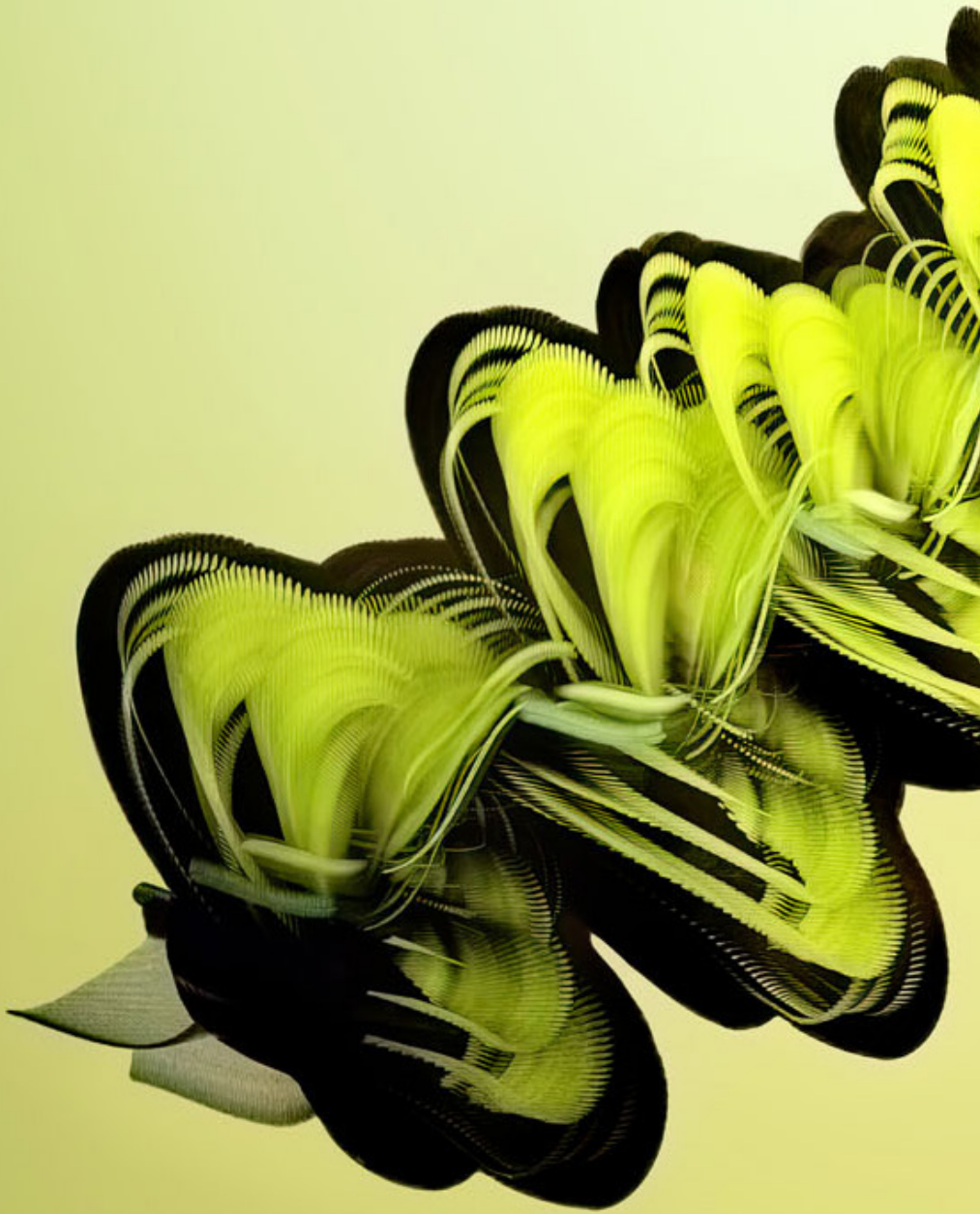
zq36

VOL 2 | 2024



About Zygote Quarterly

Editors
Norbert Hoeller
Tom McKeag
Marjan Eggermont

Contributing Editors
Adelheid Fischer
Kristen Hoeller
Raul de Villafranca
Manuel Quirós
NOUS Ecossistema
Shoshanah Jacobs

Contact
info@zqjournal.org

Cover art
Cover: Two-lined Spittlebug - *Prosapia bicincta* (6,000 fps) | pp. 2-3/pp. 72-73: Zebra Longwing - *Heliconius charithonia* | Photos: Xavi Bou, 2022.

Design
Marjan Eggermont

Web
Colin McDonald
Norbert Hoeller

Creative Commons License
CC BY-NC-ND

ISSN
1927-8314

Female Zebra Longwing (*Heliconius charithonia*) laying eggs | Photo: John Flannery, 2020. | Flickr cc

Editorial

In this issue the dimension of time fills all of our articles. We begin with a review of the classic *On Growth and Form* and ask if a treatise written over a century ago still has relevance to modern science and lessons to impart to biologically-inspired designers.

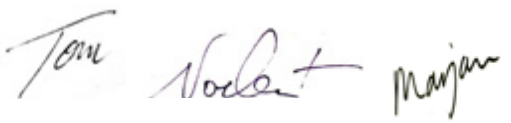
In our interview with biologist and professor of biomimetics and innovation Kristina Wanieck, she casts ahead to predict " a new S-curve" in the efficacy of BID practice, while sharing her views of the challenges that the practice faces.

Xavi Bou and Adrian Smith serve up a delicious portfolio of form across time: time-lapse images of insects in motion; their colorful paths creating forms that are newly sculptural and beautiful.

Our memoriam for aquaculture pioneer Thierry Chopin marks the end of a life well spent, helping people and planet, while Thomas Fisher marks a beginning with his recounting of Biomimetics International's inaugural symposium.

We hope you feel your time is well spent reading these articles. It has certainly been a pleasure bringing them to you.

Happy reading! ×



Tom, Norbert, and Marjan

Contents

A Diodon (puffer) fish in Mauritius.
Photo: Alain Feulvarch, 2008 | Wikimedia Commons

Article

On Growth and Form: Six Lessons for Designers

Tom McKeag

On Growth and Form: Six Lessons for Designers

Tom McKeag

"...the finest work of literature in all the annals of science that have been recorded in the English tongue." - P. B. Medawar, Nobel Prize recipient for immunology, 1958 (a)

The year is 1917, and the world is weary of its first World War, but it will go on for another year, long enough to kill an estimated 15-22 million people and start a deadly influenza pandemic. The pandemic will occult the war's casualties by claiming an additional 50 million lives. US President Woodrow Wilson will enter the European war that he had long avoided and Lenin will emerge as the Marxist leader of a transformed Russia. The madness of the Modern seems to have enveloped the globe.

Into this weary and disordered world comes a book from another century, two decades in the making; the solitary and brilliant toil of an eminent Scottish classicist and zoologist, D'Arcy Wentworth Thompson (1860-1948). It is called *On Growth and Form* (1) and it is partly an intellectual rejoinder to the revolutionary paradigm of the previous century, Darwin and Wallace's theory of evolution through natural selection of 1859 (2). In its search for truth and beauty in the Pythagorean realm of numbers, it is also a rejoinder to what this classicist called "... the unpoetic, non-mystical modern and Western world" (3).

Darwin's theory stood on four pillars: there is random variation in genetic traits; there is differential reproduction favoring survival traits; there is heredity of these traits over time that favor those with these traits; there is an end result that reflects a greater population with these traits. Despite misconceptions, Nature did not get to pick these survival traits, but had to be content with those alleles that were genetically available.

Enter Thompson, who was a prickly antagonist of natural selection and modern ideas of evolution, as they were in conflict with his alternate vision. To him it was not enough to focus on the functional endpoints of species or their antecedents, but complex organisms should also be analyzed in light of the physical forces that had shaped them. Moreover, Thompson rejected the Darwinian notion of similarity of form as the basis of evolutionary lineage, and the belief that minor mutations over a span of time were a sufficient mechanism for evolutionary change.

He reasoned that only a limited number of design solutions were compatible with physical principles and met the challenges faced by living organisms (4). Consequently, it was these physical principles that fundamentally constrained biological

D'Arcy W. Thompson and parrot, 1946
Photo courtesy of University of St. Andrews.

On Growth and Form: Six Lessons for Designers
Tom McKeag

form, thereby limiting and governing the evolution of functional morphology (5). His offered paradigm for evolution was "macromutationism", the theory that major transitions in evolution occur episodically and as a result of these outside, physical forces.

Thompson built his case this way: First: size matters; it has consequences for the organism. He cited three examples of Man, a water beetle and a bacillus in the section "On Magnitude". Each organism was affected by different dominant, physical forces: gravity, surface tension, and Brownian movement respectively, to name a few. Second: living shapes are formed by physical forces acting upon the component material of the living thing, irrespective of whether this material is alive or not. Its size, density, viscosity and rigidity are prime factors in how it responds to these physical forces. This is where Thompson hones his treatise in most of the 17 chapters of the book *"... Cell and tissue, shell and bone, leaf and flower, are so many portions of matter, and it is in obedience to the laws of physics that their particles have been moved and conformed"*.

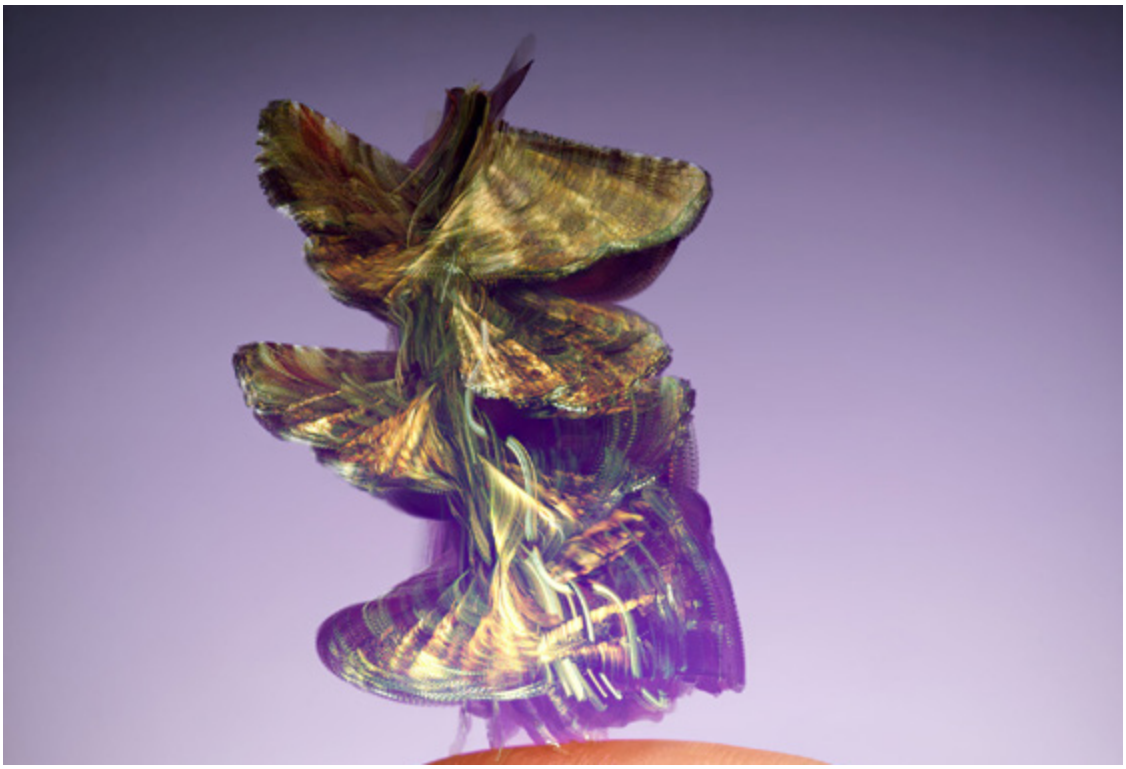
Form, therefore, was not just a signpost to indicate genetic heritage, nor a sterile catalogue of "infinite variety" that many devotees of Darwinism had espoused. Its study was a science unto itself, full of possible insights and important discoveries about the world we live in. Thompson, polymath that he was, employed a powerful and innovative tool for this study of living things: mathematics. To him it was *"essential to the proper study of Growth and Form"* (6). In this great work by the Greek classicist, mathematics meant geometry.

Most beloved of these geometries was the logarithmic spiral and Thompson cited its presence in foraminifera, leaves, seashells, horns and claws; even in the flight paths of insects. Its common occurrence seemed proof of fundamental governing principles that could be divined by mathematics (7). He postulated, for example, that just a few parameters in the forming of a mollusk shell, the shape of the generating curve, rate of its increase and size, and its change of position relative to the axis of coiling, were sufficient to represent the full range of possible shapes. It was only in the 1960s that researchers could affirm a comprehensive spectrum of possibilities with the aid of electronic computing (8).

While time and science appear to have shown him wrong in his belief in macromutation, his keen erudition and breathlessly wide scholarship continue to be a wellspring of inspiration for both scientists and designers. His grand theory of the

cause of evolution may have been wrong, but his recognition of the secondary causal influence of physical forces and his methodology for the study of form were not; in many instances just 50 years too early to be vindicated or repudiated. Eminent evolutionist Stephen J. Gould has called him the godfather of the Science of Form, writing *"... he confused his causes; but when we view physical forces not as the architects of form but as the blueprints that specify optimum shapes, we have our test for relative efficiency: the comparison of an actual structure with its optimum expressed in an engineer's terms."* (5)

What lessons, then, should a biologically-inspired design practitioner bring away from this great tome that few have read but many have cited? What makes these lessons relevant and valuable beyond the romantic recognition of a colorful antiquarian? Below are six key attributes modeled by Thompson.



