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Crochet Coral Reef

Crochet Coral Reef is the brainchild of Christine and Margaret Wertheim. A unique nexus of art, science, geometry, and environmental reflection, Crochet Coral Reef is an ever-evolving archipelago of woolen installations that not only emulates the structures of natural reefs but also enacts the evolutionary processes by which living things evolve. Just as life on earth is underpinned by the code of DNA, so these fiber forms are material incarnations of a symbolic code – the stitch patterns of crochet.

interviewer: Margaret Wertheim interviewer: Giovanni Aloi

S ince the dawn of life nature has utilized algorithmic techniques to generate mathematical forms such as the hyperbolic surfaces of corals. Craft practices too are algorithmic – the original "digital" technologies – and through the medium of yarn intricate emulations of living reefs can be brought into being.

Crochet Coral Reef by Australian-born twin-sisters Christine and Margaret Wertheim is a meditation on the interplay between nature, mathematics and iterative construction, and also a response to the decimation of actual reefs by global warming.

In a communal dimension of the project, the sisters work with communities around the world to create vastly-scaled Satellite Reefs. More than 40 of these have been fabricated, from London to Latvia, with 10,000 people so far contributing to this on-going ecoart happening.

Figurative, collaborative, worldly, and dispersed, *Crochet Coral Reef* offers a response climate change at once formal and material, monumental and tender.

Giovanni Aloi: The *Crochet Coral Reef* project resides at the intersection of mathematics, marine biology, handicraft and community art practice, and also responds to the environmental crisis of global warming and the escalating problem of oceanic plastic trash. Can you tell us how this idea came about?

Margaret Wertheim: Christine and I created the Crochet Coral *Reef* project from the intersection of a number of threads running through our lives – pun intended. We grew up in Australia doing handicrafts, which our mother taught us as young children, so when we discovered that you could crochet hyperbolic geometric surfaces we were enchanted. These forms are the frilly crenelated surfaces that corals and kelps and many other reef-dwelling organisms create in the biological structures of their beings, yet human mathematicians spend hundreds of years trying to show that such surfaces were impossible. That raises interesting questions for us about what it means to know mathematics. Does a brainless head of coral "know" hyperbolic geometry? We believe that in some sense it does, so we see our project in part as an epistemological exercise. As well as being a worldwide community craft endeavour, it's also a collective project in applied geometry and an investigation into embodied knowing through craft.

The technique of hyperbolic crochet was invented by the mathematician Dr. Daina Taimina at Cornell, and it's not coincidental that she is a great crafter who'd grown up in Latvia. A lot of mathematicians had thought it wasn't possible to make physical models of hyperbolic geometry, but she realized she could do it with knitting and crochet. She started making these models to teach non-Euclidean geometry to mathematics majors at Cornell and her original algorithm is delightfully simple. From a mathematical perspective, her models are powerful pedagogical tools because they allow you to *see* and *feel* lots of formal properties of this rather abstract geometry. They are tangible tools for realizing intangible concepts – "things to think with" to use Seymor Pappert's lovely phrase.

Once we learned the technique, my sister Christine realized that if she branched out from the simple geometrically precise algorithm and went wild, the resulting forms began to look much more organic. That's because this is what natural hyperbolic organisms do



Anita Menning

Hyperbolic Plane, from the Crochet Coral Reef project by Margaret and Christine Wertheim and the Institute for Figuring. Synthetic yarn. 2007 © Institute For Figuring, by Christina Simons

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Christine and Margaret Wertheim The People's Reef - New York and Chicago, project by Margaret and Christine Wertheim and the Institute For Figuring. Yarn and mixed media, 2007-2009 © Institute For Figuring, by Francine McDougall

> - they're inherently "aberrant." Nothing in nature is mathematically precise; with real material things there's always deviation and "imperfection." Christine coined the lovely phrase "queering the code" to describe this process of going off the perfect mathematical grid, and I think it captures nicely the spirit of the project.

> The Crochet Coral Reef queers all sorts of codes, including the code of who gets to be seen as an "artist." To date, we've had over 10,000 people involved in making more than 40 locally-based crochet reefs around the world. We call these the "Satellite Reefs" because they've "spawned," as it were, from the crochet reefs we make ourselves. Most of the people who participate in these projects are women. They come from all walks of life: there are scientists, mathematicians, housewives, and prisoners and we see all of them as our co-artists. From the beginning we wanted our project to draw attention to the power of the collective modality of art-making and in that sense, we were inspired by Judy Chicago's *Dinner Party*. Feminism is baked into the DNA of the project and for us, it's a critical dimension to the work – though this is unusual for an art and science endeavour.

