

ISSUE NO. 001

EXTRA TERRITORIAL

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MIND MAPPERS

WE ARE SURROUNDED by borders and boundaries. Many of them are desirable. Laws, regulations, architecture, shelters, vaccines, and languages are all instances of enclosures that make living a social life possible. These all enable interactions by preserving the integrity of the individual.

But these same protections can grow unbearable. Or they can come to lock in elements of society or patterns of thought that we would rather abandon. There are times when we would rather ditch our familiar habitats and become extraterritorial.

In a 1958 letter to his friend Armando Bozzoli, the novelist Italo Calvino, writing about one of his characters explains, "I wanted to put forward the figure of a committed man . . .

who takes a profound part in history and the development of society, but who knows he has to travel roads that are different from the ones that others take, as is the destiny of those who do not conform."

The balance between conformity and rebellion, or perhaps obedience and opposition, is a very delicate matter. But this does not mean, as D.H. Lawrence observed, that we have to "bury so much of the delicate magic of life." After all, a more unbuttoned relationship to challenging the status quo is what defines periods of great invention.

Extraterritorial is the Santa Fe Institute magazine that explores committed people in our community who can not help but lose themselves from time to time. Because they could only find new things by getting lost.

— David Krakauer
Editor-in-Chief, SFI Press
President & William H. Miller Professor
of Complex Systems, Santa Fe Institute

EXTRA TERRITORIAL

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HOW
TO WIN A
**NOBEL
PRIZE**

| 0001 |

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Winner of the Nobel Prize
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FURTHER READING:

*Gene Machine: The Race
to Decipher the Secrets
of the Ribosome* (2018)



Venki Ramakrishnan at the Santa Fe Institute's Cowan campus
PHOTO: KATE JOYCE

DAVID KRAKAUER: Your father and mother were both scientists and you have a sister who went into science. What role did having family members who are scientists play in your development?

VENKI RAMAKRISHNAN: I did come from a family that encouraged reading and learning. My mother, especially, really exposed both my sister and me to lots of books — everything from literature to popular science books. And there were always debates at the dinner table. The fact that both my parents were working scientists meant that we had a steady stream of visitors to the house, from all over the world. And it gave me a feeling of science as this very international enterprise. I wasn't sure I wanted to be a scientist originally. In fact, I thought I might become an engineer.

There's no question that the way I was brought up helped me go into a world of science. But I have to tell you, for a long time I wasn't sure I'd made the right decision. I thought maybe I should have gone into medical school and been a doctor. And I had many twists and turns in my career. Each time I thought, you know, what am I doing here? I could have been a doctor and had a good living helping people, and instead, I'm wasting my time doing some second-rate stuff.

Boredom and restlessness clearly had a role in your career. Did you have a sense of not quite doing the right thing, or feeling there was something more important you could be doing to make an important contribution — a sort of restless ambition?

It wasn't so much restlessness as coming to a point where I would say, wait a minute, do I want to spend the rest of my life doing this? And if the answer is no, then I'd have to ask, well, what else could I be doing that might be more interesting. That's what happened to me when I was a graduate student in physics and found myself working on a problem that I didn't think was so interesting. And in fact, I was right. That work sank without a trace.

I decided to go to graduate school again to learn biology because I didn't know any. I took undergraduate courses in biology because I couldn't even understand the introductory research lectures for graduate students. I had to learn biology from the beginning, and I don't regret doing that because it did give me a broad background.

Most people don't want to be in a position of being a novice as they make advances in their careers. You chose to do that. Is that an important part of your career — being willing to be ignorant in a field?

Yes, that's true. I always felt that you may be an expert in some area, but if you want to go into a different area where you know nothing, you have to start at the beginning. I didn't see that as a problem. The only thing was that I already had a Ph.D. in physics and there I was taking undergraduate courses with a bunch of pre-meds who were all worried about whether they were getting 99% or 98% because they have to get into medical school. It was kind of a strange feeling. But I was soaking it all in and it was all new to me and I didn't even think about the status part. I was just a student. I would say a lot of my moves have been driven by pragmatism — what do I need to do to get to the next stage?