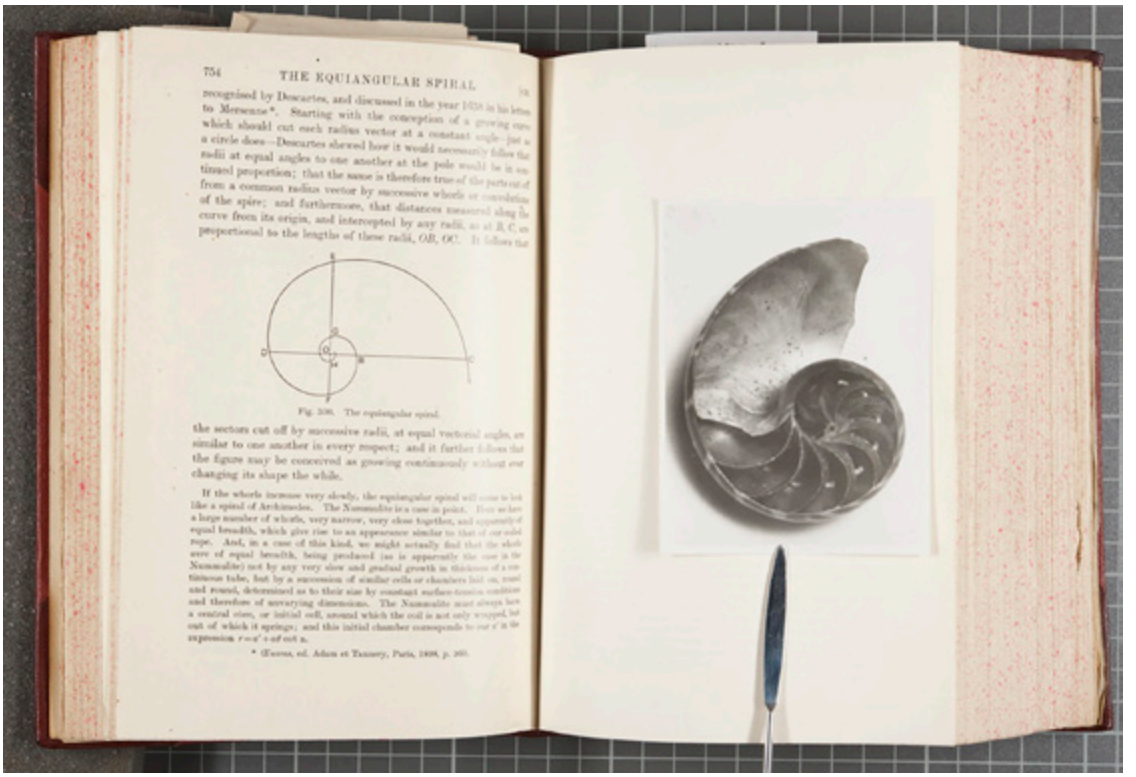
Dark marathyssa - *Marathyssa inficita*
Xavi Bou, 2021

On Growth and Form: Six Lessons for Designers
Tom McKeag

1. Knowledge

Training as a technical specialist, no matter how comprehensive, is not really sufficient to make a good (or hopefully great) bio-designer. One needs a wider intellectual field of view in order to understand the wide parameters of biology, physics and engineering; enough to ask the right basic questions and to collaborate with other experts. What's more, one needs the arts in order to communicate with the world.

Thompson was the quintessential Renaissance Man, molded though he was in the Victorian Age. While his first loves were the classics and natural history, he was also keenly interested in geometry, astronomy and physics. His education and scholarship led him to a professor position at the University College in Dundee, Scotland in 1884, at the young age of twenty-four. By 1910, he had published what is now a standard translation of Aristotle's *History of Animals*, as well as *A Bibliography of*


754 THE EQUIANGULAR SPIRAL

recognised by Descartes, and discussed in the year 1638 in his letter to Mersenne*. Starting with the conception of a growing curve which should cut each radius vector at a constant angle—just as a circle does—Descartes showed how it would necessarily follow that radii at equal angles to one another at the pole would be in continued proportion; that the same is therefore true of the parts cut off from a common radius vector by successive whorls or convolutions of the spire; and furthermore, that distances measured along the curve from its origin, and intercepted by any radii, as at B, C, are proportional to the lengths of these radii, OB, OC.

Fig. 300. The equiangular spiral.

the sectors cut off by successive radii, at equal vectorial angles, are similar to one another in every respect; and it further follows that the figure may be conceived as growing continuously without ever changing its shape the while.

If the whorls increase very slowly, the equiangular spiral will come to look like a spiral of Archimedes. The Nummulite is a case in point. Here we have a large number of whorls, very narrow, very close together, and apparently of equal breadth, which give rise to an appearance similar to that of a coiled rope. And, in a case of this kind, we might actually find that the whole curve of equal breadth, being produced (as is apparently the case in the Nummulite) not by any very slow and gradual growth in thickness of a continuous tube, but by a succession of similar cells or chambers laid on, round and round, determined as to their size by constant surface-tension conditions and therefore of unvarying dimensions. The Nummulite must always have a central core, or initial cell, around which the coil is not only wrapped, but out of which it springs: and this initial chamber corresponds to our $r = a^0$ in the expression $r = a^\theta$ of out a.

* (Œuvres, ed. Adam et Tannery, Paris, 1898, p. 300.

Page 754 and an inserted page from D'Arcy Wentworth Thompson's personal copy of *On Growth and Form* | University of St. Andrews Library's Special Collections

Protozoa, Sponges, Coelenterata, and Worms. At Dundee he established a museum of zoology, and had been appointed as a sort of scientist diplomat on several government missions. In the same year, Cambridge University Press asked if he would write a book about whales, and he instead proposed an outline of *On Growth and Form* (9). For two years he had been lecturing and publishing his ideas on the physical forces shaping living form, most notably in a two-page paper in *Nature*, *"On the Shape of Eggs and the Causes Which Determine Them"*. This paper was a warm-up for what would become his magnum opus, for it stressed the physical forces (rather than heredity, fitness and natural selection) which would create the variety of egg shapes.

2. Integration

Thompson's foundational knowledge base allowed him to think creatively about how one discipline might inform another and contribute to a multi-faceted solution. His love of Greek geometry, for example, brought him to muse on the spiral shape of foraminifera, and, in his 1910 article on the shapes of egg, a knowledge of physics was used to enter the debate on biological evolution. Here he appears to strike an uneasy peace with the Darwinians; while mentioning several final causes (like the self-centering rolling action of cone-shaped eggs), he grants them space without losing ground for his idea of physical laws creating shape. *"Whatever truth there be in these apparent adaptations to existing circumstances, it is only by a very hasty logic that we accept them as a vera causa or adequate explanation of the facts. We must state the efficient cause as well: In Aristotle's parable "the house is there that men may live in it; but it is also there because builders have laid one stone upon another .... All the while, warp and woof, mechanism and teleology are interwoven together, and we must not cleave to the one nor despise the other; for their union is rooted in the very nature of totality"*. (10) Linking the efficient cause of both organic and inorganic shapes was perhaps Thompson's greatest contribution to Science and could not have been done without this ability to integrate ideas and methods.

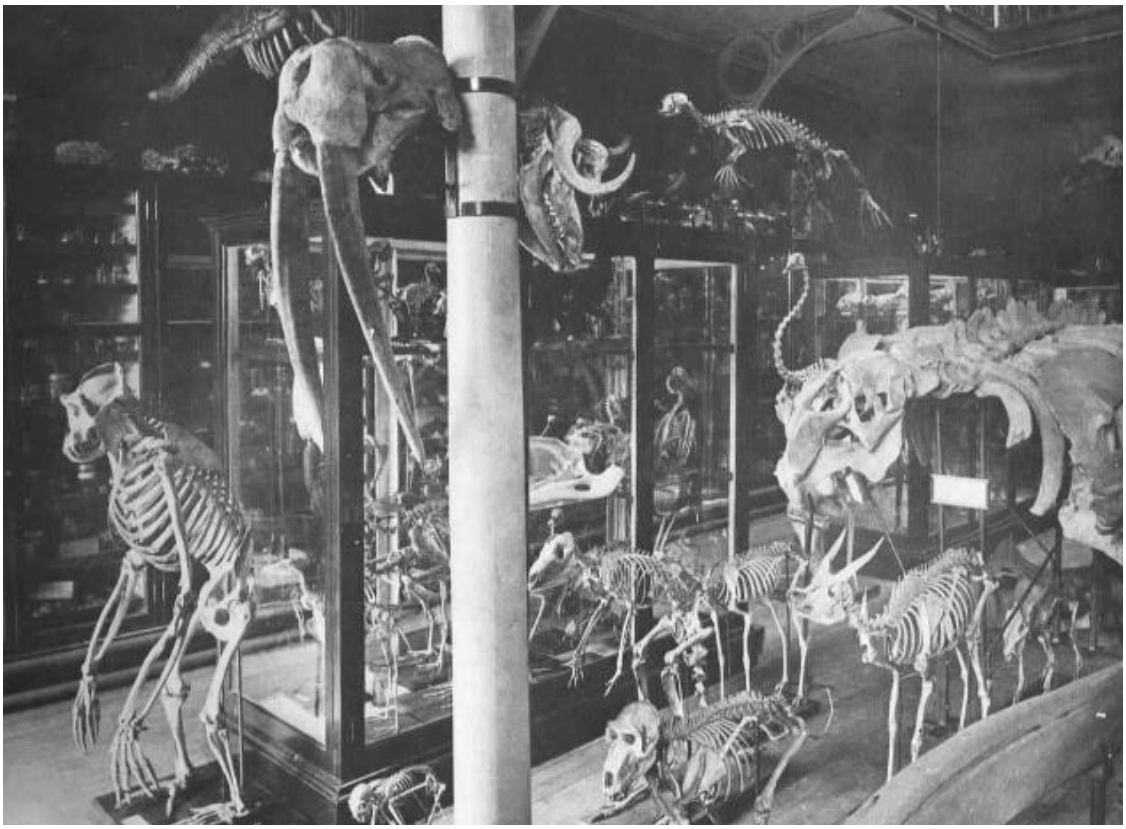
3. Framing

The major impetus of *On Growth and Form* was a search for universal laws that might explain the complexity of biological change over time. Were there golden geometries that could explain and even predict the shapes of the wide array of life that was quickly accumulating in Thompson's museum of zoology? What perhaps saves his work from history's ash heap of overly

On Growth and Form: Six Lessons for Designers
Tom McKeag

mechanistic theorems is his recognition of the limits of space and physics (and of one analytical discipline over another). He devotes an entire chapter to size because linear scale determines the nature of dominant external forces and hence the reaction of living material and its resultant shape, whether it is van der Waals forces or gravity, surface tension or viscosity. The relationship of volume to surface area in an animal is an example of a reliable predictor of limits and characteristics. External forces can be measured, too, and the knowledge of their effects and dynamic behaviors in different situations were a lifelong study for Thompson.

Framing essential parameters in the problem space is a critical skill for all designers, but is especially fraught for those investigating dynamic, living systems. One of Thompson's main contributions to



D'Arcy Thompson's original Zoology Museum
Photo: D'Arcy's Museum, University of Dundee

science was his introduction of principles of physical law to a debate about form that was dominated by adherents of natural selection and taxonomy. His new paradigm was a re-framing of essential factors in the creation of biological shape.

4. Curiosity

Computational mathematician Stephen Wolfram, in a short biographical sketch of Thompson, notes that in essence, he was a collector: Greek words, academic references, specimens, antiquarian books- and facts and statements (many typed onto index cards) were all grist for his mill (11). Continual curiosity seems to have been his modus operandi his whole life; at his death at age 87, he was still corresponding about specimens for his museum. It is hard to imagine that without this curiosity Thompson would have had the experience and energy to bring his knowledge, integration and framing to bear. A list of his lecture topics is a journey into the arcane and wonderful.

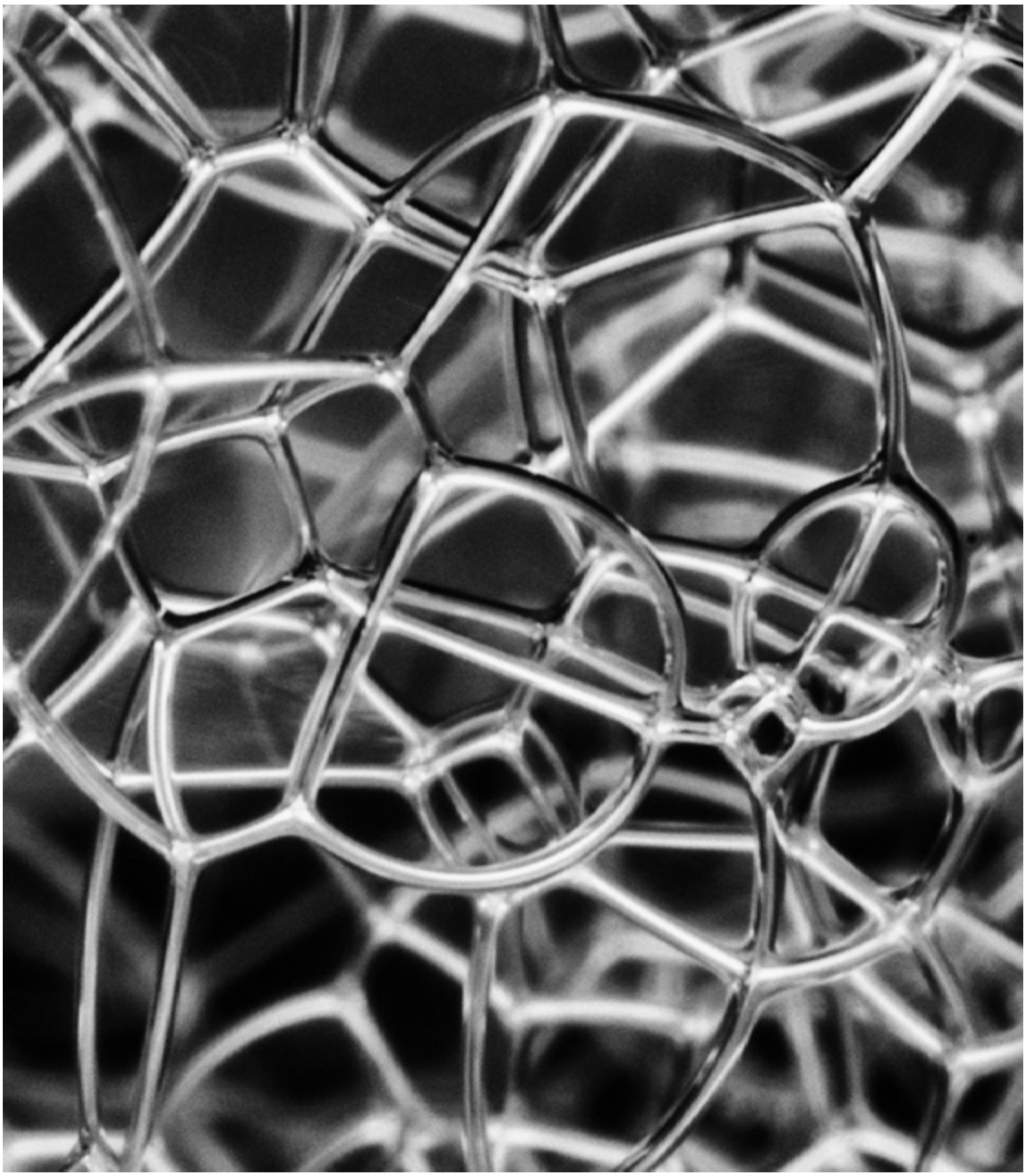
5. Rigor

Academic rigor is a hallmark of *On Growth and Form*, whether in the application of mathematical modeling or geometrical principles or the discussion of physical forces, biological specimens or the use of the English language to explain a complex analysis. Thompson's reputation also rests on his meticulous observation and measurement of the morphological features of real specimens. His illustrated examples lent weight to his arguments for a larger theory. For example, in investigating his perceived mathematical correspondence between the surface energy of soap bubbles and the formation of cells in frog embryos, he took over one thousand photographs of the eight-cell stage embryos in order to argue that there were only 12 cellular patterns possible.