> Of course, the other vital part of the project's ontology is the disappearance of living reefs due to climate change. We grew in Brisbane, the capital of the Australian state Queensland, which is home to the Great Barrier Reef, so we've been following its travails all our lives. Literally the night we started the project, in December 2005, Christine made a joke that if the Great One ever

disappeared our woolly one would be something to remember it by. Thirteen years later scientists are now saying that reefs could actually disappear by mid-century. Sadly, no one imagined this could happen so fast.

Aloi: When did you start crocheting and what aspect of the medium do you enjoy the most?

The term "freeform" crochet didn't exist then, but we were doing this in the 1970s because I think that neither of us really liked following

patterns.

Crochet is a powerful medium for sculptural making because it's so easy to go off in any direction you choose and to make it up as you go along. Knitting is more formal and technically more challenging. Knitters tend to look down on crocheters. Crocheters say "whatever" and get on with playing. Crochet seems closer to what living organisms do because it's kind of do-it-on the go. I like the feeling when I'm crocheting a new kind of coral that I can create it on the fly – which, in a sense, mirrors what evolution does.

Wertheim: Dr. Taimina's algorithm for creating hyperbolic surfaces is very simple: "Crochet 'n' stitches then increase one. Repeat ad infinitum." It's a bit like a recipe for creating fractals, although these surfaces aren't fractals. Historically, hyperbolic geometry was discovered in the early nineteenth century after a long period in which mathematicians had been trying to show that something like this wasn't possible. It relates to one of the axioms of Euclidean geometry, which is known as Euclid's "parallel postulate." This is basically a definition of parallel lines, and it makes sense intuitively, but it turns out that it isn't actually true, or at least it's not necessarily true. If you abandon this axiom what you get is a different kind of geometry, which came to be called "hyperbolic geometry." Technically, it's the geometric opposite of a sphere, and you can think of it as a geometric equivalent of negative numbers. Just as we have positive numbers, zero, and negative numbers; so, you can think of the flat or Euclidean plane as a surface with zero curvature; the sphere is a surface with positive curvature, and the *hyperbolic* plane is a surface with negative curvature. If that sounds bamboozling, it should. Early mathematicians who worked on this were almost driven mad by it. Gauss, who helped develop this and who has been called the greatest mathematician since Euclid, was so troubled by it he kept his research private and didn't even publish his work. So, it's pretty astounding to me that brainless organisms like corals and sea slugs and lettuce leaves can be effortlessly producing these forms. It's an interesting case in which nature seems to surpass our wildest imaginings. Matter triumphs over

mentation.

Aloi: You are a science writer, curator, and artist in Los Angeles where you direct the Institute for Figuring, a Los Angeles non-profit organization founded with your sister Christine to promote public engagement with the aesthetic

Wertheim: Our mother taught us to sew and knit when we were in primary school. I can't remember a time when I couldn't do handicrafts, and Christine and I grew up making our own clothes. All through high school and university, I made my own clothes. I used to be able to cut patterns, though I couldn't do that anymore, and Christine studied dress design for a year at one point and was quite a brilliant pattern designer. We taught ourselves to crochet in high school. I think it was the only craft our mother didn't teach us. I immediately loved it because it's so sculptural and freeform. The term "freeform" crochet didn't exist then (it's attributed to the Australian crafter Prudence Mapstone I believe), but we were doing this in the 1970s because I think that neither of us really liked following patterns. We wanted to explore and investigate the realm of the possible from the start.

Aloi: Can you explain the mathematical side of crocheting a little more?



Christine and Margaret Wertheim

Toxic Reef: CO2CA CO2LA Ocean, with Bleached Reef and Pod Worlds, from the *Crochet Coral Reef* project by Margaret and Christine Wertheim and the Institute For Figuring. Yarns, videotape, plastic detritus, medical waste, and sand. 2006-2016 © Photo courtesy Museum of Arts and Design, by Jenna Bascom.

and poetic dimensions of science and mathematics. Can you tell us about the scientific element in this project? I would be specifically interested in knowing more about the challenges you have encountered in working with artists and scientists; how their worlds come to or fail to communicate, and what makes a successful "art and science" project.