You've worked at a variety of institutions, but it seems the Medical Research Council, Laboratory of Molecular Biology (LMB) is very special to you. The LMB is the best-known, most successful molecular biology institute in the world. Its faculty have won 12 Nobel Prizes. What makes it so effective?

The LMB didn't encourage large groups. They wanted people to have small groups. If you needed more expertise, rather than adding people to your group, you would collaborate. The Santa Fe Institute reminds me of that aspect. You have these dynamic collaborations which form and dissolve depending on the problem.

Nobody there was working on anything secondary or derivative or uninteresting. They were all working on the most interesting question in the field. And that's partly because they have a small group. If you have a small group, you can't do a lot of different things — it forces you to make choices. So of course, you'd rather do the more interesting thing than a lot of uninteresting things.

And if there was something someone didn't understand in a seminar, they would just ask a very simple or elementary question. That impressed me a lot. But the other thing about the MRC that impressed me is that even senior scientists were directly involved in the work. And, as you know, once you reach a certain stage at a university, you become a manager. You're raising money, you're directing people. You're not actually spending much time even thinking. At the LMB, senior scientists were very intimately involved with the work. Often, they'd be doing experiments themselves. Fred Sanger, with two Nobel prizes, was doing his own experiments in the last week before he retired.

I had many twists & turns in my career. Each time I thought . . . what am I doing here?

You've described LMB as highly collaborative, and yet we know that science is highly competitive. How do you think about collaboration versus competition in science?

The LMB discourages internal competition, but there's no question, even right from Watson and Crick [co-discoverers of the structure of DNA who were awarded the Nobel Prize in 1962], that it was highly competitive with the outside world. Science is not different from other human activities. Businesses, for example, can be highly collaborative if they need a partner to provide complementary technology or expertise. And they can be highly competitive. In science, you always have both.

When did it first dawn on you that you might be very successful? Did you wake up one morning and say, I'm not only going to do consequential work but work that everyone in my field knows about and will remember as important? Perhaps even win a Nobel Prize.

I think it happened in several stages. When I was struggling as a graduate student in physics, I thought, well, where's the really exciting science happening right now? I felt it was in molecular and cellular biology, so I made that transition. But then I got stuck because I was using a physical technique that wasn't that useful in biology. And then I thought, well, you know, people are trying to understand how molecules work by determining atomic structure. So, I went on sabbatical and I used the knowledge of crystallography that I acquired on my sabbatical to solve little pieces of the ribosome. And this was okay for two or three years, but I realized, this is not going to tell us how the ribosome works any more than isolated structures like a spark plug or a carburetor are going to tell us how a car works.

I thought it ought to be possible to solve the entire structure of the ribosome. That's when I asked, what is the big question in the field? And is it ripe? Is the time right to go for it? I wasn't thinking, if I do this there'll be a lot of recognition. If this is the biggest question in the field and you're able to answer it, the recognition would be a natural consequence.

The Nobel is a bit of a lottery because there are lots of different discoveries made all the time, and your discovery has

to be something that they choose to award. There are lots of discoveries that haven't yet been awarded the Nobel or might never be.

I wasn't thinking about it, except possibly subconsciously. But you go give a seminar or a conference and people say, "this could get the Nobel Prize," it then starts to affect your psychology and then you start thinking, well, maybe it could, and then you think, well, who else would be in the running and will I be one of the three or not? It sort of wears on your psychology.

And I think that's part of the problem with these awards. They convert science into a sort of sporting competition. We discussed competition before. I think the awards make the competitive aspect worse. You might compete and then leave it to history to decide who did what but this happens in your own lifetime.

What would you say are the key ingredients to being successful in science? Is it just extraordinary single-mindedness and incredibly disciplined work?

