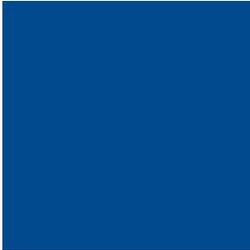


10^{-35} , 10^4 , 10^7 , 10^{80} meters

PETER L. GALISON

History of science and physics,
Harvard University, Cambridge



During our correspondence with Peter, he was in the midst of producing The Refusal of Time, a new collaborative work on the subject of non-standardized temporality, made with artist William Kentridge and destined to premiere at Documenta 13. Having worked with artists before, Peter was open to a playful exchange via Skype. You will notice there are no people in this picnic. After imagining an “objectivity picnic” and a “wasteland picnic” during our disembodied exchange, we chose to stage this picnic as close to the Jornada del Muerto (“single day’s journey of the dead man”) Desert in New Mexico, site of the Trinity Project, in which the first atomic bomb was tested. It’s a fitting location for an unpeopled picnic, and the blankness of this landscape resonates with Peter’s work on “zones of exclusion.” The Trinity tests changed the world forever, and this site resonates across the project as well – a shadow in the history of Philip Morrison, a backdrop for many conversations about the instrumentalization of knowledge, and an echo to the persisting effects of human actions in the pursuit of knowledge.



1



2

AMY: The first work I became aware of was your *Objectivity* book. Since we are artists sitting with scientists in these picnics, the line of objectivity and subjectivity is interesting to us. Also I would like hear more about the work you have done on wilderness and the wasteland in connection to the period when this film was made, and in relation to the spaces where humans may not be allowed to go. This idea of the absence of humans has a strange resonance, because for this project we are remaking the Eames picnic image with each subject, recasting and restaging, but with you we're "picnicking" remotely, so it's interesting to think about shooting a picnic with no one in the frame (*FIG. 1*).

Since the movie starts with the picnic, and the picnic is used to frame these zones within the vastness of space and time, why

don't we start with your desired location, to have this remote picnic that we're imagining?

PETER: If we were having an objectivity picnic, I would put it in a laboratory. Maybe a laboratory that was engaged in some kind of visual research, filled with microscopes, or an observatory, someplace where a twenty-first-century extension of ancient image-making technologies is to be found. That's where I'd have an objectivity picnic. And then if we were going to be having a nuclear waste picnic, I might situate that in the desert, in land that was very uninhabited, and far from the markings of the built environment (*FIG. 2*).

Or we could be literal, and have a picnic in the southeastern New Mexico desert (*FIG. 3*), which is near where the Waste Isolation Pilot Plant is. Or in



3

the other sites around the world, you would look for mountains of tuft, granite rock formations, or clay layers. Generally our nuclear waste picnic should be somewhere in the world far from human habitation, away from geological drama of volcanoes, floods, and earthquakes – distant both from the human-built environment or a large and opulent display of flora and fauna.

MICHAEL: Would there be something that you would want to eat on that picnic in the desert?

PETER: What would a nuclear waste picnic present for lunch? Some good food that would glow in the dark?

AMY: I just watched *The Day After Trinity*, a documentary about the aftermath of the Manhattan Project, and at one point they said that they were eating kind

of strange canned food – peanut butter, Vienna sausages. They were also drinking whiskey, but since the quantity was limited, they used the lab alcohol, which was 200 proof, and in that altitude it was quite a kick. Would this be an appropriate spread for the blanket?

PETER: The Trinity site itself might be a good place for a nuclear picnic. Nuclear tourism exists now as something that people do. They go to the twice-a-year openings of the Trinity site, or they go to the Pacific testing zone, or the Nevada test site. People go to Chernobyl as tourists. There's something both understandable and terrifying about this activity, where people are attracted to sites of violence or disturbance. People go to places where cataclysmic historical events have occurred, like battlefields, and in that sense nuclear tourism is recognizable. But I think this idea of going to a place where there's been such a violent history as with nuclear weapons, as a tourist event, does seem disturbing to us. At the same time we get it. It's not impossible, if you go to Sommes, or you go to one of the great World War II or Civil War battle sites, you're going to a site of previous violence. And there's something respectful, but also purulent, something fascinating

about the human presence there, and something repelled and attracted all at once.

But we were starting with objectivity, so maybe we should go back there. In an objectivity picnic, you would want foods that were very precise, and whose description could be shared by everybody. So, a cube of sugar, a cube of cheese, a bar or a standard ounce of chocolate, or something that wouldn't be so different in the way you or I would describe it.