Wertheim: In our experience, the art world has been very open to the project

but the science world has been pretty close-minded. I've been told lots of times by science people that this couldn't possibly have any real science in it, which I find interesting. I think it's a matter of gender. The project is created by two women, it is done mainly by women, and it involves a feminine handicraft, so how could it possibly be "real" science? At least that's what some science people seem to think. Yet the hyperbolic geometry we are investigating is what historically opened the door to a revolution in the understanding



Christine and Margaret Wertheim

Bleached Reef, from the Crochet Coral Reef project by Margaret and Christine Wertheim and the Institute For Figuring. Photo courtesy Museum of Arts and Design, by Jenna Bascom © Institute For Figuring

> of what geometry is. That revolution, which was explored most famously by the great German mathematician Bernhard Riemann, led to the mathematics underlying general relativity, which describes the structure of spacetime.

> When I give workshops to teach people how to crochet these forms, I always begin with a half-hour introduction to non-Euclidean geometry in which we end up talking about general relativity and the shape of the universe. Audiences get it, and we have deep discussions about how we could tell scientifically if we live in a hyperbolic or a Euclidean universe. That's actually an open question and one of the primary questions astronomers are trying to answer today: What is the structure of our cosmos. Most evidence suggests that on the very large-scale our universe is Euclidean; but there is some intriguing evidence that, after all, we might just live in a hyperbolic world.

> Aloi: The name of your organization, the Institute for Figuring is wittingly open to interpretation. Can you tell us about the multiple meanings inscribed in the word "figuring" and why it was chosen?

> Wertheim: The word "figuring" is special to Chrissy and I because it's intrinsically interdisciplinary. "Figures" are numbers. They are also scientific diagrams. Humans have figures that artists draw. In literature, there are figures of speech and figures of fun. And as cognitive beings, we figure things out. As soon as I decided I wanted to create an organization to do science communication in a new way I knew it would be called the "Institute for Figuring".

I think that's where the Crochet Coral Reef project comes from: from the fact that as a child my mother refused to buy wrapping paper, so when we went to our friends' birthday parties we had to make our own out of butcher paper and glitter.

ups."

Aloi: Can you talk to us about your upbringing and how you and Christine came to be interested in art and science and eventually in the intersection between the two?

Wertheim: We grew up on the outskirts of Brisbane, Australia, which was an intellectual backwater and a very feral environment. We lived in the bush with poisonous snakes and spiders and it was pretty isolated. There was nothing glamorous about our childhood and we went to third rate state schools that had very few facilities. By contemporary standards they were appalling, and I very much regret not getting a better formal education. But our mother Barbara Wertheim was deeply committed to giving her kids educational play toys, so we had lots of drawing paper and crayons and building blocks. We had almost no shop-bought toys or games and were expected to create our own. I think that's where the Crochet Coral Reef project comes from: from the fact that as a child my mother refused to buy wrapping paper, so when we went to our friends' birthday parties we had to make our own out of butcher paper and glitter. Sometimes I resented that: "Why can't I just have the nice new stuff?" But now I'm hugely grateful to my mom. She was influenced by educational thinkers such as Maria Montessori and Rudolf Steiner and took early childhood-learning very seriously. I am what my mother made me. She also deeply encouraged my interest in mathematics and never hinted it wasn't something girls weren't supposed to do. It wasn't until I went to high-school that I encountered this attitude when our math teacher there made it clear that girls were beneath his dignity.

categories.

Aloi: Science, femininity, crocheting, and ecology. This is a powerful contemporary evolution of a long history of sewing, embroidering, and stitching that revealed the political power of arts and crafts throughout history. Do you see *Crochet Coral Reef* as linked to that tradition and how does it surpass it?

Wertheim: There's a big debate in the craft world about whether "craftwork" that aspires to be shown in art galleries should be called "craft" or whether that word should be jettisoned and that we should only use "art", which has all the connotations of prestige and power that "craft" doesn't have. "Craft" has such domestic roots and "art" has a long history of being defined against domesticity. But Christine and I are clear on this point: we deliberately want to keep the affiliations with domesticity and female making. Our mother taught us to do crafts as a matter of necessity, just as she was taught by her mother. We all grew up in environments where making-your-own was a financial need

The name came to me in a dream. Its acronym "IFF" is the logical symbol for "if and only if" and it's one of the logical operators underlying computers. In some ways "figuring" is an old-fashioned word, it's very nineteenth century, but it is making a big comeback now. Feminist scholars like Donna Haraway use it a lot because it's a word that foregrounds embodiment. Christine and I also like its playful qualities; figuring seems to connote something children do, and we like to say that the Institute for Figuring is "kindergarten for grown-

