Video 1: Introduction & Seeing -- Color

[00:00:00]

Phillip Khoury: …art here at MIT. It's my great pleasure to welcome all of you to this, our inaugural symposium sponsored by CAST, the Center for Art Science and Technology. In a moment we're going to hear about the intellectual focus of CAST and of this event specifically, Seeing, Sounding, Sensing and what we can anticipate over the next two days. But first allow me to introduce MIT's Provost Martin Schmidt whose office houses the center who will officially open the symposium on our behalf, on MIT's behalf. Let me just say a few words about Marty Schmidt.

He was appointed are Provost last February. He has served as associate provost before that, managing the Institute space and he was the senior administrative officer responsible for MIT's industrial interactions. He also co-led the Institute's task force on the budget in response to the 2008 financial crisis. And let me say as his colleague and friend, the Institute has a lot to thank Marty Schmidt for. He's been an MIT faculty member since 1988. He earned his doctorate here and is professor of electrical engineering. He served as the director of the Microsystems Technology Laboratories, MTL at MIT. It's an interdepartmental laboratory that provides shared research infrastructure for all the campus's activity in micro and nanotechnology and supports the research of approximately 500 students and staff. It is one of our greatest laboratories in every sense.

His teaching and research is in the areas of micro- and nano-fabrications of sensors, actuators, and electronic devices, the design of micromechanical sensors and actuators and micro- nano- fabrication technology. He is the author or coauthor of nearly 200 publications and he also is an inventor on more than 30 issued US patents. His honors are many and they're too many to list here. I do want to say that his research group has transferred a number of new technologies to industry and he has co-founded or has been the co-inventor up the core technology for six startup companies. Marty Schmidt is steeped in MIT's culture of innovation and creativity and in the wider world of design and he understands how the Arts at MIT fit snugly into that culture. Marty we thank you for helping us to launch this symposium, for supporting us, for housing us in your office, and it's your show sir. Come on up.

Marty Schmidt: Thanks Phillip. It's a pleasure to be here actually. It's kind of now I realize that there's a bit of sharing of pain which is making Phillip describe my accomplishments in micro and nanotechnologies is probably distributing the pain of me having to say something to such a distinguished audience in the arts. If you paid attention to the introduction, you didn't hear arts in any of that background about me. Nonetheless I'm really delighted to be here in and in part, I'm a little frustrated because I feel a bit like the kid whose mom take some to the grocery store and you walk past the candy at the checkout

aisle, and at least in my case, your mom just pulls you through. As provost I've learned I don't get to have fun and as I read the program and realize what an interesting intersection of Arts and Science and Technology you're going to be exposed to in the next day and a half, I really am frustrated at not being able to reach that candy.
But on behalf of MIT and the Center for Art, Science and Technology, I'm pleased to welcome you all this afternoon. We are gratified that individuals from such a broad range of disciplines and backgrounds have gathered here to participate in this symposium, which I think embodies many of the aspects MIT that that I think many of us most appreciate. And just to kind of comment on a few those, first of all I think MIT has always strived to address issues a great human significance, and this symposium's ambition to create a dialogue around topics of common concern in the study of human sensory perception is timely and important as there is a renewed interest today in the study of the senses in the humanities and social sciences, and as major research institutions collaborate and coordinate to

[00:04:21] advance understanding of how the brain integrates sensory information; so a very important problem.

Second of all I think we recognize that in spite of great individual achievements, major breakthroughs are rarely made by individuals alone. And at MIT we have found time and again that a multi-disciplinary approach can yield unexpected insights and meaningful advances. In fact, I often say when I talk about MIT to outsiders that I think MIT's secret weapon is our ability to work collaboratively across interdisciplinary boundaries, and I think we're going to see some of that through this symposium today and tomorrow.

Lastly, I think we always have believed that research institutions have an obligation to share their knowledge and discoveries with the world and to make them as widely accessible as possible, and I want to congratulate the MIT faculty who organized this event, symposium chair and Professor of Art History, Caroline Jones, and Professor of Anthropology Stefan Helmreich, and I know that, although I haven't had the benefit of meeting him, Mellon Postdoctoral Fellow David Mather who is here. It is an impressive roster of participants, and the program's quite remarkable, so congratulations to each of you for your accomplishments in pulling that together.

Lastly, I'd be remiss if I didn't especially acknowledge Lore Harp McGovern, who is the honorary chair of the symposium. Lore, with her late husband Pat, founded the McGovern Institute for Brain Research at MIT in 2000. Their generous support for fundamental research in neuroscience and finding new ways to treat brain disorders has led to crucial advances in the field and had a profound impact on the work done at MIT. In addition, Lore has been a member of the Council for the Arts at MIT since 2005. The Council for the Arts, which was founded in 1972 by President Jerry Wiesner at the time, is an international volunteer group of alumni and friends who

support the arts at MIT. The council's mission is to act as a catalyst for the development of a broadly based, highly participatory program in the arts firmly founded on teaching, practice and research at the Institute. This symposium, in that way, very much brings together two of Lore's great passions, and we thank her for enthusiastically embracing those and bringing us together on this occasion. Thank you, Lore. Once again, I want to welcome you to MIT, and I hope you have a heck of a good time over the next day and a half.

