WALTON GREEN

Organismic and evolutionary biology,
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Inside of a theater, surrounded by a group of students from the Massachusetts College of Art, we hosted Walton within the context of an Interrelated Media course led by Elaine Buckholtz. The eyes and presence of the students gave this picnic a unique aura, and so it felt the most like a performance. During the picnic, students from the class were invited to ask questions; their ideas and inquiries directed the conversation differently from the other picnics. Sitting among artists, it was great to have questions related to the artistic production and representation in the movie, making us more aware of our acts of staging in this project. Small flakes of snow fell outside the window as we warmed up our conversation by talking about the role of teaching in our work and our favorite teaching and learning moments.

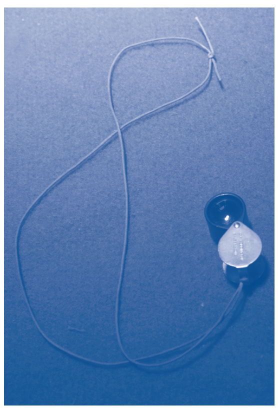
In the same space the day after the picnic, we choreographed, along with Walton, over fifty students and professors to represent the molecular level of 10^{-15} as a throng of people dressed up in solid colors en masse, instead of the colorized TV static the Eames used to visualize the smallest power of ten, which was then still impossible to see even by microscope. It was a molecular happening in dance idiom (FIG. 5).

AMY: What is paleoecology?

WALTON: It's a fuzzy area between biology and geology. Specifically I look at how plant ecosystems change and have changed through time in the past and present.

MICHAEL: What increment of the *Powers of Ten* scale would you align yourself with?

Walton: 10^{-1}. Most of what I study is on a pretty human scale. Some of it is a little smaller than you can see with the naked eye, so many botanists and geologists carry around a hand lens like this one – a small magnifying loupe that blows things up by a factor of ten, so I would include a power below what's visible to the naked eye to cover my main area of interest *(FIG. 1).*



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AMY: Can you talk about time in relation to what you do? The *Powers of Ten* used how fast we moved through space as a marker of time, connecting space and time.

WALTON: Many of the natural sciences have to deal with spatial scale, but in paleoecology, the most dramatic occurrence of scaling phenomena is with time scales. For instance, there is a longstanding debate about homeostasis or the existence of a climatic climax. We tend to observe fast changes in an ecosystem until it reaches a steadier state, more or less in equilibrium with the environment, which has been called a "climax" or "climatic climax." Climax ecosystems used to be thought of as super-organisms, implying they had births, deaths, complex interactions among their constituent parts, and responded in the way that organisms do to climate change. That idea fell into much disfavor between the 1930s and the 1980s, as the trend was to think of the biological species as the fundamental unit and the ecosystem merely as a collection of species. There has been an undercurrent of resistance to that individualistic view, of which James Lovelock's 1979 book *Gaia* is perhaps the best-known example. One can think of this debate as being about time scales: over what

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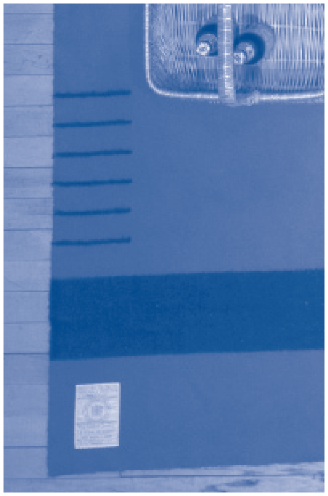

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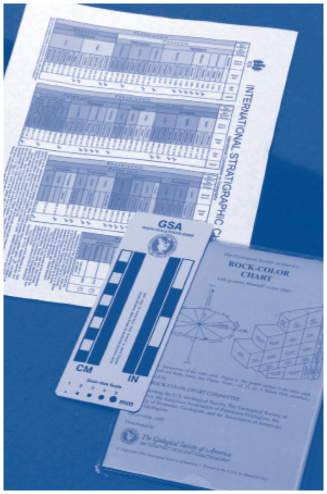

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period of time are we looking at change or stasis in ecosystems?

Elaine (a member of the audience): Can you talk about homeostasis? What does it mean in your field?

Walton: It is currently politically important to determine whether natural ecosystems are homeostatic or not, whether they are in fact stable under perturbation. If current trends continue, we will lose the polar ice caps; if that happens too fast – over the course of the next decades rather than centuries – it could have cataclysmic effects on human societies. It might or might not affect other natural ecosystems; we just don't know how good different ecosystems are at responding to changes that happen at different speeds.

Amy: Lovelock talks about that in connection in terms of cybernetics. I am not always clear on how that word is used.

Walton: I think the way in which Lovelock uses it refers to feedback. The term I use is homeostasis – the ability of an organism to alter its own surroundings and therefore maintain a stable situation. I think that the use of cybernetics implies a feedback process that allows an organism to maintain its own situation relatively unchanged. It would be reassuring to think that most natural ecosystems are in stable equilibria that they themselves perpetuate – that they have the ability to modify the world around them so that whatever the changes of the external environment, ecosystems could still survive.