Chrissy and I are identical twins and after we finished high school, I went to university to study physics and mathematics while she went to art school. I don't think we thought about it as any sort of polar opposites – I certainly didn't. Through her, I got to live in a life in art and through me, she got to live a life in science. The Crochet Coral Reef project is a genuine synthesis of our lives and I think that's crucial: Christine really knows about "art", I really know about "science" – but neither of us believes in a simple parsing of those



Margaret Wertheim

Margaret Wertheim at the Maths Blackboard, Williamson Gallery, Art Center College of Design. Blackboard paint and chalk. 2011. Photograph: Cameron Allan © Institute For Figuring

> because shop-brought stuff was expensive. Now the tables have turned, and it costs a fortune to buy the yarn to knit a sweater. But crafts are also deeply pleasurable activities and craft-objects are often immensely beautiful. We want to honor that reality and maintain a connection with the history of female making. To make this clear we like to say that our project is in the tradition of "fancywork" – which is an even more old-fashioned, domestic term. That said, I insist that the Crochet Coral Reef deserved to be in the Hayward Gallery and to be categorized as "art."

Wertheim: An individual piece can take anywhere from an hour to hundreds of hours to make. Christine has worked on one piece that's taken her at least 100 hours, probably much longer. You can do this on almost any scale: from







Mieko Fukuhara Staghorn Corals, Mercerized cotton, super-magnets, biscuit tin, and lace, 2010. Photograph: Cameron Allan © Institute For Figuring

tiny to gargantuan, and of course tiny doesn't necessarily mean fast, because some of the greatest contributors to the project have made miniature pieces of byzantine complexity. Nadia Severns, who is a professional crafter and truly superb crocheter, has made a series of miniature beaded-crochet sea creatures for the project that took many hundreds of hours to complete. We estimate that over the course of the project hundreds of thousands of hours have been spent.

Everyone who sees our exhibitions intuitively grasps this: it's like time congealed. You can't get this effect without vast amounts of human labour and commitment. Craftworks often embody this commitment of time that is the essence of attention and care. Donna Haraway uses the phrase that we are living in a time of "response-ability" and points out how much we humans are called on now to be responsive to the world around us. The Crochet Reef is an active positive, actually create-ive response to a time of trouble. By this, I mean that the *Crochet Reef* is a response to the devastation of climate change in which people are actually creating something positive rather than sinking into despair. The work is psychically uplifting - for the participants and for exhibition visitors - without pretending there's no problem to face.

Aloi: So far, the project counts more than 10,000 participants. How is this collective artistic mind coordinated and how are important decisions made?

Eleanor Kent Electroluminescent Corals, Electroluminescent wire, electronics, rocks. 2009 © Institute For Figuring

Wertheim: There are two parts of the project: the overall project which is created, managed, coordinated and produced by Christine and myself, and our project manager Anna Mayer. As was the case with Judy Chicago's *The Dinner Party*, the organization of the project isn't collective. Christine and I take all the responsibility and have done all the curation and project design. We bear all the costs of maintaining the project and its website and producing the books, and storing the artworks long-term. Personally, we have also crocheted and created a Core Collection of Crochet Coral Reef sculptures that travel around the world to places like the Hayward Gallery and the Smithsonian. This is the work that's permanent. In these installations, there are individual pieces by a small group of Core Contributors, about 50 people worldwide, who've made pieces specifically for the collection. They are really skilled, creative crafters who found out about the project early on and wanted to be part of it. Some of them, like Nadia Severns, Evelyn Hardin, Sue Von Ohlsen, Kathleen Greco, Anita Bruce, and Vonda N. McIntyre are craft masters who make mind-blowing imaginative things. They are part of the special evolutionary ecology of the project in that each of them has invented a new branch of the crochet "tree of life." In addition to this *Core Collection*, there are separate reefs, called the "Satellite Reefs", that are made by local communities. There have been 40 of these so far in cities and countries such as London, Melbourne, Abu Dhabi, and Latvia. These reefs are created

by community members using the techniques Christine and I have developed. When a community is making one of these, we teach them the basics then let them loose to create their own version, so there's a sense in which our Reefs send out spawn. This parallels the way living reefs send out spawn that settle in new locations and start to grow into new reefs. So, the artistic process emulates the organic processes by which actual reefs multiply. Each community will have its own central group of organizers who coordinate the local makers and work with them on the design of their particular reef. Sadly, almost none of the community-based Satellite Reefs has persevered. Most institutions don't have a commitment to preserving community-created art, so except in a few rare cases, they are temporary works that existed only for the duration of the exhibition.