Phillip Khoury: Thank you Marty. Before getting underway, let me say a few words about how CAST came about. CAST was created just two short years ago with the endorsement of our then-provost Rafael Reif who is now MIT's president, and through a generous grant from the Andrew W. Mellon foundation. We're delighted to have with us today Mellon Vice President Mariet Westermann who was such an important partner during the process. We thank you, Mariet, for your support throughout.

CAST is a joint initiative of the Provost Office and the Schools of Humanities, Arts and Social Sciences, and the School of Architecture and Planning. We established CAST to provide new opportunities for the arts to be integrated into MIT's already cross-disciplinary culture of innovation and creativity. CAST is committed to the distinctive vision that first emerged in the 1960s under the leadership of MIT's Center for Advanced Visual Studies. That vision was to create an environment where the arts, science and technology thrive as interrelated, mutually informing modes of exploration, knowledge and discovery. Specifically, CAST built upon the momentum created by the spectacular Festival of Arts, Science and Technology led by Professor of Music and Media Tod Machover in celebration of MIT's 150th anniversary, and that was in 2011. Since 2012, CAST has supported academic courses, artist residencies, [00:08:37] workshops, lectures, demonstrations, seminars, films and concerts, 17 projects in all. It's remarkable how many successful collaborations have been launched in such a brief period of time.

I especially want to acknowledge the leadership of CAST's faculty director Evan Ziporyn, and its executive director Leila Kinney, and its faculty advisor committee consisting of Professors Tod Machover, Jay Scheib and Meejin Yoon. CAST and the symposium is also the beneficiary of the strong and steady support of Dean Deborah Fitzgerald of the School of Humanities, Arts and Social Sciences and former dean Adele Santos, who was the former dean of the School of Architecture and Planning, and they are my collaborators and colleagues and friends, and the three of us form the executive committee of CAST. I couldn't live without them.

I want to extend now a special greeting to those of you who are seated in the little theater or the Skyline Winter Garden Room just beyond these doors and to those of you who may be watching the live webcast. We realized early in summer the extremely strong interest in this symposium

and made exhaustive attempts to find a larger venue, which simply was not available on campus. We appreciate very much your understanding about this space crunch and your attendance in spite of it. We very much want individuals in the other rooms to participate in the question and answer periods and have made arrangements for you to do so.

Now permit me to introduce the chair of the symposium and the moderator of our first panel, Caroline Jones. Caroline Jones studied modern and contemporary art with particular focus on its technological modes of production, distribution and reception. She received her education and training at Harvard, the Institute for Fine Arts in New York, and Stanford. She is a professor in the History, Theory and Criticism of Art and Architecture at MIT. Caroline is well known for her monographs, *Eyesight Alone: Clement Greenburg's Modernism and the Bureaucratization of the Senses* and *Machine in the Studio: Constructing the Postwar American Artist,* which received the Charles Eldredge Prize from the Smithsonian. At MIT, we're particularly grateful for her collaboration on the exhibitions at the List Visual Art Center where Caroline has edited catalogues and worked closely with our colleagues at the List, and I'm thinking in particular of the catalogue she edited perhaps most recently for the exhibition *Sensorium: Embodied Experience, Technology, and Contemporary Art*, and that was back in 2006. This catalogue points to her longstanding engagement with the relationship between art and science, which is also exemplified in the 1998 volume she co-edited, *Picturing Science, Producing Art*. Caroline's ongoing research interests include globalism and new media art, and she has a forthcoming book, *Desires for the World Picture, The Global Work of Art*. Caroline, we are deeply grateful to you for envisioning this symposium, for making it all happen with our colleagues, for recruiting the kind of talent that we will hear from today. It's really exciting. This is the first international symposium of this kind for this new center, and we anticipate many more in the years to come. Caroline Jones.

Seeing -- Color

Caroline Jones: Great. Thank you so much everyone for coming and for showing interest in something that, you know when you're cooking this up you think "well maybe I'm the only person interested in such a strange confluence." This has been a long time in planning, about 2 to 2-1/2 years, and it's simply thrilling to have everyone here and have this finally coming together. Like Phillip, I want to give a shout out to those in the outer rooms and who are in their pajamas watching this online. We'll do our best to get your responses and queries into the room here, and there is an email address – I think it was on the screen previously, anyway it's on the website, where you can email questions and comments, and we'll be filtering those over these days and trying to bring them into the discussion. Finally, just to the unbelievable leadership and staff at the Center for Arts, Science and Technology for their management of this complex event which, frankly, academics are not really very good at.

[00:13:12] I've been given a script to announce about the question and answer procedure. We're going to invite those with questions to raise their hands in the outer rooms when we get to that part of the program, and there'll be people to escort you actually to this room where you'll be able to ask your questions. While they're doing that harvesting, we'll begin with questions from this room, and we'll try hard to just alternate and move through those people. That is to say, if we can keep on schedule and actually finish in time, and that leads me to the other point which is that we're going to have to clear the room precisely at 4 so that they can set up for the evening's keynote by Bruno Latour who we're incredibly lucky to have join us this evening.