AMY: What two books would you suggest to be in the objectivity picnic?

PETER: The books for an objectivity picnic would certainly be scientific atlases. You could choose an early atlas of physiological chemistry, like Otto Funke's *Atlas of Physiological Chemistry* from the mid-1800s, for example. This is really where objectivity is first getting going. And then, maybe a much more contemporary atlas, a twentieth-century atlas of skulls or clouds or crystals, or an atlas of stellar spectra. So I would suggest two standard volumes that depict the working objects of science, that are visual, that both, in a sense, substantiated objectivity and helped to teach people what it meant in operation.

Those would be good books for an objectivity picnic.

AMY: And two periodicals for the objectivity picnic?

PETER: I might choose, if you wanted to continue with the themes of the Eames film, issues of the journals *Science* or *Nature* with those highly artificially colored and rescaled nano-pictures on the cover. That would give you both a sense of a very different scale, a continuation of the idea of the visual, and a challenge to the simple idea of mechanical objectivity as formulated in the nineteenth century.

MICHAEL: Can you talk about how science in general, or in your specific field, has changed during this period? Since you have such a breadth of knowledge about the history of science, I would be interested to get your take on the shifts in the edges of understanding between now and forty years ago.

PETER: Science has changed a lot in the last forty years, in scale and scope. I think that probing the microphysical world has changed in a most unimaginable way. The sophistication and scale of elementary particle research is much vaster than it was back in the 1970s, but the movie was 1978?

AMY: The movie was first released in 1968, and rereleased in 1977.

PETER: In that period, 1968 to 1977, a big particle physics experiment might involve dozens of people, and even by 1983, two of the largest, most important experiments at an accelerator had about 130 people on each experiment. At that time, physicists experienced the leap to this team size as a huge, collaborative venture, with experimental apparatus that could cost millions of dollars. But now the big detectors have teams of several thousand physicists working on them, and the cost of a detector at CERN, the European Organization for Nuclear Research, is well over a billion dollars each. One of them weighs more than 25 million pounds. The scale of nature that's being investigated is also vastly different from what it was back then, by several factors of ten, probing distances many times smaller in order to ferret out the Higgs particle, to determine if there are extra dimensions, and perhaps to discover the nature of the dark matter that constitutes most of the mass of the universe. Theoretically, physics is thinking about scales MUCH smaller than anything imaginable in the 1970s, as string theory has come to be such an important part of theoretical physics. At the same time, you also have the

development of things on the atomic scale that are the size of a nanometer – a billionth of a meter – which sounds small, but are big compared to elementary particle physics. At that scale now, you’re not just looking for what the elementary structure of matter is, you’re actually making things: putting together nano-scale circuits, trying to design the smallest transistor, and attaching nano-tubes to other things, and beginning to imagine what it would be like to produce these sorts of things in huge quantity. So nano-science – this amalgam of engineering, biology, chemistry and physics – has become an increasingly exciting part of science, but also of new forms of industry. That’s given us a manipulative relationship to the microworld that is very different. It’s not just detecting something’s existence, it’s making things, which implies questions about robustness and large-scale production, possibilities for new materials, imagining the smallest possible computational devices. All of these questions are very fundamental.

In the study of cosmology, you also have big changes over the last forty years, in this larger scale. What’s really remarkable is that cosmology has become an observational science – you can go far beyond typical speculation and really make measurements and

do physics on the very large-scale structure of the universe. And that’s extremely dramatic – to see, for example, that the universe is accelerating in its expansion. Or by studying quasars and other really deep space objects, you can begin to really make an observational science about astrophysical objects far beyond any previous observations. We not only know about the microwave “echo” of the big bang, we can look at the fluctuations in that microwave background, and these variations give clues to the earliest moments of the universe. As we see spots of the universe that heated up a little more or a little less, we can use these fluctuations to restrict what possible cosmological explanations might work, and what might not. So I’d say that the physical sciences have changed hugely, and in those three scales most dramatically – a new truly observational cosmology, manipulation and fabrication at the level of a nanometer, and the experimental probing, at least through the mind’s eye, beginning to picture through string theory, scales unimaginably smaller than the smallest of particle physics.

AMY: One of the things the film does beautifully, especially for us when we were younger, is trigger a desire to reach beyond the human scale in order to know more about this grand world that

seemingly resides outside of ourselves, and to create tools to do this. As you spoke of the lab and its devices, I’m reminded of this. Can you talk about this notion of desire as it relates to objectivity?