6. Audacity

Searching for universal laws of biomorphology is not for the faint of heart! While Thompson was limited by the analytical tools available to him, and has been proven wrong in many of his postulations, some of his ideas still remain cogent in the marketplace of modern scientific debate, particularly in the fields of evolutionary biology, quantitative biology and mechanobiology (indeed, areas of inquiry in which he was prescient). At the century mark of its first publication *On Growth and Form* had received over 6,000 citations, with 180 in that year alone, with numbers growing with the passing years (12). G. Evelyn Hutchinson had predicted this in his 1948 memoriam:

On Growth and Form: Six Lessons for Designers
Tom McKeag



A macro of soap bubbles
Photo: Paul VanDerWerf, 2018 | Wikimedia Commons

"one of the very few books on a scientific matter written in this century which will, one may be confident, last as long as our too fragile culture" (13).

Thompson operated in an age without computers, before the discovery of the structure of DNA and the establishment of the field of molecular biology. To explain his ideas about the basis for shape transformation he was forced to use an illustrative grid and to stretch that grid to show the resulting possibilities of selective dimensional change. To discuss cells and close packing he used soap bubbles, as they were much easier to observe over time. While he recognized that this model would ignore living processes and might be oversimplified, his application of least surface area, 120 degree junctures and the force balance of three-way structures are observed today in many equilibrium systems, such as the cone arrangement in certain compound insect eyes (14).

With modern scoping and analysis tools, researchers have now applied ideas to the molecular scale put forward by Thompson for the macro scale. The importance of shape molded by physical forces in the study of gene expression is one, according to science historian and physicist Evelyn Fox Keller, specifically *"...to the roles of chromatin, epigenetic markers, and ncRNA in this regulation... What Thompson said about the structure and conformation of organic forms can also be said about the structure and conformation of all the molecular components of organisms, including the organic forms of both DNA and what we have been calling genes: 'no organic forms, he wrote, 'exist save such are in conformity with physical and mathematical laws' "*(15).

With the perfection of new tools for imaging and the folding of quantitative analysis into the investigation of living form, the case for relevance of many of D'Arcy Thompson's ideas has become easier to make. While complex forms might not be explained entirely as the result of mechanical causes, mechanistic reductionism can, it appears, be selectively applied. Hit or miss, the legacy of *On Growth and Form* continues to offer portals for new scientific investigations and discoveries. Regardless of its place in the grand theories of evolutionary biology, its methodological attributes, and those of its author, will continue to inspire and inform those who care to look. ×

We would appreciate your feedback on this article:

On Growth and Form: Six Lessons for Designers
Tom McKeag

Notes

a. P. B. Medawar, "D'Arcy Thompson and Growth and Form," postscript to Ruth D'Arcy Thompson's biography of her father, *D'Arcy Wentworth Thompson : the scholar-naturalist, 1860-1948*, pp. 219-33, and reprinted in The Art of the Soluble (London, 1967), pp. 21-35.

1. Thomson, D. W. (1917). *On growth and form*.

2. Darwin, C. (1964). *On the origin of species*: A facsimile of the first edition. Harvard University Press. Original title: "*On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*"

3. "The School of Pythagoras," *Nature*, xcviii (x916)

4. Briscoe, J., & Kicheva, A. (2017). The physics of development 100 years after D'Arcy Thompson's "On Growth and Form". *Mechanisms of development, 145*, 26-31.

5. Gould, S.J., 1971. D'Arcy Thompson and the science of form. *New Lit. Hist. 2*, 229.

6. *On Growth and Form*, epilogue, p. 1096.

7. Ball, P. In retrospect: On Growth and Form. *Nature* 494, 32–33 (2013). https://doi.org/10.1038/494032a

8. Raup, D. M. (1962). Computer as aid in describing form in gastropod shells. *Science*, *138*(3537), 150-152.

9. Wolfram, *"The Victorian Tale of On Growth and Form"*, in D'Arcy Wentworth Thompson's Creative Influences in Art, Design and Architecture, p. 23.

10. On Growth and Form, p. 7 (*p. 7*)

11. Wolfram, *"The Victorian Tale of On Growth and Form"*, in *D'Arcy Wentworth Thompson's Creative Influences in Art, Design and Architecture*, p. 23.

12. T. E. Saunders, Imag(in)ing growth and form, *Mechanisms of Development 145* (2017) 13–21 p. 19

13. Hutchinson, G. E. (1948). MARGINALIA:" IN MEMORIAM, D'Arcy Wentworth Thompson"(1860-1948). *American Scientist*, 36(4), 577-606.

14. T.E. Saunders, Imag(in)ing growth and form, *Mechanisms of Development 145* (2017) 13–21, p. 16

15. Keller, E. F. *"Has D'Arcy Thompson Been Vindicated?"*, in *D'Arcy Wentworth Thompson's Creative Influences in Art, Design and Architecture*, p. 41.

Mola mola or sunfish
Photo: National Marine Sanctuaries 2016 | Wikimedia Commons

The bluewing 2
Photo: Adrián Castillo Rivera, 2013 | Flickr cc

Interview

Kristina Wanieck

Interview
Kristina Wanieck

Dr. Kristina Wanieck is a professor of Biomimetics and Innovation at the Deggendorf Institute of Technology, Germany. One of her research areas focuses on the methodology of biomimetics.

What are your impressions of the current state of biomimicry/bio-inspired design (BID)?

There was growing hype in the first decade of the 2000s, leading to questions about whether BID could deliver on its promises. It became apparent that due to the complex process, a deeper understanding of the process and its underlying steps were necessary. In spite of a focus on the process and facilitating tools, leading to international standards and technical guidelines, questions remained: what can be achieved with this approach and is it a "nice to have" or a true means for innovation.

Kristina Wanieck
Photo: Angéla Geihofer

I believe that BID will deliver in this decade a significant impact on technology, economy, science, and society through substantially different ways of production and consumption. I believe BID is starting its next S-curve towards sustainable bio-inspired innovation. As always, new S-curves in BID are dependent on new technologies enabling BID to collect the necessary knowledge to reveal its potential. In this decade, it is AI technology that will facilitate this new phase. Despite the disillusionment of various stakeholders in the past years, there is a rising trend again, and hopefully this time it is not hype but a true path to problem-solving, small scale and large scale, especially for complex challenges from climate change adaptation strategies to a value-based economy and a society that protects biodiversity and the environment while delivering socio-technological progress. This topic couldn't be more relevant today.

Bufferfly emerging from pupa, *Morpho peleides*

Photo: Tim Sheerman-Chase, 2017 | Wikimedia Commons

Interview
Kristina Wanieck

Blue Morpho
Photo: Rene Mensen, 2014 | Flickr cc

What do you see as the biggest challenges?

The biggest challenges have been known for years. How could technology-focused developments consider biological models if there is nobody talking about these models? The topic is still underrepresented in education and public awareness in many ways. First, we are unaware of what biological systems do, how much knowledge and how many solutions are found in functional adaptations that have evolved over millions of years. Second, we not only need to value how natural systems have evolved and adapted, but to also know how we can learn from them to optimize products, to make processes more efficient, and to re-think business models - this needs communication as well as teaching and training. Third, using biological adaptations for problem-solving often needs luck, as some phenomena are discovered serendipitously, but also requires hard work to fully understand biological properties, and to learn how to abstract and transfer that knowledge to technology. Therefore, we need the willingness to invest time, effort, and money into an innovation approach that is promising but still in some ways uncertain. This is a true challenge.

What areas should we be focusing on to advance the field of BID?

To me, it is any area linked to sustainability, from new technologies for responsible innovation to new business models. I believe that learning from biological systems can help create a new value-based economy by integrating strategies that natural systems demonstrate in a holistic way. To achieve this requires a lot of research, but luckily the knowledge is already out there, and it is up to us where to look and what to focus on.

How have you developed your interest in BID?

This was by chance. I had never heard of that topic during my biology studies. But then I saw a position in biomimetics at the Deggendorf Institute of Technology, and thought they might need a biologist. I got that position and learned a lot about the topic, in academia and industry, in research and innovation management. It was a completely new way of seeing knowledge about biological models and learning how to transfer that knowledge to technology. This new mindset challenged me a lot in the beginning, before I could really see the potential. What fascinated me the most were the people working in the field. They

are truly special, and the community is amazing.

What is your best definition of what we do?

We try to contribute to change and deliver ways to foster the transformation of economies and society to find solutions for urgent problems. We believe that natural systems have developed strategies and adaptations to changing environments that can help us find these solutions. Additionally, we believe that bio-inspired design can shift technological progress towards more biology aware development, helping protect biodiversity.

By what criteria should we judge the work?

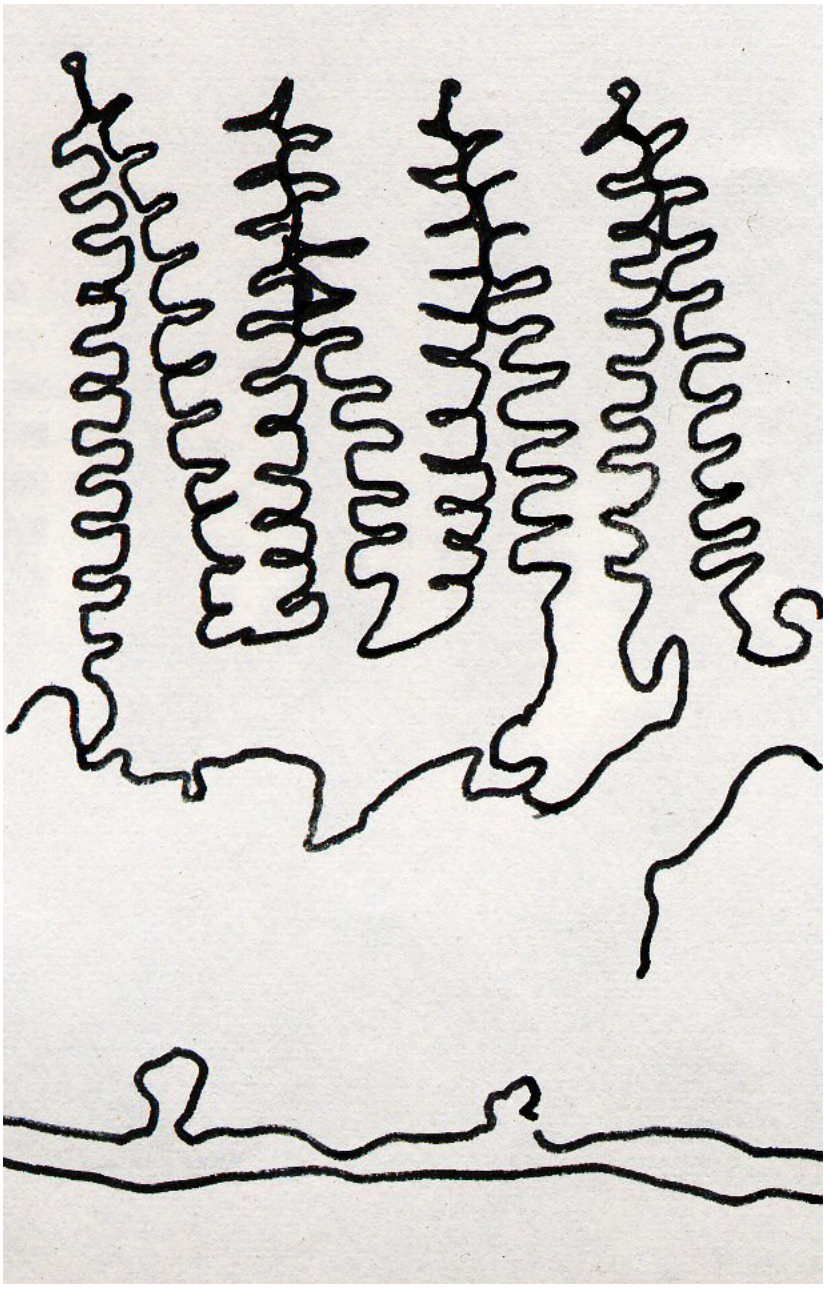
There are three criteria that clearly define if a development is a biomimetic one: a biological system must have been analyzed, it must have been abstracted into a model, and the model must have been transferred into a technological innovation. Furthermore, there are ways to assess whether these innovations are sustainable or not. An expert in the field once said that it is very difficult to judge biomimetic innovation as it is neither a biological nor a technological solution - it is created by new biomimetic knowledge. Additionally, it is commonly accepted that if the solution works, nobody asks where your inspiration came from. To me, any future development needs to recognize a responsible value-based way of design. We will need a groundbreaking change in production and consumption. It starts with each one of us, asking what is really needed and how to provide solutions for the well-being of humanity instead of individual needs.