So color is the beginning theme, and in many ways I think it's an ideal mystery with which to begin. We could make a chart like this, and I could tell a story going back to C. P. Snow in the 1950s, a story of the two cultures. You know, where we'd have a “what” for the scientist that might be wavelength electromagnetic energy, photons. For the artist, it would be tone or hue, right? We could go down this list in this way, but this symposium is not going to do that. In fact, in my brief introduction, I'm going to be mixing it up, anticipating that our visiting artist Tauba Auerbach will be talking about color and mathematics, and our participating neuroscientist Bevil Conway will be discussing color's affective and emotional potentials.

So let's begin with this kind of interesting example. How do mathematicians use color? One example comes from MIT mathematician Thomas Mrowka who collaborates with Harvard's Peter Kronheimer to untangle knots. When is a knot not a knot? The math community has a little joke by which they call a not knot an "unknot." Now it turns out that this tangle that you see here surrounded by the black is not actually a knot. It turns out to be a taurus. How can you tell that? Well, Kronheimer and Mrowka have developed a solution, a theorem using color and simple set theory. How does this theorem operate? Well, it's a game. It's a game based on set theory. You're only allowed three colors. They're choosing here red, green and blue. And at each crossing in the schematic drawing of the knot, you can do one of two things: You can either make all three ropes the same color, or you have to make all three ropes a different color. So these are the rules of the game, and these are the decisions that they have to make at each crossing. So just leading you through that, they have a schematic like this. Is it a true knot, or is it an "unknot?" They begin following their rules. Now, obviously you could take different decisions at each point. What I'm showing you is the decision that actually works. So you have to make that decision, and sometimes it's the wrong one and you have to undo it and try it again. So through some algebraic formula that I'm never going to understand, they come up with this final drawing, and the knot has been successfully tricolored. Therefore, it is a true knot. Now the only problem that they found was that some knots are so complex that you need more than three

colors. So then you have to alter the rules of the game a little bit and draw many more colors, perhaps arranged on a disk, and decisions are made in other kinds of complex algorithms. Finally, you might have to go to a sphere because you need the third dimension to handle the complexity of certain knots and so on and so forth.

The basic point I want to make to you, that as Thomas told me when I told him that each color had an emotional meaning to me, he said "No, they're just heuristics. They're simply attributes that are inessential to the basic quality of the knot, but they help us think about how it's organized and come to a decision about its knottiness."

Well this resembles the decisions of physicists, who label subatomic particles, which they call quarks, with colors simply to generate a kind of thought about the arbitrary designation of particles that can never be perceived. These can never be perceived by the human perceptual apparatus, but the color indicates that there must be some tiny difference that will allow these three quarks to be in

[00:17:44] the same orbit as they oscillate between particle and wave states. Now, none of this, as I say, can be perceived, so color is a complete heuristic, but I'm struck by the fact the color is handy for this use. The visual system's opponency, for example, which undergird our designation of complementary colors, become useful to the physicists who want to conceive of an anti-red quark or an anti-blue or an anti-green, etc. In the end, color is just one of many attributes that include what these scientists call "flavors," strange, charm, up, down. So in the cocktail party of quarks, being colorful is not all that special.

Now, philosophy long ago seized on the place of color as fundamentally ambiguous, mysterious even in the linguistic sense, perceptible yet somehow irrelevant. For Wittgenstein, it served to indicate how the rules of the language game worked. So, I'm giving you a quote from one of his aphorisms, "How is he to know what color he is to pick out when he hears the word *red*. Well, he says red means the color that occurs to me when I hear the word *red*. " This sounds like a tautology, but Wittgenstein explains that if you need to, you can consult a chart, you can point to it. The idea of *red* will be conveyed over such procedures which then lead to the logical conclusion that red is this shared designation in the language game, but of course in the worst case, the confused interlocutor looking at this chart has to wonder which red is the true red, and I chose here British Leyland so that Wittgenstein could get his hands on this particular chart. But of course, this really just raises a problem since, you know, is this blaze red, flame red, pimento? Is it poppy, fire brand, cherry blossom? I'm sorry, that's white. You see the problem. It's a very mysterious thing how we can even agree on what red is when I will never see the red that you see, and you will never the see the red that I see.

So the proliferation of adjectives here in this commercial autobody chart suggests on one hand the place where capitalism and chemical industries want to commodify the precious pigments that humans have always sought to adorn themselves and their objects. Well this, in turn, only leads us to another argument about this mysterious attribute. Let's say color's not a language game, it's an emotional signal, pure and simple. Perhaps then we should go over to the arts side to see what lies at the root of these desires. Modernists such as Matisse experimented with the idea that if color was emotion, why not saturate a canvas with a single color and embrace the tone of vibrant intimacy, as he does here in *Red Studio* from 1911. This might, in turn, have been his own considered riposte to Picasso's *Blue Period*, as here in the 1903 *La Vie*, a composition that the impoverished émigré (20:45) painted over the canvas that had been selected as part of the Spanish contribution to the 1900 World's Fair. In other words, blue was important to cancel out his previous existence as an artist. In case you're not certain of the emotions Picasso wanted to convey here, I have this version from the web from Fly Art's Tumblr feed to help you decode the message. This makes it all clear, how bleak the emotional situation really is in Picasso's *Blue Period*.

