2023

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Recommended Citation

Scott F. Gilbert. (2023). "Foreword: Symbiotic Perspectives On The Processes Of Biology And Art". *Drawing Processes Of Life: Molecules, Cells, Organisms*. xix-xxiv. DOI: 10.2307/jj.6947019.5
https://works.swarthmore.edu/fac-biology/640

Foreword: Symbiotic Perspectives on the Processes of Biology and Art

Scott F. Gilbert

This is a rather subversive book. It's a volume about science, art and freedom. It doesn't try to make bridges between art and biology because it finds no such separate entities or processes to bridge. While the disciplinary field of biology may interact with the disciplinary field of art, biology and art don't interact. They interpenetrate each other. This perception leads to a startling and perhaps unsettling conclusion: changes in our knowledge of biology demand similar changes in how biology is represented. The new biology and the new representations of biology mutually reinforce one another. As biologist and historian Michel Morange (2011) noted, 'To introduce a new representation is an event that is as important in the construction of scientific knowledge as technological developments and the unveiling of new phenomena'.

New biologies coincide with new representations. Think of Darwin's 'tree of life' or the Watson and Crick 'double helix'. Each of these representations has become an icon of biology, found on logos, t-shirts and in our minds. Other examples include Maria Sibylla Merian's depiction of a life cycle, Jane Richardson's 'ribbon diagrams' for folded proteins, and C. H. Waddington's epigenetic landscape. These drawings did not change the data; they changed the way we perceived and organized the data. The illustrations suggested new sets of questions for scientists to ask. They gave artists new ways to draw and new ways to represent living beings.

So one should expect that as biology changes, the old bottles will not be able to contain it. Twenty-first-century biology is not like twentieth-century biology. Our present biology is not about entities such as genes or organisms; it is about relationships. Here, the gene isn't a gene until the DNA gets 'interpreted' as one by the nuclear proteins (Stotz et al. 2006; Stammatoyannopoulos 2012). The organism isn't an organism without the symbiotic interactions that develop

and maintain its physiology. Twenty-first-century biology is not about stasis, but rather about processes (Nicolson and Dupré 2018). Indeed, just as physical objects can be represented as both particles and waves, living beings are both entities and processes. And these entities appear to be themselves concrescences of metabolic, developmental, and evolutionary processes (Gilbert 2017). There is an anagenic change occurring in biology, with systems biology, symbiosis, developmental plasticity and niche construction coming to the fore. What had been peripheral is moving towards the center. Complex networks of cooperation and competition between species and within an organism are becoming highlighted rather than simple competition.

Indeed, one of the most important changes presented by the new biology is the notion of organisms as 'holobionts'. A holobiont is a single individual composed of other individuals of many different species, and each plant and each animal can be considered a holobiont. About half the cells in the human body are symbiotic microbes, and they are integrated into our bodies' physiologies (Gilbert et al. 2012; McFall Ngai et al. 2013). We need these microbes to help mature and sustain our guts, capillaries and neurons. Moreover, the microbes and their hosts may be essential for the other. The holobiont cow, for instance, contains both the bovine cells derived from the fertilized cow egg as well as a set of microbes that it acquired from its maternal and pastoral environments. Amazingly, there is nothing in a cow's genome that enables it to eat grass. The digestion of plant materials is accomplished in the cow's stomach by her symbiotic microbes. The microbes, moreover, are allowed to propagate themselves within the gut of the cow. This is called mutual scaffolding (Chiu and Gilbert 2015, 2020). The microbes allow the existence of the cow; the cow perpetuates the existence of the microbes.

The holobiont is thus both an organism and a collection of ecosystems (Gilbert 2019; Suárez and Stencel 2020). This notion of bodies as holobionts may help solve a problem in visualizing the relationships between art and biology. We can represent art and biology as parts of a holobiont organism. Looking at it one way, art and biology make a single composite artscience organism. Looking at it another way, art and biology are different entities that can interact to form new types of structures. This dual *Gestalt* of foregrounding/backgrounding alternations between single and composite units characterizes physical biological bodies. It may also characterize bodies of knowledge.

Biologists and artists desperately need ways to represent such ideas and processes. How does one represent evolution when one thinks about evolution as changes in embryonic development over time? How does one represent organisms when they develop, flourish and evolve as consortia of mutually interacting symbionts rather than as monogenomic products of the fertilized egg? How does

