspective.

Additionally, the zine incorporates both scientific classification systems as well as lay names and random groupings of objects and processes.

For instance, we use the scientific names of the yeasts and refer to classification systems, such as yeast families in the descriptions of yeasts and yeast biotechnologies. Simultaneously, we loosely divide the examples of yeast-human interactions into research, body, drinks, food, industrial, and material categories and present them in random order. With such decisions, we aimed to format factual information in a simple and easily graspable way.



Figure 3. Page 11 of the book, *Yeasts As We Do Not Know Them*, related to yeast, *Pichia pastoris*, studied to develop vaccines against Human papillomavirus infection, 2022. ©Eva Direito, Patrícia Moreira, Olga Timurgalieva.



Figure 4. Page 21 of the book, *Yeasts As We Do Not Know Them*, related to recombinant yeast, *Saccharomyces cerevisiae*, applied to produce xylitol, widely used as a sugar substitute, 2022. ©Eva Direito, Patrícia Moreira, Olga Timurgalieva.

The title of our project refers to the famous bioart book, *Art As We Don't Know It*, which explores the ways in which contemporary artists engage with material culture and the natural sciences, working across laboratories, art studios, and in the field to produce their transdisciplinary projects.

²⁵ Our zine was particularly inspired by the section of the book titled, “Life as We Don’t Know It.” This section refers to the most recent developments in synthetic biology (as an area of biological research focused on (re)designing natural systems) and generally the reconceptualization of notions of life.²⁶ *Yeasts as We Do Not Know*

Them involves examples of yeast bioengineering and the most recent applications of transgenic yeasts in different research areas. At the same time, the book also aims to represent a variety of yeasts, their habitats, and applications, thus aspiring to expand common knowledge about these microbes.

Overall, the project was developed via what one may call a “symbiotic collaboration” between the practitioners from three disciplines. A biotechnologist, a designer, and a researcher in bioart, working together, shared their knowledge and skills to create a cross-disciplinary publication about human-yeast relations.

Conclusion

The challenge of dealing with complex, urgent problems such as climate change has led to the development of transdisciplinary approaches that transcend the boundaries of environmental science, moving towards intensified collaboration between the arts, sciences, and humanities. A consortium of authors with very different academic backgrounds was thus involved in the creation of *Yeasts as We Do Not Know Them*.

In developing the book, we engaged with the notion of symbiosis as more-than-mutualistic interspecies relations and attempted to invoke trans-corporeal ethics by mapping some of the material interspecies interchanges. The project showcased diverse interspecies connections focusing on the microscopic single-celled organisms known as yeasts. Throughout the book, examples of ancestral, contemporary, technological, mutualistic, and hazardous connections with yeasts allow the audiences to decide how to define symbiosis and what kind of relationships with yeasts are possible. In this way, *Yeasts as We Do Not Know Them* invites the broader public to navigate the material systems of human-yeast relations and contest potentially harmful material interchanges. Just such an approach to our material systems is crucial in times of ecological crises.

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Authors Biographies

Olga Timurgalieva is a PhD candidate at City University of Hong Kong and a former visiting researcher at King’s College London. Awarded by the Hong Kong PhD Fellowship Scheme, her research investigates the intersections of biotechnology and contemporary art, with a particular focus on fungal microbes and their interspecies

relations. Olga has worked in art institutions, including the ZKM | Center for Art and Media (Karlsruhe), and co-curated the exhibition "Here and Elsewhere" at the Kobra Gallery, The Strzemiński Academy of Art (Lodz) and the festival "Seasons of Media Arts 2019" at the ZKM. She participated in the creation of collaborative art projects that have been exhibited at Aalborg University Copenhagen (Denmark), nachtspeicher23 (Germany), and Jockey Club Creative Art Centre (Hong Kong).

Patrícia Moreira holds a PhD in Biotechnology with a specialization in Biochemical Engineering from the Catholic University of Portugal (UCP, Portugal). She is an Assistant Professor at the School of Arts (UCP). She is an integrated member of the Center for Research in Science and Technology of the Arts (CITAR). Additionally, Patrícia coordinates the Area-Focus Heritage, Conservation and Restoration of CITAR and collaborates with the Center for Biotechnology and Fine Chemistry, both UCP. Her main research area is innovation in Biotechnology for Cultural Heritage, with an emphasis on biodeterioration, sustainability, citizen science Green Conservation and bio-art practices.

Eva Direito holds a degree in Art Conservation. She's doing her master's degree in Conservation of New Media Art at the School of Arts of the Catholic University of Portugal (UCP, Portugal). Having received an artistic education, Eva works with digital and analogue photography and graphic design. During the past few years, she's been working as an Art Director in short movies for the School of Arts, some of which earned accolades. For instance, "Our House in Flames" by Miguel Mesquita got nominations at the Curtas Festival of Vila do Conde, Portugal. Additionally, "Hysteria" by Luisa Campino, with Eva as artistic director, won prizes at the Sophia Awards in Portugal.