I think persistence and single-mindedness are important because if you give up on a problem too quickly then you're not going to be able to tackle the really hard problems because, with any problem that's hard, you're going to stumble for a while. You might have to change approaches. And that requires a certain interest in the problem and a dedication to it that allows you to persist. I think being open to ideas and being open to new techniques is quite important. But I think one really important thing is to choose a problem that you feel is both interesting and important. Both are necessary.

You could do something very interesting intellectually but it's not actually important for the broader understanding of the field so it'll be what you might call "cute." And a lot of people get stuck in doing cute things. But if you choose a problem that's both interesting and you can sense that it's important to the field that's really the sort of problem you should pursue. You only have one life to live. So why not do the thing that actually matters more? I learned that the hard way.



Andrea Wulf at Santa Fe
Institute's Miller Campus
PHOTO: KATE JOYCE

THE ZIG ZAG MIND

| 0002

ANDREA WULF

Miller Scholar, Santa Fe
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Historian, biographer

Winner of the CBHL Annual
Literature Award (2010);
The Royal Society Insight
Investment Science Book
Prize (2016); The Royal
Geographical Society's
Ness Award (2016)

FURTHER READING:

The Invention of Nature
(2015); *Magnificent Rebels*
(forthcoming)

If someone wants to understand how my mind works it's the zigzag.

DAVID KRAKAUER: In a magazine like this, with interviews, what's the first thing you'd want someone to know about you?

ANDREA WULF: If someone wants to understand how my mind works it's the zigzag. I came to England as a single mom. I was really bad at school. I just scraped through — I refused to be bound by the boring stuff that I was taught at school. I just really believe people have to find their own zigzagging path.

Your zigzagging path started in India, where you were born, and continued on to England and Germany. How important was your early life to your development as a thinker and writer?

Very important — essential. My parents' childhood was in the bunkers of World War II — mine was in the heat and color of India. It made me a citizen of the world rather than a German or even a European. My home is where I am, where my mind is, where the people are that I love, but not where I was born.

My dad was a banker and my mom was a secretary, and they came back to Germany in their mid-thirties with two little kids. They checked in their careers and started again. In that respect, India showed me that you could pursue your dreams whenever you want to. There's no age limit.

Why, given your attention to character and landscape, did you choose biography and not history or fiction?

I'd have been bored shitless if I'd known exactly what I wanted to do at age 12. I like the detours. I studied philosophy and cultural studies in Germany, and then the history of design at the Royal College of Art — so, architecture, objects, interiors, gardens.

In England, everybody was obsessed with gardens, and I used them as a prism for understanding the English. My first book was about how gardens can tell the history of a place, of a nation.

Then I realized I was actually not interested in the gardens, but in the people who went out into the world to collect the plants. And then I really got interested in science and in Humboldt. I realized that I can only really understand complicated things if I'm interested in the person who thought these things, in what that person did in the bigger picture where we still feel the effect today.

I realized that I can only really understand complicated things if I'm interested in the person who thought these things.

You're interested in systems thinkers and in the emergent properties of collectives. Your biographies are networks of causality. What inclined you towards that sort of systems biography?

I find people very boring who are just interested in one narrow thing. They just don't think outside the box. That's what I find fascinating about SFI — you meet people who do astrobiology but also are interested in Goethe's color theory.

Those people in the past are the ones I like to write biographies about. The research is much more interesting because you're not just doing one topic. It allows you to see connections that are still incredibly valid today.

Your biographies go from design to the Alps to exterior gardens to communities of crazy astronomers, then Humboldt, and now, the Romantics. Could you imagine having written your books in the reverse sequence?

No. One-hundred-million percent not. I could never have written them the other way around. I thought Humboldt would be the pinnacle, the keystone on this edifice of the relationship between humankind and nature.

But, I realized I need to actually look at how we became a human species in our minds. I want to know why we have destroyed this planet, why we continue to destroy it. That's really the *Magnificent Rebels* — why are we such a selfish species?