PETER: The beginning of objectivity in science is, importantly, not the same as the beginning of science – that is not to say that Newton or Galileo weren’t objective, but objectivity simply wasn’t what was important for them; there were other virtues they were after with their science. Objectivity is a nineteenth-century conception, an attempt to extricate ourselves from the dangerous imposition of our personal aesthetic judgments, our ambitions to prove a pet theory, or from any other of our interior desires. Suddenly, the virtues of having the figure of a genius or a sage, or somebody who offered particular insight into something, became seen as a threat. For example, if each of us claimed our own truth to explain the happenstance of the flower that grows in the back of your house on this day in March 2012, we might end up imposing willy-nilly our own desires, ambitions, and prejudices onto the world. Objectivity was an attempt to get away from that danger and to set up procedures that would allow objects from the world to be printed onto the page as if we were not there. Insofar

as we could design a situation, like tracing a leaf with the broad side of a graphite pencil, that’s a way of doing something that doesn’t depend too much on what I might think the veins of the leaf ought to be doing. Not to say tracing is completely out of our hands, or even photography, but they’re in the direction of trying to replace individual will with something more procedural.

In the late nineteenth century, as the idea of a will-based self became more and more commonly understood as the basis for who we are and what we are, people began to see the will as a two-edged sword. The will could be very helpful in driving us forward in our knowledge, but the will could also be distorting. So among philosophers and scientists, people began to talk about a kind of will to will-lessness, a use of the will to suppress the will. This self-abnegation is rather like the way a religious devotee of enormous self-restraint might try to quiet passions to allow a sacred experience to wash over them. And something like that is what happened in the mid-nineteenth century among scientists: they began to talk about the supreme importance of this will to will-lessness, of the necessity of quieting their own desires. Acting with *scientific* self-restraint

became a way of holding back a kind of subjectivity that was marked by this driving will that was at the center of who we were. Objectivity allowed, or aimed to allow, nature to write itself to the page, so to speak – to draw itself on the page, as if we were not there, or insofar as possible, as if we were not there.

So the idea of objectivity enters with the idea of subjectivity; they're like left or right, or up and down. You can't have one without the other. It doesn't make sense to say, I'll describe to you what up is without down, or left is without right. They're complementary notions that define each other in juxtaposition. And the argument is that's what happens with subjectivity and objectivity. As you begin to have a will-based subjectivity, its self-restraint is exactly the condition for the emergence of a scientific objectivity. Quieting the will to impose ourselves, and our understanding of the world onto the page is the only way to allow nature to imprint itself onto the page through procedures that were conducted insofar as possible, even if never completely, as if we were not there.

MICHAEL: Is there a way to tie that into what the Morrisons and the Eamses did in this movie, starting at the blanket, with

this very specific frame, and very specific methodology?

PETER: One of the effects of the film is to show what a small piece of the universe we are witness to in our everyday-ness, in our picnic at noon. We're aware of a scale of centimeters and meters and kilometers, but we are not aware of things that are many times smaller or many times larger, many times farther away, many times quicker, many times slower. We see things that proceed on seconds, minutes, days and years, and we have to use acts of imagination to imagine centuries, millennia, or much less, geological time. And I think that the effect of the film in a sense is to call this particularity of scale to our attention and to show us science as a way of extending that vision to see that the world is both bigger and smaller and faster and slower than we can understand in our daily experience. The film calls us, in a way, to think ourselves out of the picture of nature, or to see ourselves as a small passage point on the way from the infinitesimal to the infinite. Objectivity is indeed related to that, it's saying, "when we get beyond the things that are immediately accessible to us, how are we going to proceed, how are we going to depict them, what's right depiction going to be like when we can't all gather

around and look at a turtle. If we were going to describe something that can only be seen under a powerful microscope or telescope, how are we going to convey it in a way that's going to be shareable among us, as scientists in the first instance, and as human beings more generally?"

AMY: Thinking about fast and slow and about this fictitious picnic we're having, let's jump to our wasteland picnic for a minute. You have written about nuclear waste sites, talking about their half-lives and the vast time scale related to those half-lives. How does that affect ideas about communicating with some human form many years from now to explain their danger, that there shouldn't be any digging or people shouldn't come close to these places that may not on the surface appear dangerous?