Michael: So we moved our picnic inside an auditorium as it rains outside to modify our environment *(FIG. 2)*.

Walton: This theater we are in is evocative because it is an extremely controlled urban space. Urban space is already controlled, but indoors is an even more completely controlled part of an urban space. Human society is a great example of the way in which a natural species can control the environment in which they exist.

Amy: What kind blanket is this?

Walton: It's a Hudson's Bay Company Point Blanket. The story goes that the hash marks on the edge represented the "points" or number of beaver pelts for which the blanket was traded *(FIG. 3)*. I have no idea whether that's true, but woolen blankets from England were certainly traded for pelts during the Canadian fur trade in the eighteenth century. The global ecosystem has been at the mercy of the global economy for a long time. We have been meddling with our environment for thousands of years; it's only the scale of the meddling that has changed.

Thinking about scale, I brought a couple of scales that I use in my work *(FIG. 4)*. Here is the geological time scale, which is how we usually split up four billion years of earth history. It is based on the stratigraphic record, so these colored bars are analogous to stacked sediments. These little golden spikes are times that are set by actual places in the world.

I don't know where they all are, but for each one of those little golden spikes, there is a real rock in a real place that corresponds to a point in time when that piece of rock was deposited. The geological time scale sits behind everyone who studies the whole extent of the earth's history because that is the way in which things get put into context.

Thinking about the *Powers of Ten*, I wonder what the film would look like if it used a different scale, like the power of two? Of course the ten is common, in history we talk in terms of decades or centuries and it gives us a chance to make some kind of order. But the geological scale isn't related to a base-ten system; it is originally based on what plants or animals are found in the rocks. Before radiometric dating, we had no idea what the absolute years on these were, but we could still organize time by reference to the fossils found in different bodies of rock. We still use those divisions – like the Paleozoic, Mesozoic, and Cenozoic – though we can now put actual dates on them.

MICHAEL: Walton, can you describe the magazines you brought to the picnic?

WALTON: I suggested this issue of *Science* because it provides a good example of the time scales at which ecologists work and the interaction between time scales and ecological patterns. Ecology is very much an observational science, so modern ecologists study things that happen on time scales that you can observe – either you go out and look at what happens in the forest or you run experiments on plants that will grow in the framework of a four-year National Science Foundation grant. So anything that is emergent at time scales longer than you can examine directly is largely inaccessible, but this issue of *Science* represents an attempt to discuss ecological processes that take place over long periods of time.

MICHAEL: There was this old silk weaving factory outside of Tokyo that had a record of silk from each season. So, scientists can use this archive, going back centuries, to study the carbon isotopes bound into the silk. You can see the molecule of carbon change in the silk because the worm ate leaves that had trapped the pollution in their cells. The silk becomes a long timeline, a thread …

WALTON: Yes, the historical record is sometimes longer and richer than we give it credit for. We have about three thousand years of written history; we can't read it all, and they weren't recording Celsius temperature all along, but there definitely is written information from longer ago than our current quantitative climate records. That reminds me of one of the books I brought, *Man Makes Himself* by Gordon Childe. Childe was an archeologist, and this book was intended for the lay public. In the "Time Scales" chapter, there is a quotation which makes the point that each day, year, decade throughout history was as full as the last day, year, decade reported in the newspapers, but we are just ignorant of all that detail; we get only glimpses of it via the inanimate, inarticulate physical record. My field attempts to make sense of some of that record. This other book, by Paul Feyerabend, *Against Method*, is an attempt to provide an antidote to what I think of as a very damaging aspect of my field – the idea that there is one objective historical reality and one scientific method by which this objective reality can be reconstructed. Some of my colleagues, and many journalists or popular writers who cover the sciences, forget or don't understand how the sciences are embedded in human societies just like art or politics or anything else. There's always a pitfall between the idealized search for scientific and historical truth and what constitutes the received wisdom of the day.

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Brian (a member of the audience): One of the things that strikes me in the *Powers of Ten* me is that you start out at a picnic which is in a way about nature – or going out in nature, but really it is it is about the relationship between picnickers, and then you span way out and it makes you think about the fact that we are actually on this rock hurling through space in complex interactions with these other rocks. Then when it comes back and you take something that looks very solid like your hand, and you go far enough in there, you realize that it is not solid at all. This is mostly empty space and these tiny little pieces are whirling around each other in these complex relationships, I mean compared to geology where you have this hard, rocky evidence.

(FIG. 5) Studio for Interrelated Media students at Mass College of Art enacting 10^{-14} – "As a single proton fills our scene, we reach the edge of present understanding. Are these some quarks in intense interaction?," Philip Morrison, *Powers of Ten.*

Walton: I am trying to decide what level of metaphor to respond to. I think the analogy between hard rock and hard evidence is an interesting one. And you're right, the evidence throughout the natural sciences feels hard and objective and therefore the place that the squishiness comes in is the inference and theorizing that connects it. At a metaphorical level, much of the fuzziness comes in the theory, though there is a lot more fuzziness to observation than we realize. The more carefully you look, the more you can see how observations shift based on the level of detail that is visible. For instance, an area of a computer screen that looks white from a distance is actually little red, green, and blue dots when seen from close up with a hand lens. Whether it is a bunch of red, green, and blue lights or whether it is one white light depends entirely on whether you are using a magnifying lens. So the fuzz in observation comes from what we are deciding to look at and at what scale you look at it.