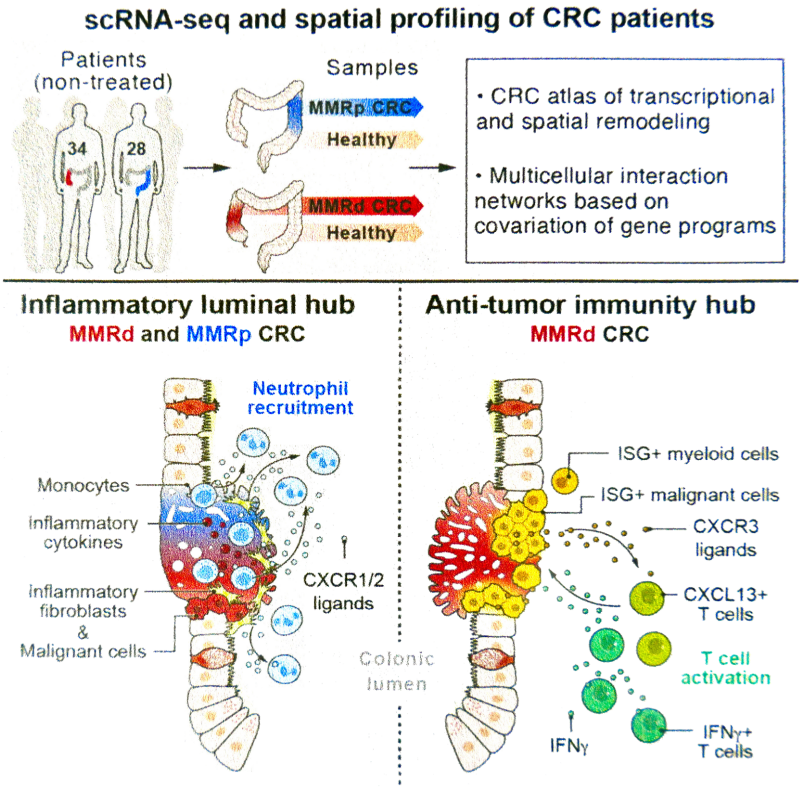

FIGURE F.1: Showing processes process in a 'Graphical Abstract'. This is from article 'Spatially organized multicellular immune hubs in human colorectal cancer', by Karin Pelka et al. (2021). It is from the journal *Cell*, which expects each article to be accompanied by such a graphical abstract. The upper panel represents the process of experimentation; the lower panels are interpretations of data, showing interactions in the gut between cell types in the production of inflammation (left) and anti-tumour immune cells (right), respectively.

one represent a life cycle that takes instructions from external living and abiotic sources? In short, how does one represent a biology of converging processes? How does one reconfigure one's laboratory, or one's studio, to study these new phenomena of investigation? Can two-dimensional imagery be revitalized in the era of animation and virtual reality? So this book is not, and cannot, be solely about how new art can represent and help generate a better science. It is also about the reciprocal processes whereby new science can promote new types of art and art practices.

The ability to use computers for visualization has changed the way we view data, but not how we view biology. Microarray data, for instance, are often

graphed as 'heat maps', wherein one can visualize changes in the expression of several genes as conditions change. This improves the readers ability to see patterns, but this merely puts colour onto data otherwise represented as '0, + or +++'. Similarly, cluster analysis is now being taken from the social sciences to group biological entities as similar or dissimilar according to mathematical algorithms set with particular thresholds. But this, too, does not escape the static paradigm. It excels at distinguishing 'types'. Moreover, these types need not be 'real', but those that best fit the paradigm that informs the algorithm (Rosenberg et al. 2005; Yoder 2014). But biology has become a science of processes, and we are frustrated by our inability to represent these processes on paper.

Biological journals have realized this moment. Many of the most highly cited journals in the field now require 'Graphical Abstracts', and such abstracts are being required by an increasing numbers of journals over the past decade. Most of these Graphical Abstracts represent processes – either the biological process being delineated or the experimental process through which these new processes were found – and sometimes both, as in Figure F.1 (Hullman and Bach 2018). In these Graphical Abstracts, we can still see the power of drawings. In one sense, these drawings can be constricting. Graphical Abstracts provide a before-the-data channel for the mind to follow. The possibilities of the viewer's contribution is being narrowed. They are a biasing technique, marginalizing other interpretations. Note the multiple use of arrows in such a figure. These are the processes. It is in the arrows that the science occurs, and these processes are thereby hidden from the reader.

But these diagrams and drawings are not merely a lesser form of scientific illustration (Abrahamsen et al 2018). The Graphic Abstracts are different than illustrations, for they can more readily generate thought concepts. They can become carrier bags in which new ideas can be put together, jumbled up and reoriented into new configurations. One has freedoms in a drawing that one doesn't have in a photograph or realistic illustration. And the role of the audience is different. The viewer is more a participant in a diagrammatic process than an observer of an illustration.

Also, this book is not the answer to how biologists can best represent processes and the world of becomings. Rather, it is an embryonic landmark *towards* representations that can capture movement – a temporal dimension – on a two-dimensional surface. It is part of the process. The book is the product of biologists, philosophers and artists working together to formulate new ways of representing our new approach to life. It is a mutualistic symbiosis, where identities are transformed, information and nutritive substances shared, and where new organisms emerge.

ACKNOWLEDGEMENT

I wish to thank Dr Nir Hacohen and Dr Karin Pelka for allowing me to use the Graphic Abstract from their paper.

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