So vision is the best understood of any of our perceptual cognitive systems, but color, a fundamental part of our visual systems, remains the most mysterious of our perceptions. On the one hand, it's sufficiently detachable from objects that it can float free from signification for a mathematician or for an artist who's interested in modeling the abstract qualities of higher dimensions. On the other, it's so crucial for life as we know it that it evolved over countless millennia in two separate evolutionary pathways for the human species and via convergent evolution in many other species to convey some kind of clear advantage to those millions of other creatures. If other species' evolution took many different paths to end up with color vision, just what is the advantage conveyed by this perceptual ability? Most theorize that it conveys some capacity to communicate to other seeing creatures. Being colorful allows one to signal is the theory, and being able to see color allows one to perceive those signals while navigating in a world illuminated by the visible spectrum, which we've evolved to perceive.

[00:22:27] Our cousins in the primate family have a clear color expert in the mandrill, whose face and rump – but I'm sparing you that imagery – have an astonishing capacity to broadcast arousal and aggression through changes in color.

Now what of structural color? This is a whole different animal. This creaturely capacity has lately come to interest Tauba Auerbach very much. How does it work? The modifier *structural* gives you a clue. It is the structures at the nano level, the structures of the tissues, which literally baffle the unwitting photon as it enters the transparent (usually) kind of cell structure. Numerous insects, birds and plants have developed structural color for signalling to each other through unique color fingerprints that

seem to work intraspecies to indicate potential mates and hive members and perhaps to indicate to other species to stay away. So if protective coloration is one kind of adaptation evolved to avoid predation, the development of structural color suggests a canny partner. Since there is virtually no color to these surfaces if they are in shadow or dappled light, but a full color signal when the structural surface is dazzling in the sunlight.

Now we come to the point where the real experts enter to replace my ramblings with actual insight. I will not reiterate the information that's available in your programs that gives bios on each of these participants, but I do want to thank Bevil Conway for leaving his lab for the day and Tauba Auerbach for skipping out on her commitments to the New York Book Fair to be here. I also thank Alma Steingart, a postdoctoral fellow at Harvard Society of Fellows who got her PhD here at MIT in the Science, Technology and Society program studying the anthropology of collaborative mathematicians for being here to help us have this very interesting conversation.

I've referred here to Tauba Auerbach's interests in color as a kind of heuristic for modeling higher dimensions, but in fact Auerbach's work is saturated in color of every kind. Her art threads throughout your program, and this colorful object we're looking at here is what represents the artist herself in the bios. One of the three massive and perfectly cuboid books, the *RGB Colorspace Atlas,* materializes with sober wit the colorspace defined at an international conference in 1923 to allow commercial printing, science and art to proceed with precise mathematical precision. In other words, they agreed on three coordinates that would designate specific colors that could then be reproduced around the world. Probably she is best known in the art world for her fold paintings. I know she is going to show us some of these. Auerbach is fascinated by the codes we devise to communicate and model dimensionality. Here, the completely flat stretched canvas is an index of its prior existence in a three-dimensional condition, folded, piled up, and sprayed from different angles with different and often complementary colors. Particularly appropriate for what she wants to discuss today is her artist book, *2, 3*, which also interrogates the relation between dimensions, in this case the second moving into the third. Here's a very embarrassing home movie, and I know Tauba's going to hate it because it's imprecise, but I'm going to show it anyway because using pop-up technology this book also models the fourth dimension in the sense that as you open it, as you experience it in time, you have a kind of theoretical access to time as the fourth dimension. And I hope she's going to explain to us exactly whether time is the fourth dimension or not because I'm still unclear whether it's a model or actually IS the fourth dimension. Anyway, this is why we're here, right? Also, this whole amazing series of bound books also explores some classic geometries and some extremely seductive desirable geometries from the sphere to the pyramid and here the twin octagonal bipyramids that we just call the gem shape.

By contrast, Bevil Conway has made color perception the research focus of his career as has Auerbach, but he explores the neuroanatomy of the retina at the minute and microscopic scale, and even, I want to say the subatomic scale because he gets into firings and electromagnetism at that level. He also

[00:27:10] tracks the perceptual pathway back into the brain and reveals that color is indeed processed quite separately from the perception of shape and form, for example, to quite different purposes in our functioning in the world. What may be less well known to his community of neuroscientists or other scientists who use his work, is his own practice as a sculptor, a maker of incredibly precise assemblages of glass and silk, and a painter whose technical mastery of watercolor makes small miracles on paper as here. Bevil's fascinated by the idea that no light can be captured in a work of art that is not produced in the human perceptual system. In other words, you're merely reducing the amount of light available to the retina by painting on the piece of paper, you're subtracting the available light, and yet of course phenomenal effects of light are produced by this traditional medium which he practices so beautifully today. When I photographed the scene that you see here and expressed dismay at the digital camera's incapacity to capture the delicate colors of the Cape Cod sunset seen through the woods, Bevil just said "Well that's what painting is for." So, you know, I'm switching the game here. Our scientist is an artist, and our artist is a scientist.