If Europe is about gardens, then the Southwestern United States is about wilderness. What's that relationship between the tamed wilderness and that thing that we've barely touched?

In 18th-century Europe, you have the very formal gardens of the Renaissance, the Italian gardens, the French gardens, Versailles. Britain is this constitutional monarchy, and they

want to create something particularly English. The English garden is like the constitutional monarchy — there's some freedom, but you clip the tree. There's a lot of symbolism.

The wilderness, in America, is such an artificial construct, and very, very complicated. When the nation is founded, you have this war alliance of 13 colonies who, once they've declared independence, actually have to become a nation emotionally. They have to find something that holds them together.

Thomas Jefferson has these fights with the French scientists who say, like, everything's degenerated in the New World. So Jefferson runs off to prove that everything's in fact bigger and that nature is the thing that makes America so different and so much better. Lewis and Clark then move out to the West and everything's just so spectacular, and wilderness becomes synonymous with liberty and freedom in America.

Most of the people you're talking about are men. Where's your great biography of an extraordinary woman?

Women have not been thought important enough, so we lack the sources — the letters and diaries — that I need to write the kind of biography I write.

Now, in the new book, there is Karoline Michaelis Böhmer Schlegel Schelling. She is the heart of the *Magnificent Rebels*. I found her as I was doing the research and thought, oh my gosh, she's so interesting. And I didn't really think about it that she's a woman.

There's another from very early in my career. There's a story about this female botanist who joined Louis de Putonvi's exploration. She dressed up as a man, as the assistant of the botanist. It was such an extraordinary story, but there's not a single scrap of paper written by her.

Is there something that fascinates you about the pre-20th century world?

I cannot imagine a scenario where I would write about someone in the 20th century. I venture into the early 19th century and I start feeling a little bit uncomfortable. I had to do John Muir, who obviously goes into the early 20th century. It was the first time in my life that I had to look at letters that were typed. You lose so much about the person because their handwriting is so important. The way they've written letters, you know, the way it's rushed, scribbled in.

I'm interested in the past as a way to understand why we are who we are. There's such a huge paradigm shift with the Scientific Revolution, with the Enlightenment. The 18th century is really the cradle of so many great things today, and so many problems today.

You are a student of these very successful, but often very eccentric personalities. Is the world now less tolerant or less generative of that kind of character?

I don't like boring people and that's why I choose these people, but I don't actually see them as eccentric at all. I see them as complex. There's a multilayered person. That's what I like. If it's eccentric for the sake of being eccentric, it's quite shallow and superficial.

What is more difficult today is to be someone who holds many complex issues in their head, because knowledge has grown so exponentially. So that's why we now have to do stuff like what you do in the Institute. You have to bring people together. It's the hive mind now rather than one mind.

They put the self at center stage and it has remained there ever since.

Are there some general characteristics of those quite extraordinary people?

They all look out for themselves. They're all very aware of what they want to do and what they can do. The art of being selfish can be something positive when we look at it in this correct historical context. But this freedom comes with a moral duty. The people I've written about tip-toe this fine balance.

How do you square the circle of being a maverick individualist who has the very best ideas and being a part of a society where you have to conform?

Well, the Romantics invent some terms. They add the prefix "sym-" to philosophy, to physics — so, symphysics, symphilosophy. It essentially means "together." They believe that a communal type of working and thinking will create something much bigger than the sum of its parts, and only when you put these parts together does it become something extraordinary.

It goes horribly wrong, it all ends in disaster, because they cannot put their own egos aside.

I don't like boring people and that's why I choose these people, but I don't actually see them as eccentric at all. I see them as complex.

But while they do it, they come up with extraordinary things. For example, Goethe's *Faust* would not be *Faust* as we know it had it not been for the young friends in Jena who inspired a very tired old man in his mid-forties. A lot of the themes they were discussing about the unity between the self and nature, between the arts and the sciences, all became themes that were incredibly important in *Faust*.