Aloi: Crochet Coral Reef installations have been exhibited in art and science museums worldwide, including the Andy Warhol Museum (Pittsburgh), the Hayward Gallery (London), the Science Gallery (Dublin), the Chicago Cultural Centre (Chicago) and the Smithsonian's National Museum of Natural History (Washington D.C.). Seen by more than three million people, the *Crochet Coral Reef* is now one of the largest participatory science and art endeavours in the world. What are the important messages you would like viewers to take home from the exhibitions?

Wertheim: That coral reefs are harbingers of radical climate change that is now inevitable. We all need to think about our own behaviour and what we can personally do to cut our consumption. This is not a problem of "them" but of "we" and of "me." We are all implicated in the environmental crisis that's unfolding. And as Donna Haraway teaches us there will be no easy solutions: we must live through this "time of trouble" as responsive beings attentive to what we can do with a sense of hope but without fantasizing that simple solutions will suddenly be invented to take the pain away. The message we'd like to convey with the *Crochet Reef* is that cumulative action counts. Coral polyps are tiny brainless organisms that can do almost nothing on their own, but collectively they build the Great Barrier Reef: the first living thing seen from outer space. We, humans, are also individually guite powerless, but collectively our actions matter and have import. It is by acting together that we can build new ways of being on the planet.

Aloi: You have been mentioning Donna Haraway a few times throughout the interview. So I assume that you are pretty much up to scratch with the humanities' awakening to the importance of animals, plants, and ecosystems. The recent philosophical shifts that have marked the past twenty years are tangible manifestations of this turn; something that I hope will impact the minds of those who study at university today. Have you and Christine been influenced by other authors besides Haraway?

Wertheim: Oh, yes. The influence of feminist science thinkers such as Heather Davis, Sophia Roosth, Evelyn Fox Keller has been critical on my work, not just the Crochet Coral Reef, and feminist artists such as Judy Chicago and Mierle Laderman Ukeles have been important to both of us. As with Ukeles work, our project is also a response to waste. There is a whole part of the Crochet Reef that is made out of plastic bags and videotape and other cast-off plastic debris. The worlds' oceans are drowning in plastic and the *Reef* is also a response to that – we got into the plastic issue in 2006 long before it was fashionable. Ukeles idea of what she calls "Maintenance Art" has been a big inspiration for us over the years. We see our project also in the tradition of female maintenance work, of the caring activities that women do (so often invisibly) for other creatures – for babies and other beings.

Aloi: The Crochet Coral Reef has been exhibited in many countries around the world. Have you noticed differences in the ways in which the piece is received?

Wertheim: One of the lovely things about the project is how universal it seems. People respond everywhere with a sense of delighted recognition, even if they've never seen a living reef. It seems that these curly crenelated forms are embedded in our minds as "reeflike". When we started the project, I wondered if people who didn't live in coastal places would recognize it as a reef, but this cognition appears to be guite general. Sometimes people say, "Oh when I first walked into the gallery, I thought I was looking at a real reef!" Which is funny, because real reefs don't look much like this at all. Christine stresses that "it's not a documentary, it's an artwork." But it doesn't seem to matter how fanciful the architecture or the materials or the colours; as long as you do these hyperbolic forms the human brain reads it as a coral reef. One begins to wonder if this is embedded in some subterranean level of our minds. Or is it perhaps connected to the fact that life comes from the sea?

Wertheim: I'm writing a Ph.D. about the project and reflecting on the guestion of what it means that we find mathematics realized in the material world. Christine is reimmersing herself in the study of psychoanalysis and its relationship to the origin of language and ideas about the gendered self – which was the subject of *her* Ph.D. For both of us, making and thinking are equally important to be a being in the world.

thor of six books, her writing has appeared in publications including the New York Times, Aeon, and Cabinet. Christine Wertheim is a poet, performer, artist, critic and curator who has authored three books of poetics and edited three literary anthologies. She is a faculty member at the California Institute of the Arts where she teaches courses on critical theory, feminism, pataphysics, and rubbish. The Wertheims's work has been exhibited widely, including at the Hayward Gallery (London), Science Gallery (Dublin), Andy Warhol Museum (Pittsburgh), Museum of Arts and Design (New York), Van AbbeMuseum (Eindhoven), and the Smithsonian (Washington D.C.) They are invited artists at the Venice Biennale of Art, 2019 titled You Live in Interesting Times curated by Ralph Rugoff. More info at: margaretwertheim.com / christine-wertheim.com / thief.org / crochetcoralreef.org

The message we'd like to convey with the Crochet Reef is that cumulative action counts.

Aloi: What are you currently working on?

Margaret Wertheim is an internationally noted writer, artist and curator whose work focuses on relations between science and culture. The au-