PETER: Nuclear waste has a time scale that goes with it. There are relatively short-lived radioactive particles that are dangerous to us, things that live for a matter of seconds, minutes, or even years. Some of the most dangerous of these are radioactive cesium and radioactive strontium, which attach respectively to our flesh and bond to our bones. With a thirty-year half-life, after sixty years it would be a quarter as dangerous, and in 120 years it would be a

sixteenth. If you wanted to get to a zone where it was relatively safe, the standard wait time is ten half-lives, so that it would be about a thousandth as radioactive as it is now. If you waited these ten half-lives, or 300 years, much of the dangerous stuff that surrounds Fukushima or Chernobyl would be a thousandth as dangerous as the day they emerged their respective disasters. But there are other radioisotopes that are much longer-lived, and they are the ones that set the huge time scale that people have to consider with regard to nuclear waste.

Plutonium-239, used to make nuclear weapons, has a half-life of 24,100 years. That means if you want it to be roughly safe and wait those ten half-lives, your picnic would take place in 241,000 years, and even then, it decays into other things which aren't that good for you either. And Plutonium-239 is not by any means the longest-lived dangerous isotope. So, to secure this material that has plutonium in it, we better keep it away from people for a very long time. At Yucca Mountain, a proposed nuclear waste site, the scale they were considering was about a million years. One of the questions was, could you keep this out of the environment, an environment that people might come to, for something

like a million years? At the one operating nuclear waste plant in the United States called WIPP (Waste Isolation Pilot Plant) in southeastern New Mexico, the Environmental Protection Agency chose a time scale of 10,000 years. They thought 5,000 years is about the length of recorded human history; 10,000 is the same order of magnitude as the actual half-life, which is 24,000 years. Since we can't really imagine more than one or two times human recorded history, and it's almost impossible to imagine 24,000 years, let's just choose 10,000 years as our regulatory period. So the Environmental Protection Agency told the Department of Energy (the people that wanted to make this waste repository), that they ought to be able to vouch for their efficacy – not just geologically keeping this material out of human contact for 10,000 years, but in warning people of the future not to dig there for 10,000 years.

(FIG. 4) Warning text and pictographs created for the United States Department of Energy's Waste Isolation Pilot Plant.

For most of the people concerned with the project, the marking problem was actually the bigger problem. The site was chosen because there is a mile-thick layer of salt, the very existence of which

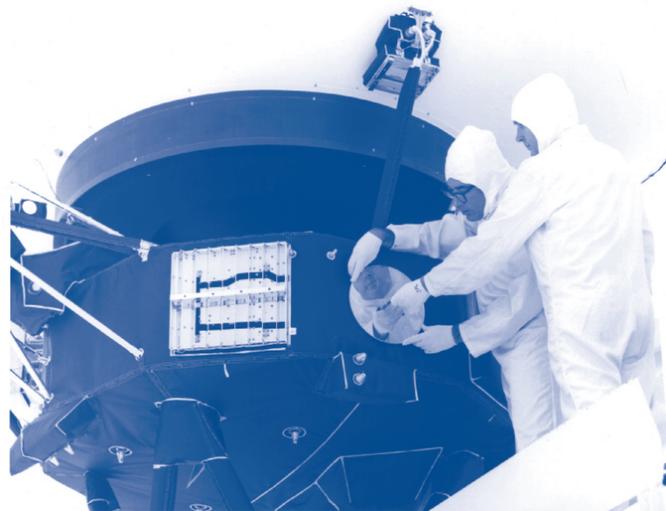


4

suggests that there's not a lot of flowing water that could endanger the waste (otherwise the flowing water would have dissolved the salt). You don't want flowing water that could carry nuclear waste far away into people's neighborhoods. But though salt is a good medium for guarding the waste, and flows back around the waste to encyst it, salt is relatively easy to dig through if you are hunting for something underneath it – for example if you were digging for oil or gas, both of which are copious in southeastern New Mexico. So, one of the big concerns was this: how do you imagine the future 10,000 years from now, and what scenarios would lead people to the waste inadvertently? The DOE brought in experts in geology and material

science and linguistics, semiotics and architecture, even science fiction writers. And they tried to imagine what kinds of scenarios might lead people to intrude accidentally into the waste site, and then how you would warn the far future so that didn't happen. The search-for-extra-terrestrial-intelligence people have been thinking for a long time about how you would communicate with critters a lot different than us, so they brought them in too.