Now, Alma Steingart will return us to the confluence of color's emotional and mathematical potentials as they thread together. When she contextualizes the work of mathematicians, for example like Brown University's Thomas Banchoff whom she brought to the attention of Tauba Auerbach last fall – and this is part of the longer process of the artist residency program here at MIT where we just harvest people from other universities, we just get whoever we can to talk to the artists we want to work with. Banchoff's pioneering computer models of hypercubes and other fourth dimensional topologies were done by painstakingly plotting points on a computer graphics terminal in the 70s and then photographing the screen frame by frame. The computational step is an important one, and I hope both Alma and Tauba will help us understand the role that it played in understanding the conceptualization of higher dimensions.

So we then come back full circle – how color communicates to us on some mysterious and available level to make apprehensible those dimensions that we otherwise have a hard time thinking about. I'll leave you then with the mystical mathematical meditations of the mathematician Charles Howard Hinton who found color essential to communicating the nature of what he called the Tessaract, a fourth-dimensional aid he imagined to evolving the human to the next level of existence. With that charge in mind, let us begin.

Tauba Auerbach: Hi. I'm going to start with a story about a time when I was in kindergarten. I had a friend come over to play, and we were in my bedroom and we wanted to close these shutters that were too high for us to reach. So without being invited to do so, she got on my bed with her K Swiss and opened or closed them, I can't remember what it was, did whatever it was to the shutters that we were hoping to do. And when I watched her do that, I had a thought after which I would never be the same which went something like "I would never stand on her bed with my shoes on because I was taught that was very rude and, therefore, I will never be her and she will never be me, and I will forever be trapped within the bounds of my own consciousness." It wasn't probably said that way at the time. For weeks after that, I would wake up in the morning and lay in bed and say the word *me* over and over to myself alternating between asking it as a question and giving it as a kind of bewildered answer, and it was a cerebral tangle that I enjoyed and hated. It was like a joyful frustration of trying to contemplate my own ability to contemplate, but it also registered as something of an existential or spiritual crisis. I felt totally deflated by the idea that I would never transcend my body or my senses or my mind and that I was separate from the universe and separate from other people. And this led to a whole host of questions, some big and some smaller and some kind of classic like "what if my red is her green?" This is a photo from *Life* magazine in 1966 of a mathematician tripping on acid with his cat, meaning his cat is also on

[00:34:24] acid. I guess he did this on a regular basis, and, though I question the ethics of dosing your pet, I definitely appreciate the spirit of the desire to do so. The distance between the man's consciousness and the cat's consciousness are an exaggeration of the distance between mine and my friend's, and there are a few ways I've thought about this, like, structurally. Here they are, dots for their minds. The sort of boring way to think about what's happening here or maybe first and most predictable way is that there's sort of an area that their consciousness can dwell in and that that gets expanded and then hopefully they overlap a tiny bit. But another way to think about it is maybe that they're coming together by virtue of a shared change so, in this case I've used color, a yellow arrow and both of their dots become slightly yellower, and it's by the shared experience of yellowing that they come together a little bit, or like a phase transition, maybe they're solids and they melt and then they can comingle.

For five years, I was in a relationship with another artist who was a dichromat, colorblind, and he and I communed with each other psychically over the shared experience of looking more than anything else. So I guess I no longer see that "what if my red is your green" idea as such a problem. I also have sort of another question about this thing. What if you could take this distance between them and you could transpose the key of cat into the key of man and then transpose the key of man by the same process to something? What's over there? I often wonder about this when I'm hanging out with people's pets. I also fantasize about making new drugs all the time, if there are any chemists who want to talk about that – like a miracle fruit

for the eye. I don't know if you know what miracle fruit is. It's this berry that you can eat, and it'll make sour things taste sweet for a period of time after eating it. So what if there was something we could do to our vision like that?

If you couldn't tell from that little series of slides, I tend to think about all kinds of things, interpersonal things, problems, arguments, ideas through models and a lot through gestures as well. So sometimes I think about this same consciousness problem as having a format of this non-orientable surface, like if you want to try to get to the other side of that membrane that bounds you from the universe and from others, you maybe can get there, but you would always be on the same side also so if you follow one of these paths around you get to the other side, but you've never left the surface. More recently I've been thinking about this very simple metaphor model, and thinking about it in terms of a way that I want to cultivate my creative space right now too. So I'm thinking about a system or an area that's cohesive and has an edge and that there's a place at the edge where it doesn't just drop off sharply, and it doesn't just fade away, but things go a little bit haywire and something special, like the foam or froth at the edge of the water on the beach happens. And this space is changing and texturally different from the rest of the ocean, and it's undulating and just kind of a hard band to be in, but that's where I'm trying to be in my work and just in my life in general. And even though that's at the edge of the water, and maybe you could think about the gesture of getting there as sort of like pushing outward or dealing with the edges, I don't think about it strictly in that way. I think you have to equally, or I feel that I equally need to dig inward. So I think about yes an expansion, but also a kind of burrowing on a microscopic level, like tunneling into everything that's in between, but that kind of seems more like the gesture of burrowing is important here.