What are you working on right now?

My team and I continue to work on the methodology and the process of biomimetics and how to make it transferable to any sector and usable for anyone interested in the topic. We do that in many ways, analyzing existing tools and developing new ones, as well as evolving the process such as integrating innovation management perspectives. We are working on a filtration system for microplastic in ocean water, an adaptive architecture for hot areas in Africa, an optimization of an exoskeleton, and a value-based communication tool.

How did you get started in BID?

As mentioned earlier, I started by chance and mostly self-educated myself. To become a manager for innovation and product development, I learned in more detail about



Ink drawing of the 'Christmas tree' thin layer optical interference structures that create the brilliant iridescent (blue) colours of Morpho butterflies. Each subtree has about 10 thin films, seen in cross section. From an electron micrograph. Drawing: Chiswick Chap, 2012 | Wikimedia Commons

Interview
Kristina Wanieck

the potential of bio-inspired design and its link to innovation. I visited research labs at different universities in Germany and other countries, spoke to experts in the field and coordinated a regional network of industry partners. I initiated R&D projects with industry in the automotive sector and functional surface optimization. It was mostly learning by doing. I experienced the most interesting learnings via transdisciplinary meetings with experts from all over the world. Each participant of these meetings brought a new perspective. Every day brings some new findings for me.

Which work/image have you seen recently that really excited you?

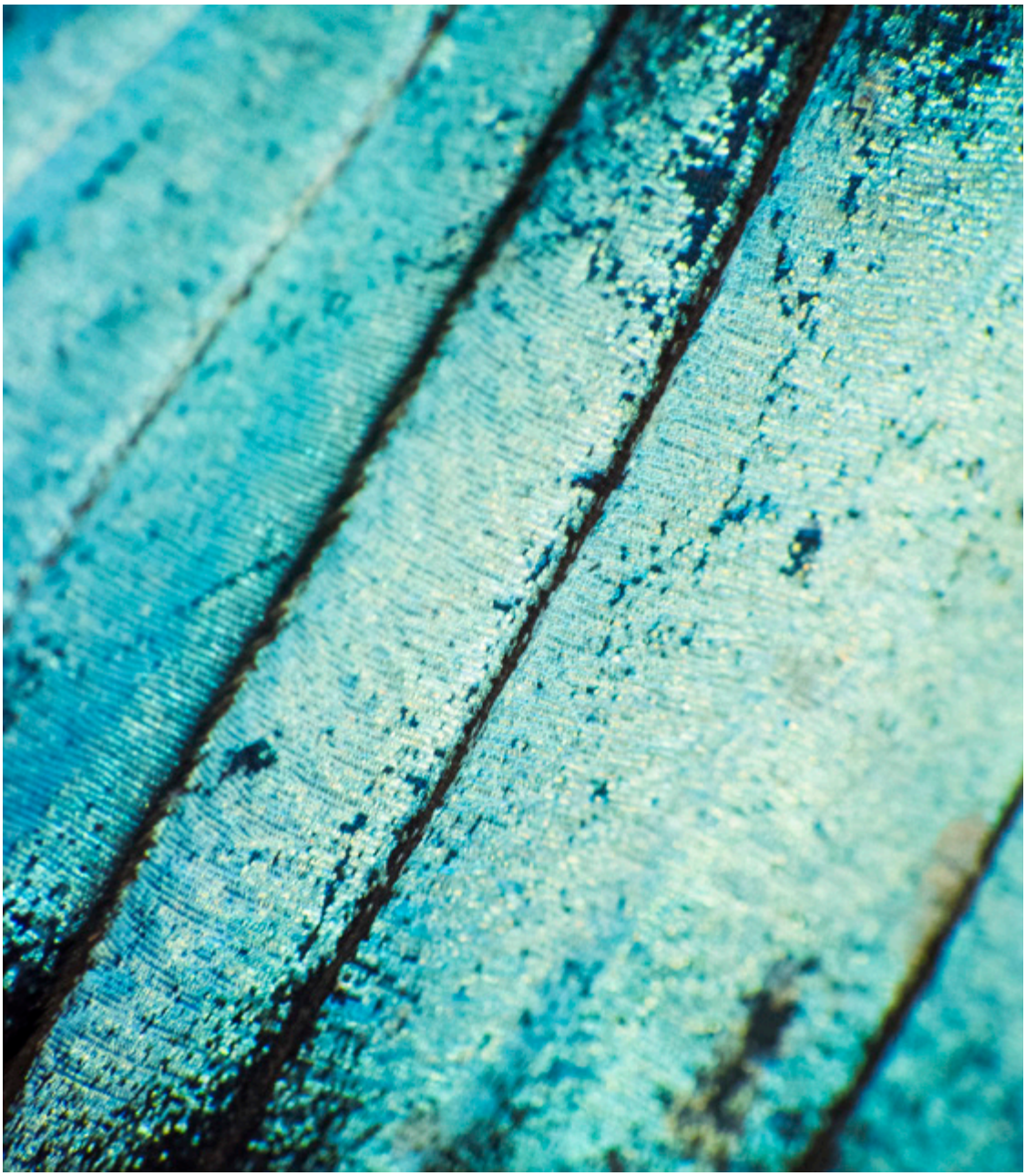
I had the honor to be a jury member for an award aimed at young scientists in biomimetics who have researched an idea and are able to turn their findings into a functional demonstration. We want to show how important research in this field is and that it is valued. The topics submitted were diverse, ranging from novel materials, innovative closures, exoskeletons, and medical technology applications. The winner was an oil-absorbing material that can collect oil spilled at sea. This demonstrates that biomimetic can solve real problems and contribute to environmental protection. I could see the huge potential and the various entry points that young researchers have to engage in biomimetics. It is not so much the individual development or idea; it is the overall potential that we need to tap.

What is your favorite biomimetic work of all time?

My all-time favorite example is the morpho butterfly and the inspired display technology. The way it is presented is often misleading, as it was not a 1:1 transfer of the biological principle. But the mere chance that a butterfly can contribute to generating new ideas for a display technology is mind-blowing to me, because these are two realms that usually don't overlap. This paradigm of bio-inspired design challenges us to re-think in so many ways, and on the other hand it fosters our own awareness about how we function and what our mind is able to achieve. This is my favorite part of the topic.

What is the last book you enjoyed?

It is a book that I always re-read and have done so recently, *The Power of Now* by Eckhart Tolle.



The bluewing
Photo: Adrián Castillo Rivera, 2013 | Flickr cc

Interview
Kristina Wanieck

Who do you admire? Why...

I admire many, starting with my mum for her unbreakable trust and belief, her strength with lightness and her pure joy of living. And with my family, my friends, my peers, or any person I meet, my admiration is for kindness and dedication in whatever they do.

What's your favorite motto or quotation?

There is always a solution to any problem – this helps me calm my kids or manage challenging situations at work.

Blue Morpho Butterfly
Photo: William Warby, 2009 | Flickr cc

What is your idea of perfect happiness?

Perfect happiness to me comes from a place of deep gratitude for just being alive. Not to need anything and having all – especially, with few material things around.

If not a scientist/designer/educator, who/what would you be?

This is an interesting question. I often considered having a small boutique with flowers in Paris, if I ever left my job. It comes from my deep wish to make lives more beautiful with little things. Today I think I would try to work in a movement with bigger impact, as the problems we face as humanity are too big. We need a movement that changes mindsets – otherwise change is not possible. Isn't bio-inspiration such a movement? ×

We would appreciate your feedback on this article:

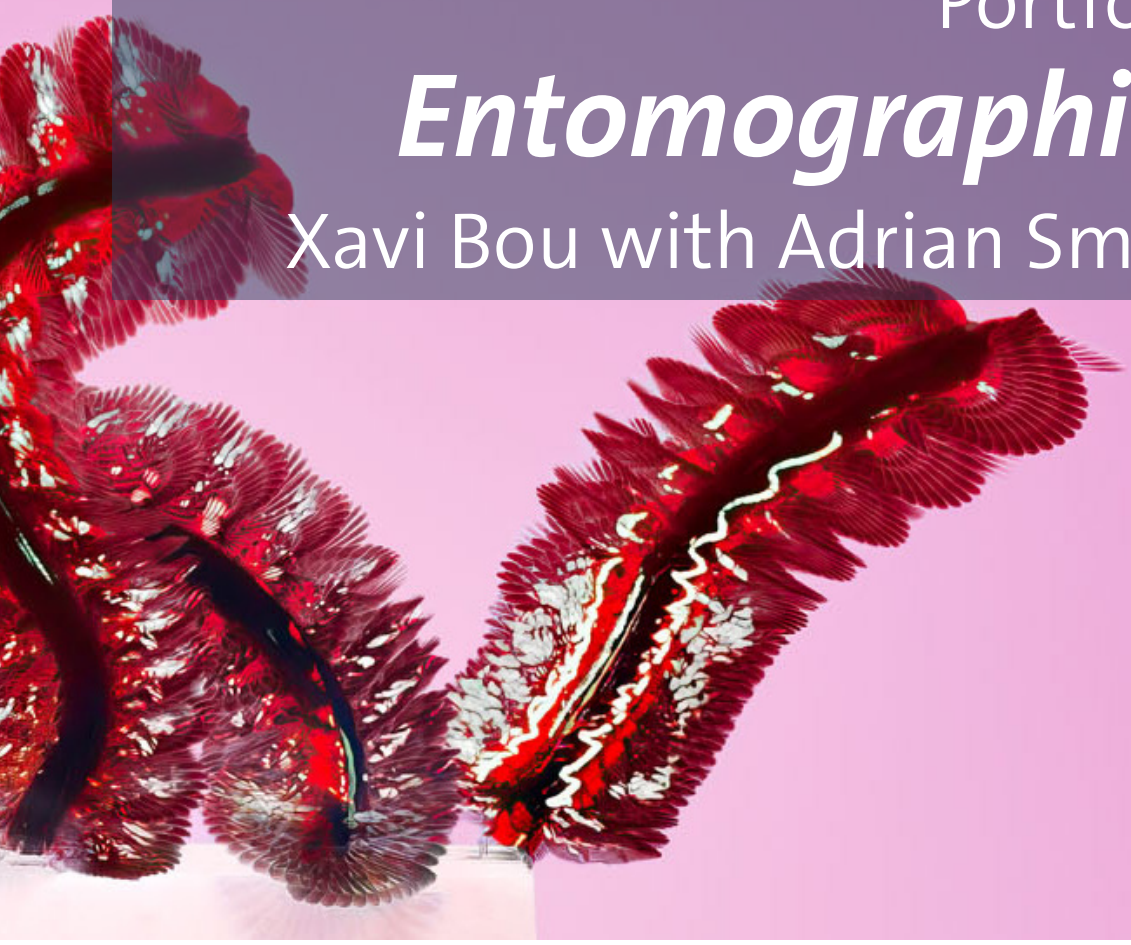
Close up of Blue Morpho Butterfly
Photo: Neil Hall, 2016 | Flickr cc

Multicolored asian Lady Beetle - *Harmonia axyridis*
Xavi Bou

Portfolio

Entomographies

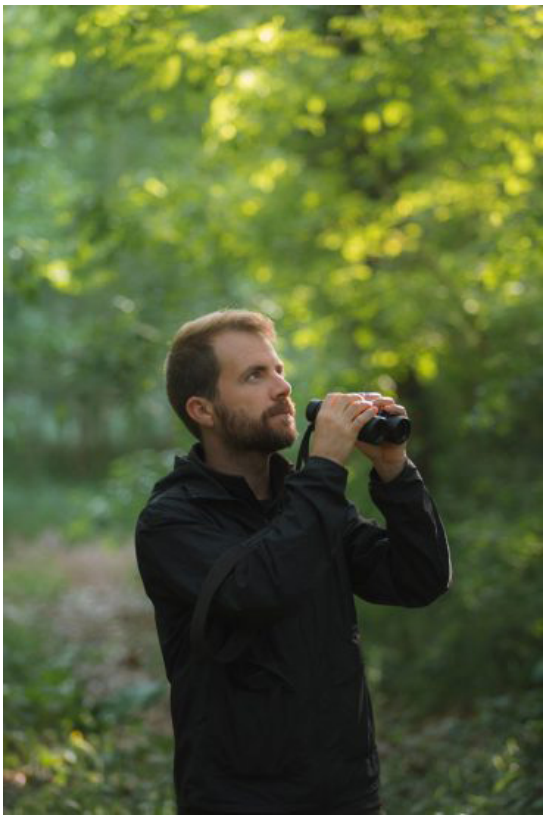
Xavi Bou with Adrian Smith



Entomographies
Xavi Bou with Adrian Smith

Could you tell us about your activities since 2017?

Xavi: The first five years I was exclusively focused on my ornithographic project. Focused on the search for the most complex and interesting flights to make visible, this led me to work with starlings especially, trying to go in search of that hypnotic dance they do when hawks attack them. I have also been working a lot with birds with incredible flights like swifts, which are birds that live in the air, some species even sleep in the air.



Xavi Bou

I also have published the book of my project with Lynx Editions that I'm very proud off.

Initially I was reluctant to apply the technique I created for ornithography to other types of movement. But I realized that I was missing the beauty of the natural movement of many other types of animals. It was about three years ago that I decided to expand this vision to other types of fauna.