Countries last hundreds of years, languages last hundreds of years, maybe thousands if you're lucky, but 10,000 years is a long time by any standard. It's much farther from us than Stonehenge, or the pyramids, or the Acropolis, or the Indian burial mounds that



5

are scattered across the United States. So the DOE even asked the search-for-extra-terrestrial-intelligence people to come in, and to think, for instance, about what they had done, when they had designed images that would communicate with an unimaginably different culture, back when they put these golden records on the side of the Voyager spacecraft (for example), and what it meant for them as they contemplated sending a message that would last longer than the earth. They were looking at sending message that would be there after human beings, at least on our planet, didn't exist any more. In a way, it's all

so distant from us that it defies our ability to do anything like the kind of systematic science that is familiar from our own disciplines.

(FIG. 5) The Voyager Golden Record, carrying *The Sounds of Earth*, is attached to Voyager 1 in 1977. Made of gold-plated copper, and encased in aluminum, the information etched on the record is expected to last one billion years.

MICHAEL: I mean, people could still have picnics.

PETER: I hope so! Even in deep space and even in the far future! It would be very sad if we have a future with no picnics.

AMY: Were all those people together in one room contemplating this?

PETER: Yes, there were meetings of the scenarists and monumentalists. It was sometimes hard for them to communicate, among their different disciplinary idioms. The geologist had one standard for what it would mean and the material scientist had another, and so did the astrophysicists. It's a necessary and impossible problem. It's a little bit like the way Kant begins the *Critique of Pure Reason*, where he says there are some problems that are too difficult to solve and impossible to avoid. And that's a little bit

like our relationship, we have all of this nuclear waste, the current situation is not possible, we can't leave it where it is, it's not safe. And all of the alternatives present difficulties of one sort or another, so we have to contemplate both where to put it and how to think about the very far future. One's a difficulty in space and one's a difficulty in time. And they're both damnably hard.

Einstein once said something – I won't remember the quotation exactly, but it was in the midst of the horror of World War II, and he said that it gave him a measure of comfort to think that ours is just one small planet, in one small solar system, in the vastness of the universe. I think there is a way in which there is a consolation, of a strange sort, in reflecting on these scales that are other than ours – times longer and shorter than our lifetime, spaces vastly larger and smaller than our planet, things other than the everyday size of washing machines, desks, and books.

AMY: Can you reach behind you and pull out a random book from the shelf behind you?

PETER: Well let's see ... here's a book I like, it's called *The Great Devonian Controversy*, written by Martin J. S. Rudwick in 1985. It's a book about the nineteenth

century, where geologists were arguing about the history of the earth, and how to think about the Devonian (geologic formations in Devon, England) as a layer of our geological past from far back (we now put the Devonian at about 400 million years ago). The Victorians needed to understand geology in part because they wanted to find coal, which was the sine qua non of their society. It's what ran the empire, illuminated London, and produced the steam that made their machines of the industrial revolution run. And so you had to understand the geology, but there were big debates. How did you interpret fossils, and how did you think about whether a layer was distinct from another? How did you know whether a stratum was indeed the same stratum coming up somewhere else in England, how did you order them if they had been all tumbled among one another by there by the vicissitudes of deep time? So, I think that the struggle over different scales is something that has been with science for a very long time, whether it's a great controversy in nineteenth-century geology, or whether you go back and look at Robert Hooke's seventeenth-century discovery of the microscope, and his efforts to describe worlds smaller than any we could know. It was all utterly unfamiliar. Suddenly a flea

looked like a giant creature, and new kinds of living entities came into focus at a scale no one had been able to imagine. I think the microscope and the telescope are in a sense the paradigmatic figures of science that take us beyond the picnic blanket up and down.

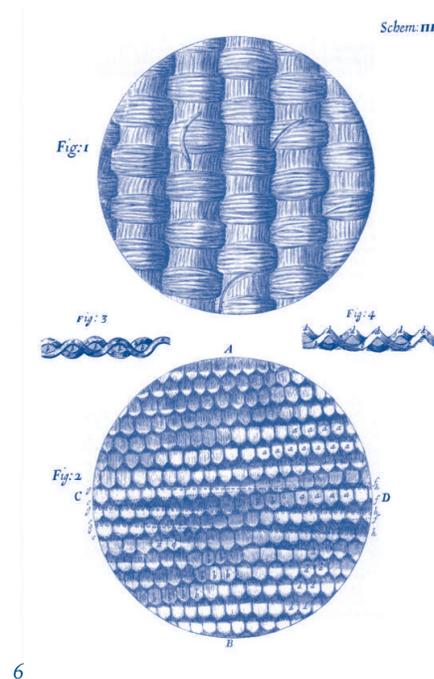
(FIG. 6) Robert Hooke wrote *Micrographia* in 1665 to detail his observations through various lenses. Here he illustrates and describes a fly's eye and a plant cell; Hooke coined the term "cell" because their walled structure reminded him of a monk's quarters.