To borrow a Sagan-ism, we're made of star stuff. There definitely seems to be something to be gained in understanding and connecting with what's out there by going deeply into what's inside, and I think there are so many different ways to get there, I think drugs sure, but meditation, daydreaming, night dreaming, and for me the act of creating and sharing in other people's creative output like, I think of the experience of watching a really skilled musician improvise, and when they're really in that state of where it's flowing, for lack of a better words, that's all built on a foundation of a cohesive system of knowledge, that middle part of the ocean, things kind of make sense. There's practice and theory, but then to really

[00:40:16] improvise beautifully you have to tap into something and kind of surrender to it and really be in that sort of frothy band at the perimeter, and it's like watching music move through someone instead of them making it, and I find those kinds of experiences, to participate in or to witness them, those to be really the transporting sort of spiritual mind altering and communing experiences that I was thirsting for and sort of mourning when I was a kid.

Another way to get there I think is also just by what I would call hanging out with certain ideas. So one idea that I've hung out with a lot in the last few years is of four-space and beyond, although I don't like the word *beyond* for a variety of reasons, I just mean four and four-plus and dimensional space. So a really brief primer on the fourth dimension, and I'm used to speaking to art audiences, so I sort of don't know how much is obvious and how much isn't here. If you go to the left of this diagram, a line, a one-dimensional body, is bounded by points, zero-dimensional bodies. A two-dimensional body, a plane, is bounded by a one-dimensional body, a line. A three-dimensional entity is bounded by a two-dimensional entity, a plane, and likewise, the Tesseract, the four-dimensional cube, would be bounded by a three-dimensional object, the cube. So a three-dimensional object is a surface or a slice through a four-dimensional object, and if you think about all of our space, all of our three-dimensional space being a slice or a surface, I think that's a really beautiful idea to spend time with. So Thomas Banchoff and Charles Strauss made this really beautiful video that Alma turned me on to, and then Banchoff kindly sent it to me so I'm going to play an excerpt. I wanted to play the whole thing, but I'm kind of pressed for time, so I'll just let it go.

VIDEO: Viewing objects in three-dimensional space, we are aided by the devices of perspective. As we rotate a 3-cube in perspective, we see each of the 6 bounding squares as the smallest, furthest away square and then again as the largest, closest square. This is not the top view of some two-dimensional creature swimming in on itself. It's a rotating three-dimensional cube, and we are quite used to these perspective distortions. But now we go to four-space. We change our perspective, and we proceed to walk around that four-dimensional cube. As we walk around, we see each of the 8 cubical faces as the smallest cube when it's furthest away or the closest cube when it's largest. This is not a three-dimensional creature swimming through itself. It is the shadows of a rotating four-dimensional cube. This is the best rotation where the red cube, now largest, now flattened out, now turned inside out as the smallest, furthest away cube. And if we become comfortable with rotations, every once in a while we see a rotation, which confuses us once more. Rotating directly toward us and away from us we find another very strange view of the rotating four-dimensional cube in perspective. At the end, we go back and end at our three-dimensional cube.

In addition to projections and rotations, we can use the device of slicing. Slicing a square by an edge parallel to one side gives us a segment for a while. Corner first gives us segments, which grow and come back off ending at a corner. We can use the same technique to slice a three-dimensional cube. Parallel to one face we get a square for a while. Edge first, we get rectangles, which grow and come back off ending at an edge. Most interesting is corner first. What do we get halfway through? We can see that a bit more a slowly, triangles which become cut off so that halfway through we cut each of the 6 bounding squares in precisely the same way. We obtain a perfect, regular hexagon halfway through the cube.

[00:46:07] We can use the same techniques to slice a four-dimensional cube. We position our three-dimensional knife parallel to one face to get a cube for a while. Square first, our slices are square prisms that come back off ending at a square. There are two more symmetrical ways of slicing a four-dimensional cube. Edge first gives us triangular prisms. Halfway through, a hexagonal prism. Coming all the way back off, ending at an edge. Most interesting, most challenging, what do we get when the slice comes through [00:46:56] corner first along the long diagonal? We can see that more slowly, a small tetrahedral pyramid, which grows until it hits the vertices and becomes truncated, cut off, so that three-eighths of the way through we have four equilateral triangles, four regular hexagons. One hexagon exactly halfway through that red cube. This is a semi-regular polyhedron already known to Archimedes. Halfway through, we cut each of the eight bounding three-dimensional cubes in precisely the same way. We get eight equilateral triangles fitting together to form a perfect, regular octahedron, a platonic solid. We complete our tour of the four-dimensional cube by showing slices, which go off at a point not situated at the center of the screen. One last pass, tetrahedra, tetrahedra cutoff, in the middle the octahedron, tetrahedra cutoff the other way, coming back off, ending at a point, completing our tour of the four-dimensional cube.

Tauba Auerbach: So amazing, right? I love the idea of a three-dimensional knife. I think that's a beautiful formulation. So to follow up on the question of what role does time play in this, my answer to that would be that time is a way to possibly obliquely observe the fourth dimension. It's through the use of time that we can see the knife move through the tesseract, and because of this, well if we go down a dimension, there's sort of an example that I would give so if we follow this arrow of time, here's a sphere moving through a plane which is the red line. And as the sphere passes through the plane, on the plane, or to the perspective of the plane, there would be a tiny dot that would appear and then a slightly larger circle, and it would get bigger and bigger and smaller and smaller and smaller and contract and then disappear, similar to how that knife looked going through the tesseract. And if you were a plane or being and you lived on the plane, you would experience it like this. You would be seeing it from the edge so you would see a dot appear and then it would be a slightly wider line, wider and wider and wider, and then smaller and smaller and smaller, and then it would seem to disappear.