Looking at plants is not going to tell you anything about what scale to look at, but maybe it says something about what not to make claims about. To take it back to *Powers of Ten*, it's very clear that when we get to the edges of the movie, science gets a bit hazier than when we are close to our own scale. The more proxies between the observer and the phenomenon being observed, the harder it is to be sure everyone will agree on what is being observed. As new technologies, like electron microscopy or gene sequencing, become influential, I think you have to be more careful about making pronouncements about the way things work at scales about which you alone have data. At human scales, at least we all have eyes, and can all weigh in on the question of whether a computer screen is white or colored. As we move away from our own scale – either microscopically or telescopically – the methods of observation become more influential.

Amy: What would happen if we had to wear telescope glasses all the time?

Michael: We would trip a lot.

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AMY: In thinking about your field being so dependent on the eye as a tool, can you tell us about Geert Vermeij, the blind paleontologist who can identify fossils from touch?

WALTON: Yes, Geert Vermeij. He relies on morphology – meaning the study of shape – which is not uncommon in my field. One might think of that as being a very visual thing, but in fact shape is not necessarily visual. Vermeij has been a very successful invertebrate morphologist without any visual tools. He just feels the shells of the animals he studies.

MICHAEL: Speaking of shapes, you brought some leaves here onto the picnic blanket?

WALTON: Yes, my Ph.D. was on leaves and leaf fossils and what you can learn about the fossil ecosystems from consistent patterns in leaf shape. The reason I brought these is they are from the same tree at about the same time, but they are vastly different in size *(FIG. 6)*. I brought them because I thought it was an interesting point that sometimes scale matters and sometimes it doesn't.

ELAINE (a member of the audience): Do the shapes of leaves denote a place?

WALTON: There are some attributes of leaf shape that have been used as signifiers of climate. Leaves with teeth tend to be found in places that are cooler, but no one really knows why. People have been studying this since 1915, and we still aren't sure why. There are theories, but none are particularly persuasive.

ELAINE: Can you talk about place more broadly in your field? Does your field favor parts of our fossil record over others?

WALTON: Yes, there are all sorts of biases. First of all, the different periods of history only come to the surface at certain places. If you want to study a particular time period, you need to go to where there are rocks that date to that time period on the surface. There are very complex reasons why particular historical periods come to the surfaces at particular places in the earth. It is more difficult to work in Iraq than it is to work in Canada, so probably more people are studying periods of time that outcrop in Canada, for example.

ELAINE: Speaking of place, it implicates the presence of features generated by natural disasters as well as man-made disasters like war. Do they have implications in your work?

WALTON: What I am studying now is so far before human societies that there are no anthropogenic disasters, but I think that question has been answered in the affirmative: human societies are totally capable of doing things that make marks in the geological record. For example, you can see when the Romans started smelting silver because there is a spike in the lead found in the ice caps. Of course, we are not the first species or group of organisms to be responsible for changes in the global climate record. Before there were plants there was not much oxygen in the atmosphere, and it's because of the evolution of photosynthetic plants that we have oxygen to breathe. So that returns us to the idea of natural ecosystems creating their environment and being affected by the environment they've created; it's all feedback. There are even ecologists who would argue that there are no environments unaffected by human societies and that the whole notion of natural as distinct from anthropogenic is an artistic creation of the Romantic Movement. So we are all studying a constructed reality and have to worry about the meta-analysis, artistically and scientifically.

MICHAEL: The *Powers of Ten* was meta in so many ways. The whole picnic was of course "produced," but none of that is visible in the film. Our picnics have that element too, although we're more open about the apparatus around them and our role in that process. Actually, this is the most stage-managed one, since we're picnicking literally in a theater.

WALTON: The business of film production, deciding what to include and what to exclude, has a direct equivalent in the sciences. One of our biggest challenges going forward in the computer era is deciding how much stage-managing of scientific results to allow, especially now that raw data can be published electronically for free. If too much stage-managing is allowed, you end up getting mostly people's opinions and being unable to catch errors, as is the case with many contemporary journal articles – the information provided in the article is not really enough to replicate the results obtained. On the other hand, many of the previous generation of professors retiring now are leaving dusty brown cardboard boxes full of thesis projects and unpublished data, which often get dumped. My computer is full of incomplete studies and data that aren't good enough for a peer-reviewed article. Should all those negative results and unfinished projects be published online? Could we make sense of all those outtakes, or would we just get lost in irrelevant detail? If scholarship is just what has survived as this collective archive has been moved from closet to closet and library to library through time, it requires optimism and a certain amount of faith to believe that what is published at any given time is reflective of any immutable truth.