First of all I thought about insects, since it is a very wide and very diverse group of animals, as well as unknown to the general public and incredibly endangered. My initial approach was similar to that of *Ornithographies*, but it was a failure. I realized that I had to change the perspective in order to capture the complexity of these animals. So I understood that I had to get closer and change the point of view. Then I was faced with a logistical and technical challenge that was difficult for me to overcome. I did not know how to manipulate these very delicate animals nor did I have such a technical camera. It was then that I learned about the incredible work of Adrian Smith from the North Carolina Museum of Natural Sciences. I proposed to collaborate and the result is what you see.

After the insects, I continued exploring, recording plankton and underwater life. It is interesting to see the similarities and differences of such disparate groups of animals.

I like to think that although today it is very difficult to discover new species, especially for someone outside of science, I am creating my own cabinet of curiosities, not with new species but with another way of seeing nature.

What are you working on right now? Any recent exciting projects you want to tell us about?

Apart from working with plankton and different forms of aquatic life, this last year I have been focused on a new project, again with birds but with a new perspective. It is still in progress so I cannot show you anything. It is being very stimulating because I do it in collaboration with ornithologists, in their ringing campaigns. I enjoy and understand my work more and more as a collaboration with science.

I hope all these new projects will become a new book soon.

I am also developing new short films, often reusing material that I had captured for other projects. I think that this combination of media greatly enriches a project. ×

https://xavibou.com

@xavibou

Hecale longwing - *Heliconius hecale*
Xavi Bou, 2022

Entomographies
Xavi Bou with Adrian Smith

Could you tell us about your collaboration with Xavi?

Adrian: I think Xavi and I are both interested in visualizing the natural world in new ways. In our own work, we both use cameras to see organisms moving in ways that are beyond what we can normally experience. Once we connected, working together was an easy fit because we both were excited about what we would get to see by creating these images. I would gather and film the insects at 1,000s of frames per second in the lab and send the footage to Xavi in Spain for him to dissect and reconstruct. I think the resulting images are astounding. They transform these insects into something closer to the blur of motion we experience when they might fly by, but also presents them as portraits of intricate motion and detail.

What are you working on right now?

It's back to science for me! I just published a study about how globular springtails jump and am working on several other research studies about both insects and humans. Of course, I am always working on making new videos for the Ant Lab YouTube channel too.

Any recent exciting projects you want to tell us about?

Flipbooks! I've recently published a series of three flipbooks featuring insects in flight (there are 6 sequences in each book) with the company FlipBoku. They are amazing. Like the art collaboration, for me, it's an exciting way to exhibit insect biodiversity. I think it's really cool that people can now get a flipbook that is 100% moths! Who wouldn't want that?! ×

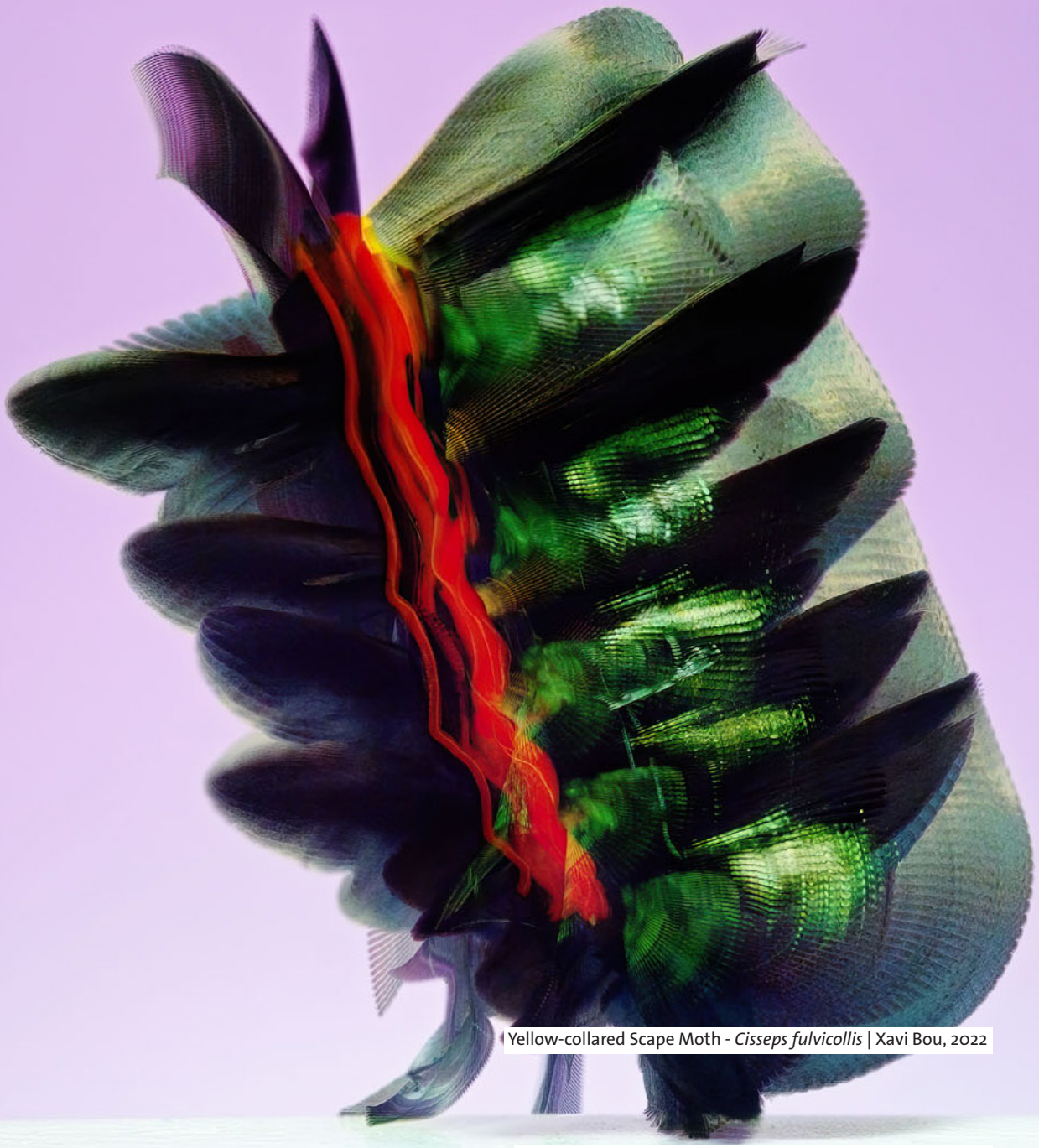
https://www.youtube.com/@AntLab
https://flipboku.com

We would appreciate your feedback on this article:

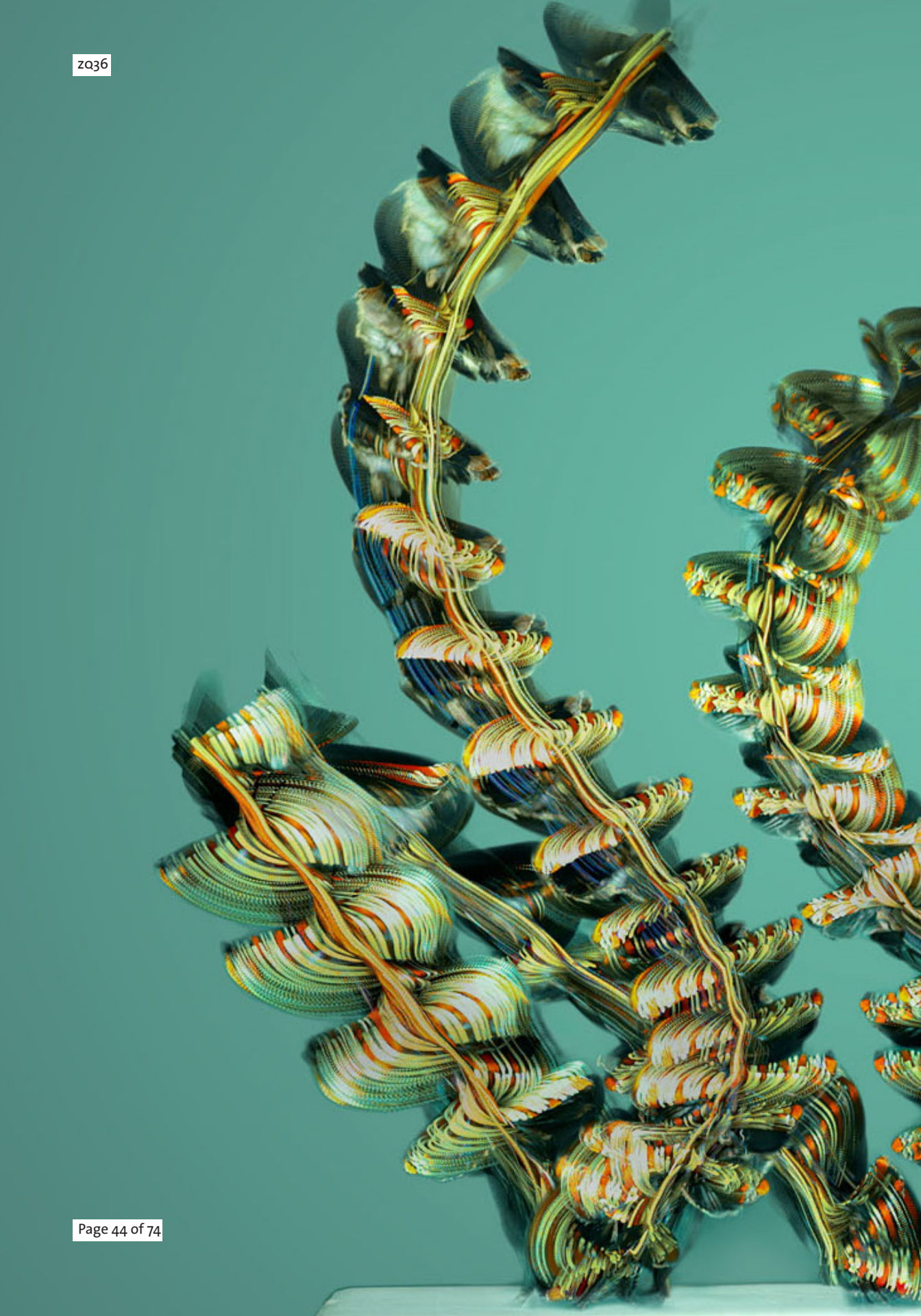
Two-lined Spittlebug - *Prosapia bicincta*
Xavi Bou, 2021 | (6,000 fps)

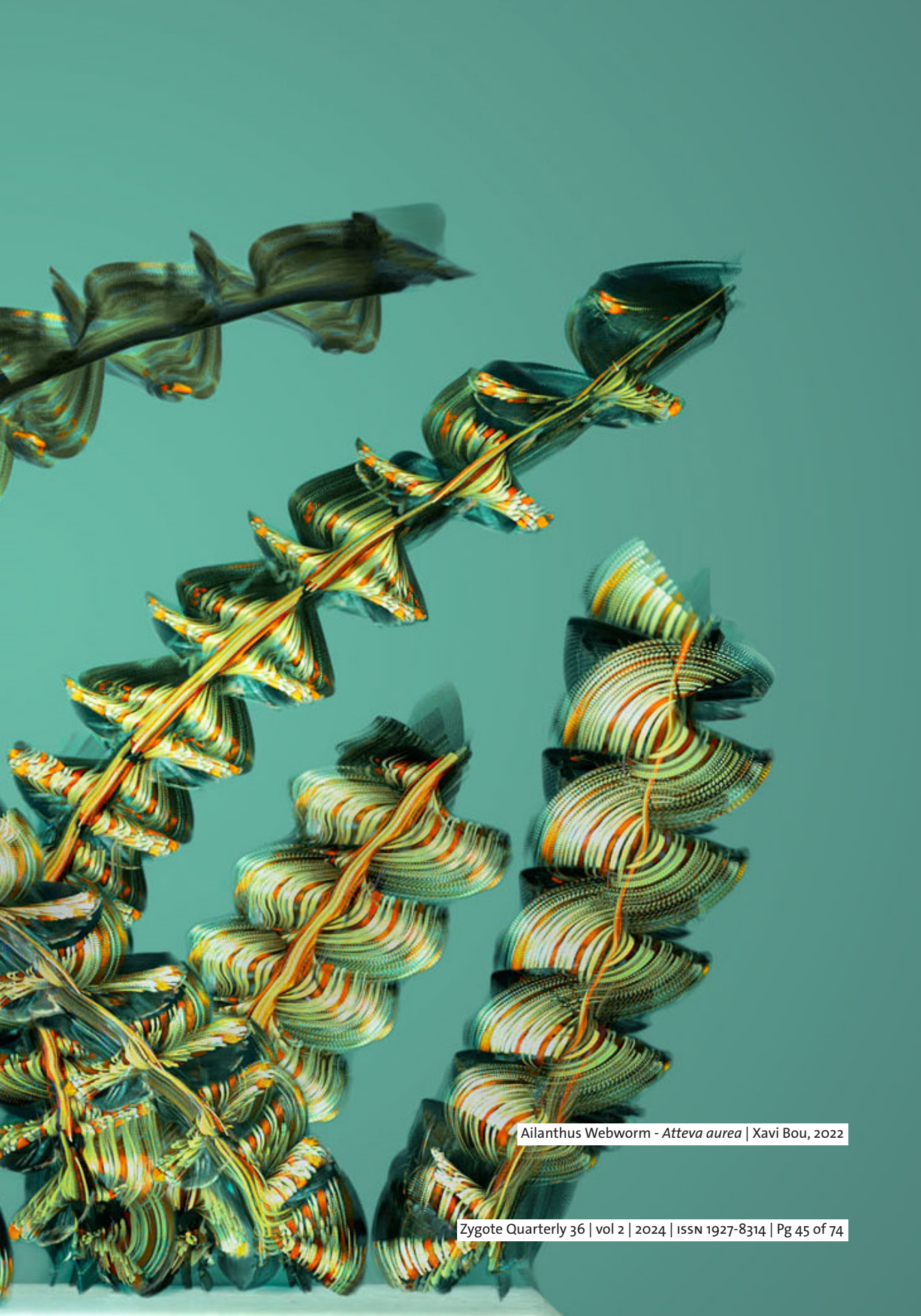
Dark-winged Fungus Gnat – *Odontosciara nigra* | Xavi Bou, 2022