I think part of the reason that I feel like this idea is so useful to me in thinking about consciousness in general is that I've come to think of consciousness itself as a four-dimensional material passing through this 3D slice of the universe that is our 3D slice. Consciousness seems to appear as if from nowhere, expand, change shape, contract, and then seemingly disappear. I think the process by which the chiral molecules in your body begin to slowly flip so that they become racemic after you die is also a nod toward this idea. I know it's more complicated than a simple flipping, but in order to… I don't know how much I should explain about this, but if a

molecule is mirror asymmetric, there are two ways that it can be assembled, and if they're chiral one is considered left-handed and one is right-handed, and in living tissue the great majority are, I think it's left-handed. Maybe someone can correct me, but they're all on one side of this mirror, if you will. And at death, slowly, this balance starts to go toward 50/50. So in order to flip over a one-dimensional object, a line, you have to move it through two-dimensional space. In order to flip over a mirror asymmetric two-dimensional entity, you have to pick it up and flip it over in three-dimensional space. And the same is true for a three-dimensional object. In order to turn a mirror asymmetric three-dimensional object into its mirror image, you would have to flip it over in four-space. So I had to use my artistic license to sort of make this speculation that this process that happens when whatever animates us leaves this vessel, is a nod to the fact that maybe there's interaction between higher spatial dimensions and consciousness itself.

So color. Color is of particular interest to me for a variety of reasons, the first being that I feel that it acts on the part of our being that is in that frothy band. There's an extent to which you can reason about it and describe it and transmit it, but it's also extremely evasive to that process. It's very changeable, it's very visceral, and it sort of outstrips reason and language, and it's powerful and slippery. And it also seems to have a reciprocal relationship with active modeling in general, particularly with modeling surface and space. So all the time we use color to organize things, just to code and organize and make

[00:53:20] them more manageable, and very frequently it's used to model surfaces in space or elevation. We're very familiar with this kind of map, this topo map, where color is coding where this material is positioned in space. But then to try to model color is another weird, very problematic challenge, and I love how it's happened in so many different dimensions. So it can be organized just as a simple line, as a section of the spectrum. That line can be bent into a circle, and there are so many different ways to actually form this circle because of how much area you're going to give to each of these colors, how they're going to be distributed. This is someone's attempt, I can't remember whose. Newton did this also, but this is not Newton's. Assigning the spectrum to an octave because the relationship between the lowest frequency and highest frequency in an octave is close to the relationship between, the ratio between the lowest frequency and highest frequency of visible light. So a lot of people have made an attempt to draw this correlation, and this person took that circle of hues and turned it into a helix, saying every time you go one step up in the helix you are going up an increment in brightness. I wonder how he determined the chirality of the helix. This is Newton's drawing on the same subject.

Things get really interesting when you move into three dimensions. There are a couple different ways of modeling color with three-dimensional solids, and they all sort of fall apart, in my opinion, at some point. So the one that I

used for that book that you saw earlier and will see again is the tristimulus model that takes these three sensitivity ranges that are measured for three types of cone that the typical human retina has, sensitive approximately to blue, green, and red light, and assigns each of them an axis. So you get this cube where all of the values of red, green and blue are zero, that corner of the cube is black, and the opposite corner were all values are at 100%, that corner is white, and in between you have the secondary colors or pigment primaries: magenta, yellow and cyan. And it's very elegant, but distribution-wise it's kind of flawed. There's also this opponency model that Bevil will maybe talk a little bit more about, that places these three axes according to antagonist relationships between how colors are perceived in the brain. So the first, the RGB model is really dealing with the retina, and this is about what happens after the retina because there's a complicated processing system at work there. So a different solid emerges from red/green, yellow/blue, and white/black opponency, and here too, that solid is sort of imperfect because things are distributed irregularly. So the more accurate, I suppose, these get, the more unruly and sort of inelegant they become, and I really like that color evades this perfect, elegant organization. I think therein lies a lot of opportunity and just some of its power. Here's a cross-section through one of them. And it gets way more complicated when you're trying to recreate color so here's an RGB cube. One of these is the gamut on the screen, and one of them is a printer gamut, and you can just see that the cube is getting distorted over and over. What you end up with is just nothing like what you started with. I would propose that there should be a color model that accounts for contrast, so one that would place every color next to every other possible color, and I don't know how many dimensions that would have to be.