MICHAEL: What is underneath the blanket? In geological terms or metaphorical terms, what is hidden under the blanket?

PETER: [laughs] Freud would like to know that too, right?

AMY: Yes! But can you say something about how we can picture the hidden – things obscured by nature or for that matter by people?

PETER: One of the things that was amazing about filming my documentary about hidden national security policy, *Secrecy*, is when I started the project with my colleague Robb Moss, we didn't know whether people would talk to us, or under what circumstances. We wanted to



6

talk not to pundits, but with people who made, distributed, and kept secrets. I didn't know whether people would see a kind of resonance between personal secrecy and national security secrecy, between sexual or biblical secrecy, and the secrecy of nuclear weapons and espionage, of hidden sites and secret projects. One of the things that was interesting to me in filming, over quite a few years, was that this connection was not at all hidden, and that every single person we talked to, whether they were from the National Security Agency, or the CIA, or they were critics of secrecy, or journalists

whose job depended on uncovering and exposing secrets, they were all always very aware of the connection between personal and political secrecy. In fact, the film opens with a very senior, long-term official of the National Security Agency, saying, "secrecy is like forbidden fruit – we can't have it; it makes you want it more." It was at the surface of things, not in the hidden depths. So people experience secrecy in a suite of connected rooms. They talk about the secrets of nature, or the secrets of state, or the secrets of their own lives, as linked, psychologically if not practically. That was very interesting to me.

It was interesting graphically, and filmically, in understanding what the allure of secrecy was – why people trust secret knowledge more than open knowledge. For instance, if you talk to a congressman, and he or she says, well, I've seen one report that was in the *Washington Post*, or an open session at the U.N., and another set of developments which were given to me in a classified briefing, there is an enormous temptation for the politician to believe that which takes place in the classified briefing. Though everybody's aware of that temptation, they are, even so, not entirely able to ignore it. The language of seduction is pervasive; it is all over this world, the temptations of secrecy, and the burdens of secrecy. So I found that very interesting. There's a kind of mobility of these concepts and the affect that goes with secrecy. There was a moment when I was interested in finding a psychiatrist who worked with people who have to handle professional secrets. The whole idea of psychiatry is so closely tied to trying to understand even secrets that you've kept from yourself, and trying to bring out aspects of the unconscious into the preconscious into the conscious. This process of digging and unveiling is, like science itself, often thought of in metaphors that go back a thousand years,

akin to removing the blanket ... science unveiling nature

Exploring the ties between our affect and our policies, our science and our imagination, is partly what interests me in the filmmaking and writing that I do. It is true about objectivity and it's true for the nuclear waste, it's true for the first film that I made, too, about the moral-political arguments about nuclear weapons, and it is true for my approach to the history of physics. It's not that something is nonpolitical because it's psychological, or not psychological because it's political, but it's always both. We don't put aside our psychological selves when we enter into the political realm, or we don't put aside our political realm when we enter into the psychological. So that interests me a lot, artistically, historically, and in the dynamics of politics. Matters of state and matters of our inner state are never that far apart.

AMY: Before we leave the blanket, is there anything you would like to add that we didn't touch upon?

PETER: I think for me the center of the film and the center of what I've tried to get at here is what it means to step away from a more everyday-ness. Science offers a broader canvas on which our piece is only in one corner.

I think that's a consolation, sometimes, for us. It's what Einstein said, in the quote that I paraphrased liberally, that it's a relief that the earth is just one small planet in the broader world. But it's also exciting to people, because we respond to the strangeness of these other worlds – from microscopic illustration like Hooke's *Micrographia* to the surface of Mars to the bizarre effects of gravitational lensing or black holes or a galaxy hitting another galaxy deep in space or the discovery of the Higgs particle (if that's what's happening at CERN). There's something wonderful and exciting and invigorating about these other worlds. And then of course we have to return to the blanket and our picnic (*FIG. 7*), and figure out how to deal in our corner of the canvas, the finite, troubled, worrisome, fragile world we live in. And that, I fear, is even harder.



7