They created some amazing works and shaped the modern mind in good and bad ways. They put the self at center stage and it has remained there ever since. It is up to us how we use their legacy now. Right now, we have the Russian interference with democratic elections, fake news everywhere, politicians who are just liars. Everything that we have taken for granted since the French Revolution — that we have political rights, that we can form our own opinions — all of that is hollowed out at the moment. So, this is a good moment to look back at a moment in the past, which I think was essential for this very core of our society, which is free-thinking,

What is *Magnificent Rebels*?

Forget the French Revolution. The real revolution in the 1790s happened in Jena, this quiet little university town in Germany. A group of rebellious playwrights, writers, poets, scientists, thinkers, translators, literary critics, all came together and shaped the modern mind. They followed the philosophy of one of them — Johann Gottlieb Fichte — who basically says the self initially posits itself, and in this initial act, the *icht* creates the *non-icht* — the knowledge of the external world.

Another philosopher, Schelling, takes Fichte's philosophy and goes a step further and says the *icht* and *non-icht* are one living unity. That means that self and nature is the same thing, so when we go into nature, we learn something about ourselves. This philosophy of oneness becomes the heartbeat of Romanticism.

In the Scientific Revolution, you have this idea that you can observe everything in nature, you can experiment, and you can understand it. There's this big cut between us and nature, and the Romantics bring that together.

To this day, most of us will admit that nature does something to us very visceral. It soothes. There's something emotional. We can't really explain it, and that's something the Romantics gave us.

THE NOVEL AS A
**WORLD
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| 0003

TOM MCCARTHY

Miller Scholar, Santa Fe
Institute; Santa Fe NM

Novelist, Essayist,
Visual Arts Collaborator

Winner of the Windham-
Campbell Literature Prize
(2013); Shortlisted for the
Man Booker Prize (2010, 2015)

Further reading:
Satin Island (2015); *The
Making of Incarnation* (2021)



Tom McCarthy at the Very Large Array, New Mexico
PHOTO: KATE JOYCE

We are all awash in a **sea of mimicry & simulations & feedback loops. . . .**
We live in a giant novel.

DAVID KRAKAUER: As a novelist you are always attending to detail, while on the other hand, your life is *simulated* because every moment becomes potential fictional material and invention.

TOM MCCARTHY: Thomas Mann writes this wonderful novella called *Tonio Kröger*, which is basically an autobiographical account of becoming a writer. It begins with this originary sense of inauthenticity. While all the much more handsome German school boys are good at sport and just innocently play and be, Tonio feels himself always to the side. He's watching them play and be, and he's aware of himself watching them play and be. We're back to Kleist puppets, marionettes. He has that distance, alienation, *der Fremdon*. He calls it *Erkenntnis*, like insight is a kind of distancing thing, which means he has that higher elevation of the poet, but he has this almost — what do you call it? — *amputation* sense that he's lost some kind of purity of being. And, of course, every other moment of his life becomes this kind of observing life from the outside.

I guess this is the lot of the writer, but at the same time, I'd say this is the lot of the human, because we are all irremediably mediated all the time. We are all awash in a sea of mimicry and simulations and feedback loops between . . . and this is what Ballard says: We live in a giant novel. You know, our world is made up of fictions and politics conducted as a brand of advertising, and advertising conducted as a brand of politics and fantasies and pornography and this and that and product placement, and what we do is a kind of amalgam of a set remixed reenactments. So, maybe the artist is someone who gets this and, having access to the source code, can then start maybe exploring that and maybe even, hacking it a little bit somehow.

But here we've moved beyond the question of simulation. **It's something else.** It's the production of situations or immersive environments.

Speaking of source code, your novels, like our science, are full of models of reality.