After thinking about four-space for quite a long time, I stumbled on the idea of the tetrachromat. The tetrachromat is a person, a woman because of where the genes are for the M and L cones on the chromosome, a woman who has evolved a fourth color receptor, or fourth cone class, and here are some potential variations on the bottom row here with four different sensitivity ranges. And when I came across this idea, I saw a really good opportunity to possibly use that to get closer to understanding four-space and use the idea of four-space to get closer to understanding the tetrachromat reality, and I put together this show called *Tetrachromat* that sort of started with this set of books as a point of departure. The *RGB cube* is elegant and is, like I said, is flawed, but it's also familiar and sort of omnipresent now as a model. So I took that cube and decided to slice it in three directions and bind those slices into books so here is how they look open. My thinking was that if you could kind of back
[00:59:20] away from this, manipulate it, move it around, and slice through it, you would have some kind of insight as to coming out of that space. If that theoretically is the color space that we are in, it might be valuable to stand over it and be the boss of it. And these books were sort of the artery or point of departure for the show. They ran through the center, and around them were a series of paintings. These fold paintings are made by taking

canvas, crumpling it up or folding or rolling it, holding it tightly in these sort of bundles, and sometimes steaming them into those shapes, and then spreading the canvas on the floor, and in its creased shape, spraying it obliquely with different colors of paint and different angles, then stretching it on stretcher bars, and the result is something that's totally flat but really looks convincingly to protrude into space. I started this with just the ambition of sort of softening the boundary between the discrete states of two dimensionality and three dimensionality and thinking "well if I can do that then that implies that there's the ability to make a crack in the three dimensional wall of this space," and maybe we can just see through that crack or just point ourselves toward it or glimpse something on the other side. And I started with very, very straightforward color strategies of a dark and a light coming from opposite directions, but it quickly got more complicated, and I think that's when it got more interesting. I would fold and spray and then refold and respray so that there were sort of warring creases on the surface that couldn't possibly coexist. And then I got more into using sort of difficult color relationships like sort of puce, a purple that turns into a brown, and the purple is coming from the bottom, and the brown is coming from the side so there's a shift across the canvas, and that shift is really apparent in that first one that I showed you where the darker side on the bottom of the canvas is on the right, but the darker side on the top of the canvas is on the left. I think the most successful ones were the ones with three colors where I somehow got to a point that was just on this side of the line from ugly, and of course that's a moveable and subjective line, but for me it was about calibrating being in that little spot, like being in that frothy spot but with color. And I don't see any way to do that with reason. I can only really do that with my stomach, so I was painting, for this series painting and painting and painting. I would paint so many of these, and then I would edit very harshly at the end, and that was a very intuitive process. So there was sort of this strategic process of how to fold and spray and how to create this convincing illusion with a strategy instead of being a virtuosic painter, but then the act of painting and the act of editing was just stomach-based. I'm going to skip a few things. These are some books…

In the same show, I introduced a new series of paintings I'm still working on now that are just made of woven canvas. So this is very much the gesture of going inward. Originally when I read about the tetrachromat, I thought "oh, there's a sensitivity to a color outside of the range of colors that we see," but as you might have noticed in those first graphs, that's not the case. The sensitivity is actually in between the colors that we are already sensitive to, so in fact, the tetrachromat has the ability to distinguish between things that look exactly the same to us, and there's a greater richness and texture, and in order to understand that, that's really more about burrowing in than looking outward. So I thought I would build this surface on which I had been painting for years and sort of taking for granted from scratch, from within, and try to make images of depth and light and shadow with just one color and only structure, so these are just woven from canvas strips but still on the same traditional stretcher bar supports. This first one was intended to

just sort of feel like a corner, like three planes meeting, but they got more complicated from there. There's often now, sort of like architectural marks and something like a ray of light sweeping across it. Here's a close-up. And most recently, I've been most interested in making gradients and a sense of transparency, which has been an extra challenge. Here, a transparency is created by first sort of an opaque band going diagonally like lower in the canvas where the weave is very, very dense, and then that slowly dissipates and you start to see that background pattern coming through it. These are so hard to see on the projector, I'm sorry. Maybe this one's a little better. So there's this almost set of windows or frames and then a diagonal sweep going across that [01:06:00] through which you can still see a little bit of that background pattern. So what about this one… it looks like nothing [01:06:09]. Oh I enhanced this one so maybe it would be more prominent. So this was my attempt to getting a little bit closer to the tetrachromat's experience, getting closer to higher dimensionality. And lastly, there was this series of shadow weavings. I didn't come up with that term. It's like the name of the weaving technique. I won't explain the technical side of it, but essentially these end up being monochromes. The warp and weft are each strung with alternating colors, and the structure of the weave is just a sort of basket weave that alternates directions so what you see is the edge of an area done a certain way, where its system breaks down and turns into the system.

I'm going to skip to my last thing, which is a one-minute guided meditation. I hope that you'll humor me and really try it and also really try it later when you're not in a room full of people and listening to my nervous voice. This is something I was doing a lot when I was preparing for this show. So I want you to look straight ahead, be comfortable, sit up straight and bring your attention to your peripheral vision. Take a couple breaths there, and just think about hanging out in that space. Now without pushing or forcing or even thinking aspirationally about it, allow the edge of your vision to fall back behind you just a little bit and think about it as falling or surrendering and take a breath or two. And without losing that, observe how the interior of that boundary feels. For me, the texture of my vision gets a little bit more particulate, and if you're like most people, and like me when I first started doing this, you've totally forgotten that there is peripheral vision at the top and bottom of your visual field as well so bring that into your attention and try to hold that all there at the same time and be there with it, all the while not letting go of the center. Thanks.

Caroline Jones: So Bevil's taking a bathroom break and encourages everyone to stand up and sit down again. So after you've meditated you can aerate, elevate, sit down, thereby covering his escape and return. Thank you.

[End of Audio 01:10:02]