Sapho longwing - *Heliconius sapho* | Xavi Bou, 2022

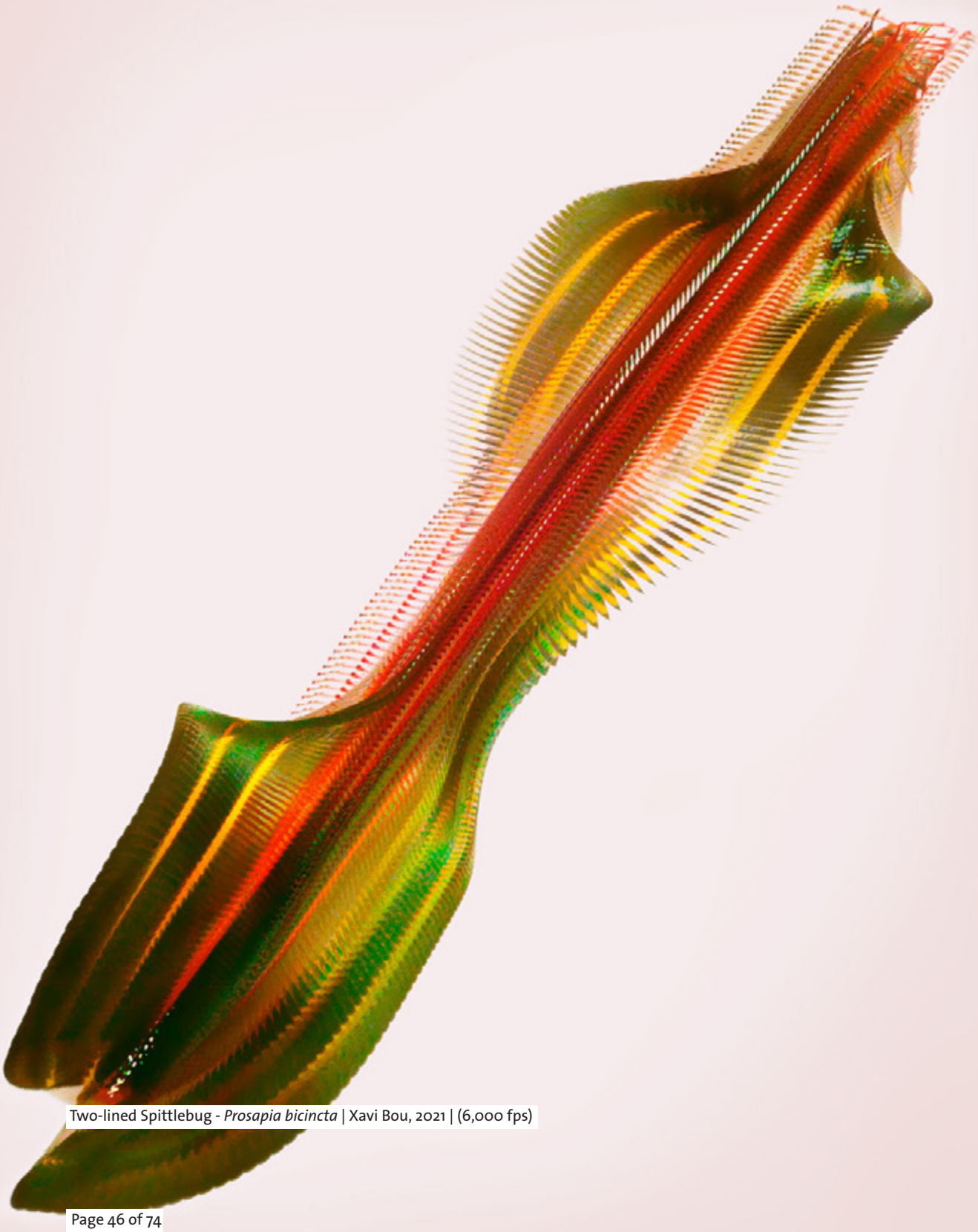


Yellow-collared Scape Moth - *Cisseps fulvicollis* | Xavi Bou, 2022





Ailanthus Webworm - *Atteva aurea* | Xavi Bou, 2022

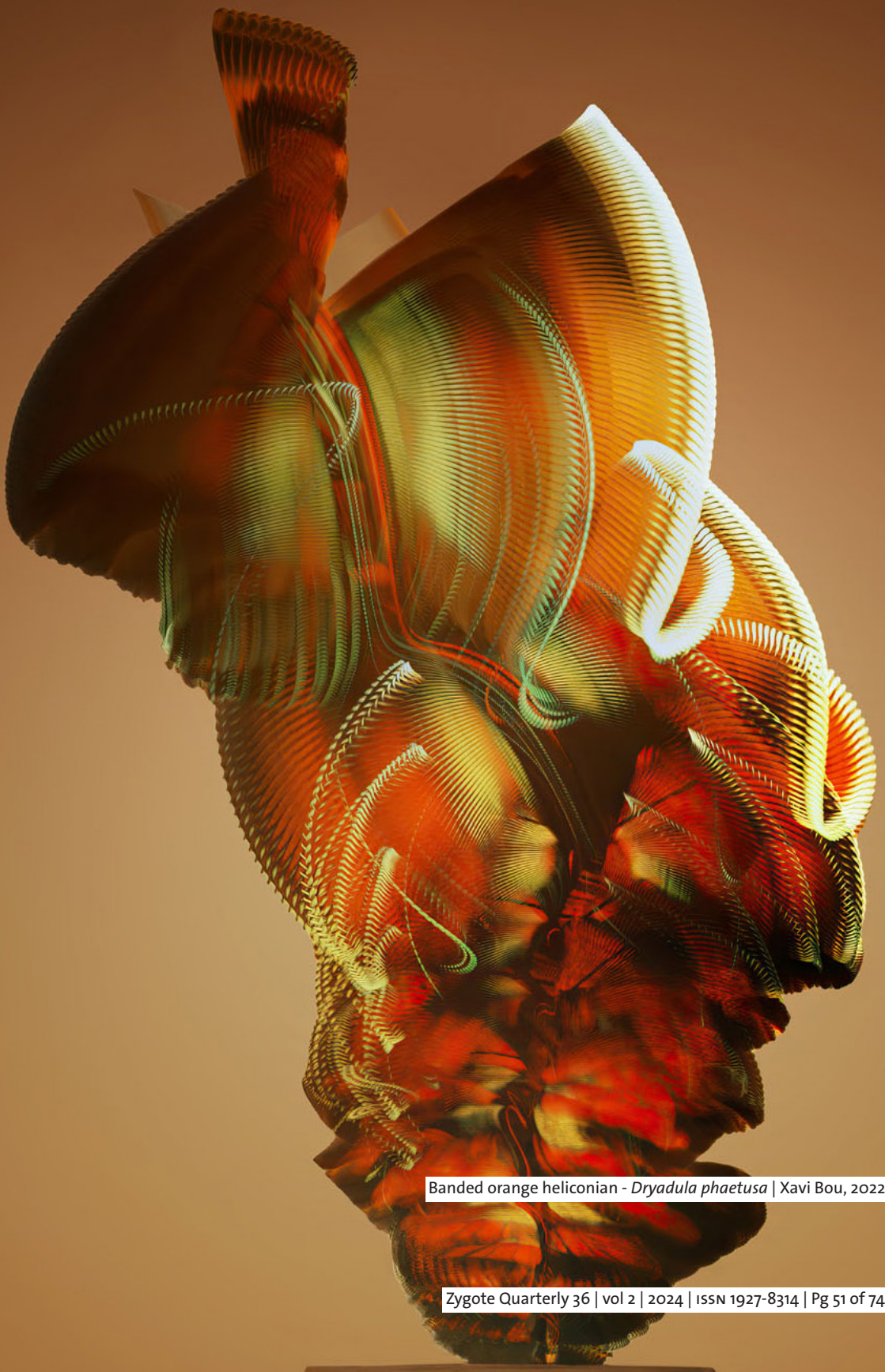


Two-lined Spittlebug - *Prosapia bicincta* | Xavi Bou, 2021 | (6,000 fps)

Blue-frosted banner butterfly - *Catonephele numilia* | Xavi Bou, 2022 | (1,500 fps)
Living Conservatory NC Museum of Natural Sciences

Wasp | Xavi Bou, 2022

Postman butterfly - *Heliconius Melpomene* | Xavi Bou, 2022 | (1,500 fps)



Banded orange heliconian - *Dryadula phaetusa* | Xavi Bou, 2022

Tulip-tree silkmoth - *Callosamia angulifera* | Xavi Bou, 2022

Thierry Chopin in 2017 holding a spool with a twine covered with microscopic kelps being unwound around a rope to be put at sea (Magellan Aqua Farms Inc.). In six months, the rope is covered with 2-3 m long kelps. | Photo: Caroline Longtin

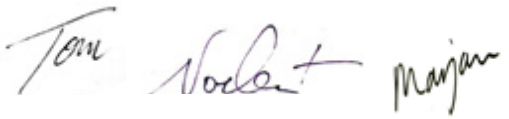
In Memoriam

The Legacy of Thierry Chopin

In Memoriam
The Legacy of Thierry Chopin

Thierry Chopin contributed an interview on integrated aquaculture as a system in ZQ19 *(https://zqjournal.org/editions/zq19.html), exploring the opportunities but also the challenges in this field: academic silos that inhibit collaboration, lack of interdisciplinary research funding, and regulations that focus on a single species group. He described his transition from focusing on seaweed to aquaculture and more recently the "Turquoise Revolution" that he described as "where production activities are no longer in conflict with the environment, but protect it."*

In early 2024, Thierry and 19 co-authors had just published "Deep-ocean seaweed dumping for carbon sequestration: Questionable, risky, and not the best use of valuable biomass" in One Earth. *He proposed an in-depth* Zygote Quarterly *article with the provisional title "Nutrients or not nutrients? That is the question..." that would explore our strange and complex relationship with aquatic nutrients. He planned to start work as soon as he had finished some grant applications. We were shocked and saddened to hear of Thierry's untimely passing shortly after he retired from University of New Brunswick, Saint John. Below are brief testimonials from some of his many professional admirers.*



The International Seaweed Association
With great sadness and a feeling of profound loss, we announce the passing of our former President, Thierry Chopin, on July 18, 2024, at his cottage in Prince Edward Island, Canada.

Thierry just retired as a professor at the University of New Brunswick Saint John on June 30 after 35 years of dedicated service. During his tenure, he mentored countless students who went on to successful careers in Marine Sciences, governance, medicine, and other science-based fields. He was enjoying his retirement, spending less time working and more time relishing the Canadian summer with his beloved wife.

Thierry will always be remembered as an enthusiastic advocate for Integrated Multi-Trophic Aquaculture (IMTA) and a passion for seaweeds. His influence extended beyond the seaweed world, earning him great respect in the broader aquaculture community, as evidenced by his engaging posts on Facebook and LinkedIn. He inspired at least two generations of young scientists. He was both surprised and delighted when he realized he was teaching the children of his former students. "I think it is time to retire," he remarked with a smile.

For those who wish to honor him, the Chopin family respectfully requests

contributions to the **Thierry Chopin Award for Graduate Coastal Studies** at https://www.unb.ca/donate. Please select "Other" when choosing the project and list the award name in the provided text field. This award will continue his legacy and support the next generation of coastal studies scholars. Let's keep the "Turquoise Revolution" alive

♡

Thank you Thierry, for your unwavering dedication to bringing seaweeds into the spotlight and advancing various fields over the years. Your knowledge lives on in your students, and your love endures in your family and friends.

In name of the International Seaweed Association,
Leila Hayashi (Vice-President)
Helena Abreu (President)

Dr. Amir Neori

Thierry's exceptional communication skills, both verbally and in writing, along with his boundless energy, humor, geniality, and enthusiasm, have been invaluable assets in advancing the field and inspiring others to join the cause.

University of Haifa-Leon Charney
School of Marine Sciences

Dr. Natalia Ospina-Alvarez

I had the pleasure to work with Thierry on the EU-funded ASTRAL project (focused on Multi-Trophic Aquaculture), of which he was a key and active member. I am based in the Azores and during our regular meetings, he always expressed a desire to visit our impressive archipelago. This wish came true when he travelled to Terceira Island as a guest speaker at the last edition of the 'Atlantic Innovation Week' in April 2023, where he discussed the 'Turquoise Economy'. He was so thrilled to stay in a turquoise room - he humorously concluded his presentation with an acknowledgement slide to his 'Turquoise' hotel room, typical of Thierry's wit and sense of humour. The whole room was laughing, homework was accomplished, and everyone went home remembering the Turquoise Revolution.

Eat seaweeds
Photo: Thierry Chopin

In Memoriam
The Legacy of Thierry Chopin

What I remember most about Thierry, apart from his remarkable scientific knowledge, is his more human side. He always had a smile on his face and anecdotes to share about his wife, his daughters, and his students. Many of the great people who are role models are remembered for their scientific, political, and artistic contributions. We remember the 'figure' but rarely the human being behind it. Thierry was a great human being, with a big heart and a sense of humour, and that is what I will always remember from him.

Innovation Manager in Blue Economy, Atlantic International Research Centre (AIR Centre), Portugal

Gregg Yan
There's no greater contribution to humanity than to change the world for the better. Professor Thierry Chopin did so his way – on his own, often-brilliant, often-humorous terms.

His aquaculture approach was called Integrated Multi-Trophic Aquaculture or IMTA. It's a bit of a mouthful to say, but IMTA nonetheless fed many, many mouths since it combined the cultivation of plants and animals that naturally rely on each other in the Food Web.

By championing IMTA, Professor Thierry reminded the world's fish farmers not to forget how nature herself does things. His passion wasn't just limited to science and aquaculture. He loved a good time, influencing the creation of freshly-brewed beer made from kelp. To this gifted Guru who has earned his place in the Great Science Laboratory Above, we all raise a toast.