As you say, I think something we both have in common is that we're interested in building models. You could think of the novel itself as a kind of model, but in my novels, often the characters build models of the world within the novels. So there's this kind of regress of modeling. In the last novel I wrote, *The Making of Incarnation*, in fact, the first scene I wrote — that advances the plot in absolutely no way at all, I love it all the more for that — is set in a wind tunnel where the Austrian Olympic bobsleigh team has put their bobsleigh and the two men that ride it in a Dutch wind tunnel which models aerodynamics and force, so that they can cut 0.005 seconds off their pace and move from silver to gold at the next Olympics.

You make a model of the world, you create an environment that's realistic or plausible, and you simulate. What interests me about the wind tunnel is not just the data that it will produce about speeds and resistance and drag. It's the fact that the trainer is in there with his suppressed homosexual fascination with his athletes. You've got the statisticians with their histories, the Dutch wind tunnel engineer, who's from a generation of polder burghers in this scooped-out hollow land. . .

And at one point in that passage, the narrator asks what machine could render all of this, and it's a rhetorical question, really. The machine, the ultimate machine, is the novel. But it's not really representing something that was already there. It's producing a bigger machinic assemblage, perhaps. But here we've moved beyond the question of simulation. It's something else. It's the production of situations or immersive environments.

Let's talk about *Frankenstein* a bit, because that book feels like a sort of Tom McCarthy *avant la lettre*.

Frankenstein is an absolutely seminal book. It's a point very much where science and poetry or science and fiction overlap and also machine culture. At that time in England, jacquard looms were replacing manual laborers, so manual laborers were breaking into the factories at night and smashing the looms. They'd created this mythical persona called Neil Ludd who maybe existed and maybe didn't, but that's whence *luddite*. It was a capital offense to smash a mainframe weaving machine. Lord Byron had given his maiden speech in the House of Lords praising the luddites. And he was conducting this scandalous incestuous affair with his semi-sister. Then he turns up at Percy and Mary's place on the Swiss-Italian border. All these things are at play. And Mary just brilliantly absorbs and transforms this and produces *Frankenstein*, which is about machine culture, politics, and incest. Incest is a very central strand running through that book, the economy of the family. It's about creation, not as some kind of sublime thing, as her husband imagined it, but as something quite monstrous.

Memory is something of an obsession of yours and of your protagonist in *Remainder*, and many writers that you admire, including Nabokov, Bergson, and Proust.

For me, I guess what's interesting about memory is not so much remembering as the processes of reconstruction or reenactment. So in *Remainder* the hero has been in an accident. He's been hit on the head. He lost his memory, but he got it back quite quickly. He said it was boring. It was like watching a soap opera in a binge watch. You just get it in installments. And if he'd watched another set of files or videotapes, he would've had that memory and he wouldn't have cared or known any different. So having, you know — it's not *Memento*. The issue is not that he's lost his memory, it's that he's lost his sense of authenticity and a kind of essential trueness to a moment of experience, whether it's now or in the past.

And he spends all these resources and money reconstructing a memory which he recognizes from the off might not be authentic. Proust writes about how you can remember a staircase in a house that never existed because you take the wallpaper from one house and the banisters from another and the carpet from a third and you collage them and that's what you remember. This is what my guy is doing. He's made this construct in his head, which for him represents this moment in which if he could just walk up and down that staircase, the image, the light, and the dust and the sound of neighbors cooking liver and practicing the piano and making mistakes and practicing the same passage again and again, and again. If he could do all that, he would somehow be authentic.

We'll never finish reading *Hamlet*. It needs to be contested. It's a **site of contestation**, like science. It's a lot of work and it will never be over. And thank goodness.

As a writer of fiction you have a very deep engagement with the idea of technology

Technology. Where does it begin? Heidegger points out that *techne* for the Greeks and *poesis* meant something like the emergence of the beautiful into the true. So *techne* is any kind of process through which being emerges and takes on form and configuration. So of course a camera or a typewriter is technology by that definition. But so is taking a crayon and drawing on a wall of a cave — or speaking, for that matter, especially language. Language would be the ultimate technology. In my own books, I've figured technology in various ways. In one of them it's the radio, which I think is an amazing device for "worlding," especially emergent radio. You know, you get these kids in the first decade of the 20th century, basically early hackers, just clobbering together radio sets and tuning in to ships in the Atlantic and Imperial stations in Africa and interference and the galactic crackle of Aurora Borealis that's just spilling out of their headphones.