Executive Director, Best Alternatives
https://www.facebook.com/OurBestAlternatives/

Bonnie Waycott
I remember Thierry as a passionate, friendly individual whose contributions to aquaculture were extremely significant. His knowledge and experiences were impressive, and he always took the time to share these in a fun and easy-to-understand way. He will be deeply missed, but I'm sure that his legacy will continue to inspire us all.

Freelance writer and consultant specialising in aquaculture and fisheries https://bonniewaycott.com/

Janet Kübler
Thierry was a colleague of more than 30 years and in that time, I don't recall ever seeing him not enjoying the moment. When we met, we were both trying to better

understand the relationships between seaweeds and their dynamic environments. Over time, like many ecologists, we embraced the role of humans in marine ecosystems and how the ecosystem teaches us how to be involved.

Thierry was surprised to learn that there was a name for that: biomimicry, and was delighted to embrace being a biomimic. Delight was key to how Thierry Chopin approached his work and his life. He had an exceptional willingness to play and prototype designs or combinations of species in aquaculture, to great success. That led him to be thought of by many as the granddad of integrated multitrophic aquaculture.

I have never met another scientist who radiated such playful joy in his work, dancing with the ecosystem trying to find better ways to work with it to feed people while improving the capacity of the ecosystem to support life. He is missed and he can continue to be an example of working with Nature, as much as possible like Nature.

Senior Research Scientist, California Regenerative Aquaculture Hub, California State, University, Northridge, and President of the California Seaweed Festival

Dr. Barry Antonio Costa-Pierce

I'm sad beyond words knowing now of the sudden passing of Thierry Chopin.

For over 30 years we were brothers in the science and practical actions that have led to the expansion of environmentally responsible aquaculture worldwide, in differing climates, water chemistries, and species. Thierry, a Brittany/French immigrant to New Brunswick, Canada, and me an Azorean/Portuguese to Southeastern Massachusetts, USA, shared much more than marine science as we became dear friends and garrulous colleagues, with our mutual love of diverse cultures, and their wonderful and strange seafoods, music, and, of course, wines.

I first met Thierry at some point in the 1990's at joyous Aquaculture Association of Canada meetings throughout Canada. By then, Thierry was already a globally renowned scientific leader in phycology/seaweed aquaculture. By Y2K we were furious friends working along the same lines with – always – different views and pathways towards the same goals. We invited each other to many important gatherings in North America and worldwide, and we had glorious, good fun together arguing, agreeing and most importantly being in the "joie de vivre", that exuberant enjoyment of life that he had about what we were doing and trying to do to make aquaculture more sustainable and community-based.

In Memoriam
The Legacy of Thierry Chopin

Now, the recognition of IMTA is everywhere worldwide as one of the most progressive pathways towards the future of aquaculture in all salinities of water. Thierry defined ancient aquaculture practices and brought them into a modern era of important applied aquatic sciences, defining the principles of IMTA, and making a "Chopin taxonomy" of more sustainable aquatic food systems of tremendous global importance.

Thierry knew we were on the same pathway; he was always very opinionated about everything I did, for sure; but it was never to impede; it was to make the work better. I'm heartened that IMTA will be with us forever, as it will forever be aligned with Thierry and his legacy.

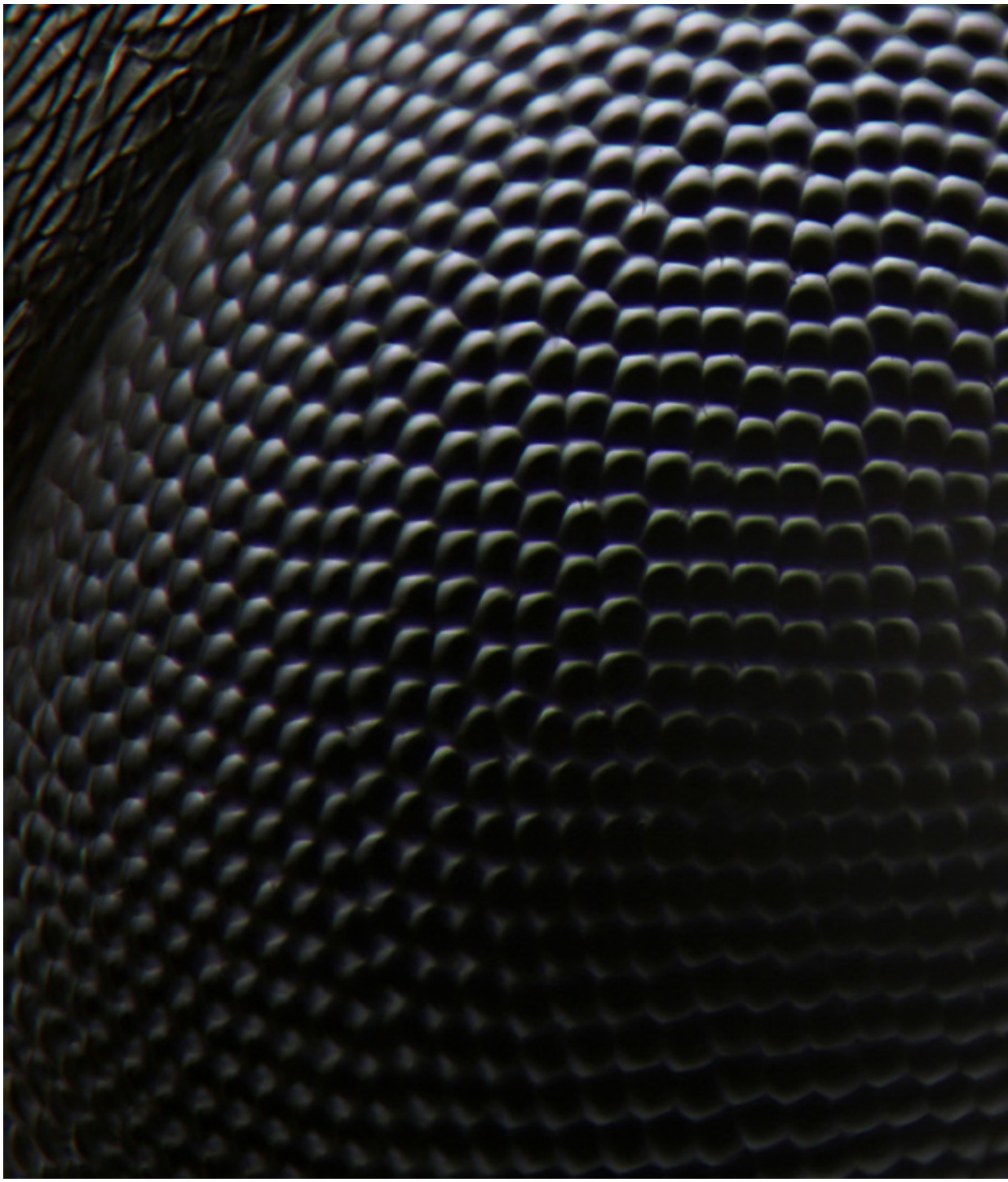
My trips to New Brunswick to lecture in his University of New Brunswick (UNB) classes demonstrated to me what a great mentor he was to his many students. I'd stay with him, Kathy his wife, and his family. These times stand out because you don't really know someone until you do. The last time I was with Thierry and his family was this year to speak to his class at UNB. Kathy and Thierry talked about the fact that he was to retire soon; and, what did THAT mean? We made great plans to stir up the aquaculture cosmos even more than our last two impactful and controversial papers had done. He and Kathy had made a perfect plan for their future. I saw pictures of the renovations being made to their beautiful house on the shores of Northumberland Strait, Prince Edward Island, Canada, and listened to their many plans for more global discoveries. And, of course, we discussed how Thierry and his many colleagues would advance the "Turquoise Revolution."

A true lion of our global community has passed into the light. In the words of Dr. Seuss, which makes me smile through the tears, "Don't cry because it's over. Smile because it's happened." ×

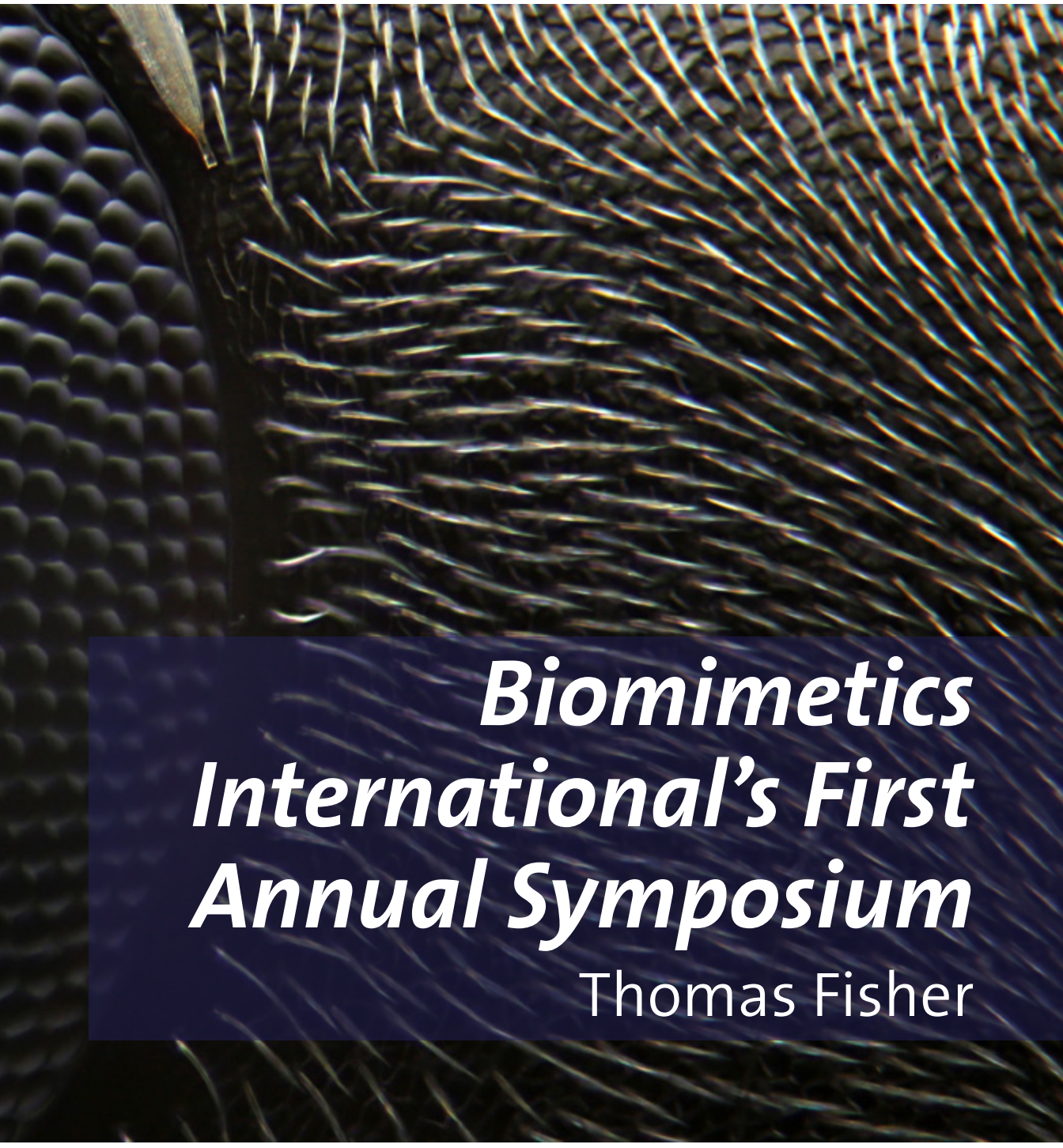
Professor, Faculty of Biosciences & Aquaculture, Nord University, Norway
President/CEO and Chief Scientific Officer of Ecological Aquaculture International, LLC.
Adapted from his 10 September 2024 AASA keynote introduction when he agreed to try and replace Professor Chopin, with the full understanding that nobody really could.

We would appreciate your feedback on this article:


Thierry Chopin with 2-3 m long kelps.
Photo: Caroline Longtin



40x Black Ant (*Serviformica sp.*)
Photo: Macroscopic Solutions, 2014 | Flickr cc



Biomimetics International's First Annual Symposium

Thomas Fisher

Biomimetics International's First Annual Symposium

Thomas Fisher

Biomimetics International (https://biomimeticsinternational.com), a new association for the rapidly emerging biomimetics/biomimicry/bio-design industry, held its first annual industry strategy symposium – Biomimetics24 (https://www.biomimetics24.org/) – at the University of Minnesota in October 2024. The event displayed the tremendous diversity and great potential of this field, which studies nature for ways to solve complex human challenges. As Michael Wright, the executive director of Biomimetics International noted at the start of the symposium, biomimicry/biomimetics "suggests that we subordinate our human hubris and start looking to nature for inspiration, if we are going to survive. Nature has had 3.8 billion years to evolve things ... and the number of possibilities for us to learn from is almost infinite." Acknowledging the important role of "Janine Benyus, who launched biomimicry," Wright began the day-long lineup of inspiring speakers, from a wide range of disciplines.

The morning talks covered the fields of engineering, planning, architecture, and construction. Shashank Priya, Vice President for Research and Innovation at the University of Minnesota, and his colleagues have built tunneling robots based on how a millipede burrows by generating a sinusoidal wave motion along its body which creates a much higher thrust at its head, with 48 pairs of legs that allow it to never lose contact with the ground even as half of its body arches up. His lab has also developed bio-photovoltaics that mimic photosynthesis in plants with living cells embedded in a liquid electrolyte layer in the solar panel, and efficient underwater vehicles based on the propulsion of jellyfish, which creates suction vortices in the water by simply opening and closing its bell-shaped body.

Turning these innovations into marketable products remains a challenge for biomimetics, and Priya has played a pivotal role in solving that by overseeing an operation at the University of Minnesota that has created 260 companies since 2006 (some of them focused on biomimicry) with an inhouse venture capital firm, Discovery Capital, able to make equity investments of up to $1.5 million per company in order to accelerate the process of taking a lab-based research to the marketplace.

Tom Fisher, Director of the Minnesota Design Center at the University of Minnesota, followed with a talk about how his center has looked to Indigenous communities and landscapes to find new solutions to societal problems. He showed how two non-profits launched by his center

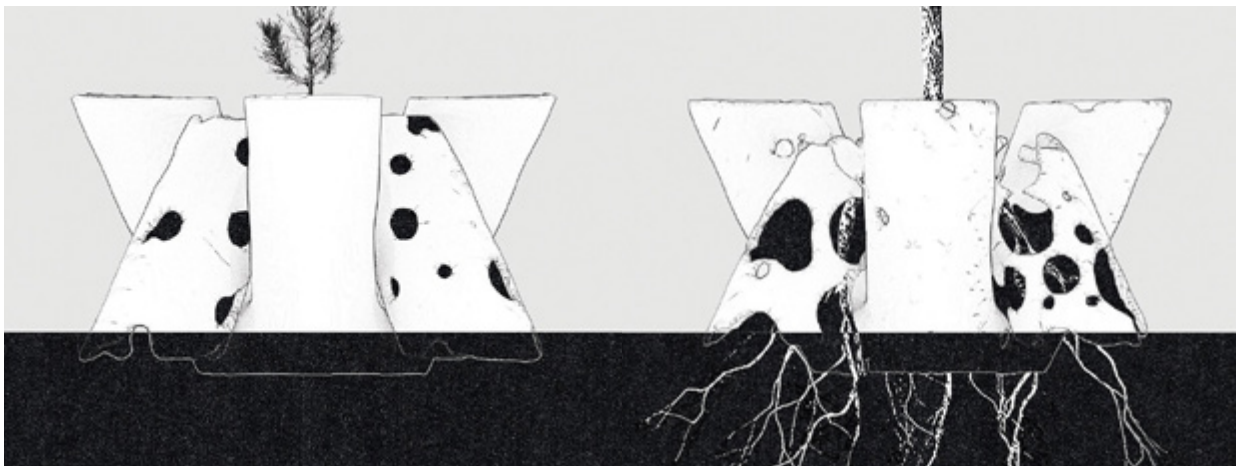
Millipede macro | Photo: Mark Dumont, 2018 | Flickr cc

Biomimetics International's First Annual Symposium
Thomas Fisher

– Settled and Envision Community – address homelessness, inspired by the "patch dynamics" of ecosystems, and how we could greatly improve biodiversity and reduce atmospheric carbon by dramatically reducing the human footprint through compact settlements, micro-manufacturing, and agroecology.

Marc Swackhamer, Professor and Chair of the Department of Architecture at the University of Colorado Denver, views buildings "through the lens of biology... as a temporary gathering of flows, which feeds on past waste streams and supplies nutrients to future buildings." He described his lab, HouMinn, as a "decentered practice," that "relinquishes control to other people and other species." His lab has developed innovative biomimetic products such as "nurse pods," which can rapidly regrow a forest after a fire by using unfired clay vessels with a mycelium collar to nurture sapling trees, and "zippered wood," which uses discarded 2x4 lumber and low-tech technology to create fluid shapes that recall the trees the lumber came from.

Blaine Brownell, Professor and Director of the School of Architecture at the University of North Carolina, Charlotte, has tried to "make sense of technology in the context of biomimicry ... through hyper-natural design, which works directly with natural forces and processes rather than against them." He showed a range of examples including silk leaves, where living chloroplast cells are injected into silk fibers to photosynthesize; anti-microbial interior surfaces, based on the way in which

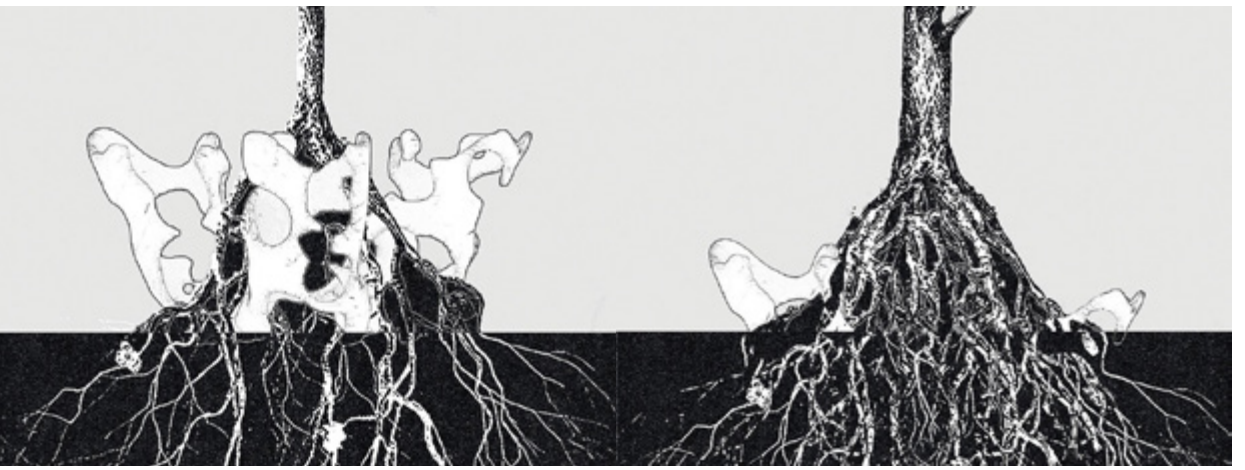


Nurse Pod
Project collaboration between the LoDo Lab, HouMinn, and HiLo Lab | http://houminn.design/home/2024/7/8/nurse-pod

dragonfly wings prevent pathogens from accumulating on them; and building sun shades that have algae embedded in them to absorb carbon, generate energy, and produce food.

The next three speakers - Emilie Snell-Rood, Professor, Ecology, Evolution and Behavior at the University of Minnesota; Peter Niewiarowski, Professor of Biology at the University of Akron; and Prasad Boradkar, Dean of the College of Design at the University of Minnesota – addressed biomimetics as a field. Snell-Rood observed the siloed nature of biomimetic work, with much of it going on without collaboration with biologists and without exploring the full range of biodiversity. She then described how her lab has distilled core concepts of biology, relevant for bio-inspired design, into a series of open-access educational modules and lesson plans. Her goal is to "have design frameworks that are both accurate with respect to the biology and useful with respect to designers."

Niewiarowski then talked about Akron's biomimicry Ph.D. and a fellows program, which connected academia and industry to accelerate innovation by having graduate students working 20 hours per week in corporate R&D in areas ranging from biomedical and health care to environmental engineering and educational to industrial manufacturing and aerospace. He also advocated a "two-way flow" of ideas between the engineering and biology fields, so that there are benefits for both in doing this work. He ended with a plea that we need to train biologists and engineers to be

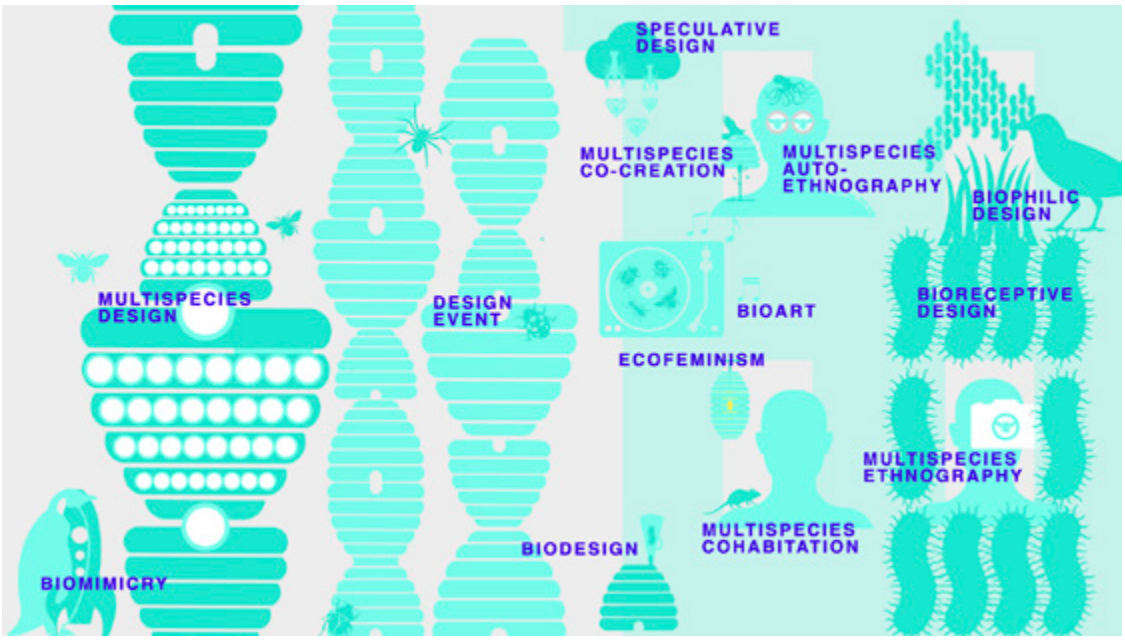


Biomimetics International's First Annual Symposium
Thomas Fisher

broader thinkers and that we identify and lower the institutional barriers to doing this interdisciplinary work.

Boradkar built on that by asking why the design community has had such an "extreme, myopic focus on the needs of people when we are one of millions, if not billions of species on the planet?" and "How do we go beyond this notion of thinking of us as the apex predator and thinking of us more as living in a network of species from whom we can learn?" He urged us to "think of redesigning design itself," by using the "biomimicry spiral" that reframes problems as functions and looks to nature for a specific functional solution or for principles or patterns that can guide a design. "It's all about redefining our relationship to nature, thinking of ourselves as a part of nature and learning from it, while moving from a human-centered to a life-centered approach to design."

After a brief presentation by Wendy Meadley, CEO of Expo 2031 Minnesota, about the first international horticultural expo coming to North America with the theme "Human Nature - Where Humanity and Horticulture Meet", the afternoon speakers represented the industry side of biomimetics. Chris Campbell, Founder and



Recent diagram placing biomimicry among more-than-human design approaches
Diagram: Svenja Keune, 2024 | https://designandposthumanism.org

CEO of Simplifi Automation, spoke about work done in partnership with NASA to develop an "artificial nose" that mimics the highly sensitive olfactory sensing system of dogs. "Nature has already designed these receptors to be selective and sensitive," said Campbell. "Our job now is to combine them with electronics so we can use them," primarily to monitor our health and diagnose disease through the analysis of our breath.

Matthew Aghai, Managing Director of Viridian Ecosystems, talked about biomimetics in reforestation after a 12% decline in forest land cover over the last 20 years. He brought an inspiring insight into how biomimetics could influence policy. "By rebranding forests as critical infrastructure, we can unlock investment, spark innovation, and accelerate restoration efforts." He showed a device that hydrates seeds and twists them into the ground in a process learned from self-burying rhodium seeds and a way to treat seeds with gustatory deterrents based on the way plants ward off predators through taste and smell.

Stephanie Grota, Vice President for Responsible Sourcing & Sustainable Capabilities at Target Corporation, addressed the impact and responsibility that companies like Target have to elevate sustainable brands, eliminate waste, and make sure that they benefit both people and the planet. Inspired by nature's circular economy, she described how Target now encourages customers to bring in unwanted goods for recycling, turning old children's car seats into storage crates and plastic bottles into textiles. She acknowledged that companies like Target still have a lot to learn and continue to take action, "So we need groups like this and minds like yours," she said, "to teach us, collaborate with us, and help us collectively build the solutions for the future."

John Pournoor, CEO of Government Analytica, spoke about the role governments can play, the need to focus on the public value of biomimetics, and how "environmental policy will drive an increasing share of the industrial policy and economy." The more biomimetics can address grand challenges, the more likely it will be that governments invest in it, he said. He urged the biomimetics community to engage in the "inspirational education" of decision makers with "designs that expand the minds of those who are looking at solutions."

The symposium ended with a panel moderated by Devry Boughner Vorwerk, Founder and CEO of DevryBV Sustainable Strategies, who observed that "biomimetics is a leadership tool and an innovation tool, based on the universal value of

Biomimetics International's First Annual Symposium
Thomas Fisher

valuing nature and valuing people." Another panelist, Dana Thompson, Founder and CEO of Heti Products, spoke to the way biomimetic thinking can lead to innovation, such as her company's low-dose, hemp-derived THC beverage, Heti, which takes the byproduct of the hemp that is used for the distillate to create hempcrete housing for indigenous community members, starting with the Santee Indian Reservation, where her family is from. Biomimetic ways of working also make sense economically. As Arnoud de Villegas, Managing Director of Viridian Ecosystems, observed, "For every

Slimemold | Smokies, North Carolina
Photo: Jason Hollinger 2013 | Wikimedia Commons

million dollars invested in landscape restoration, we can generate 40 jobs, which benefits families and communities as well as the landscape."

Ultimately, Biomimetics24 demonstrated the need for everyone – the public and private sectors, businesses and universities, biologists and engineers – to work as nature does in a more integrated, circular, and evolutionary way. Biomimetics is not just a new way of learning from nature and applying its principles to human activity; it also represents a mindset shift in how we think and work. With it comes the recognition that we are not smarter or better than nature, but are just one of millions of species on this planet, most of whom are older and wiser than we are. And with that comes the need to break down the organizational silos and linear thinking that have led to so many of the social and environmental challenges that we now face and to adopt the interdependent and mutually supportive ways in which ecosystems work. As Michael Wright noted at the end of the event, "Nature scales through networks," and networks like Biomimetics International will certainly help this significant movement - and the nature-inspired mindset of biomimetics - scale. ×

Thomas Fisher is a professor and director of the Minnesota Design Center at the University of Minnesota. His research has focused on sustainable architecture, design ethics, and community-based service design. Recognized in 2005 as the fifth most published writer about architecture in the United States, Fisher has written 9 books, over 50 book chapters or introductions, and over 400 articles in professional journals and major publications. Named a top-25 design educator four times by Design Intelligence, he has lectured at 36 universities and over 150 professional and public meetings.

We would appreciate your feedback on this article:

ISSN 1927-8314