And Caliban in *The Tempest* describes how the isle is full of sounds, sweet airs, a thousand clashing instruments humming about mine ears — all transmitted, mediated through a figure called Ariel, right? But I think with the emergence of radio, the situation Caliban's describing which in Shakespeare is magic, becomes literal. It's happening materially in the 20th century. And I find that incredibly poetic in the original sense. This is a bringing forth of the true into the beautiful.

In my last book, I'm very interested in early and mid-20th-century forms of notation of movement. Early industrialists who would make analog models of the path the worker's hand made as she packed soap or as he assembled airplane propellers on a Charlie Chaplin-type *Modern Times* assembly line.

One of the main players in this kind of sub-industry was a woman called Lillian Gilbreth, who devised this slow photographic method of capturing in stereoscope the hand and then modeling it. It's amazing what she did, and very aesthetic. It looks like art. But the most amazing thing is that she went to high school with Isadora Duncan and Gertrude Stein and Jack London, all of them in the same 1890s Oakland high school. So there's this intersection of industrial capitalism, dance, and avant-garde literature. And then when you factor London in as well, late 18th-century frontiersman adventurism, which all kind of erupt at this time. So, yes, that's technology too. I guess I'd say technology is the site of some kind of blossoming of worlds and all their poetic and political senses.

Some people describe your books as difficult. We hear this criticism all the time in terms of complexity science.

Alain Robbe-Grillet once said that Dickens and Balzac's novels, for all their brilliance, don't really need readers because they do all the readers' work themselves. I think he was being a bit unfair, but the logic of his argument is quite good. You know, why should *Finnegans Wake* read itself for us? That's what we're here for, right? I mean, the novel is not just entertainment. It's a site of work to be done and of work that can never be completed. We'll never finish reading *Hamlet*. It needs to be contested. It's a site of contestation, like science. It's a lot of work and it will never be over. And thank goodness.

What is the Santa Fe Institute?

Despite our best efforts to treat the world as discrete, disconnected, and independent, our species' latest brush with a global pandemic proved it to be otherwise. We might wish for simplicity, but we have to learn to live with complexity. In practice this means contending with connections — and understanding these as codependent systems.

The great revolutions in mathematics and science have for the most part been simplicity rebellions. The Greeks described the heart as both hearthstone and soul, and then William Harvey showed it was just a pump. Aristotle conceived of a unique law of creation—spontaneous generation—for every organism smaller than an insect, until Francesco Redi demonstrated that every visible lifeform is just another reproductive generation.

Natural science has made great progress by taking conceptual jumbles and revealing them to be tangles comprising a small number of simple underlying analytical threads. This approach, which can be characterized as parsimonious, minimal, or economical, has proven itself to be predictive, extraordinarily powerful, and very often intuitive.

But there are areas where theory has failed to make predictive contributions comparable in scope and precision to those achieved in the sciences of physics, chemistry, and geology. These are all areas dominated by living processes, from simple cells up through to complicated assemblies of organisms in societies. There is something about life that resists — at least at first blush—the attempt to unravel its various knots into a few simple threads. This is the signature of complexity. The steadfast reluctance of the evolved and social world to conform to our desire for simplicity.

Hence our bewilderment at the enduring specter of war, the intractability of inequality, the recurrent waves of migrations and social reactions, the challenges of coordinating a global response to climate change, and the inexorable increases in extinction events across the globe. Simplicity can get us only so far.

AT THE SANTA FE INSTITUTE, our researchers endeavor to understand and unify the underlying, shared patterns in complex physical, biological, social, cultural, technological, and, even, possible astro-biological worlds. Our global research network of scholars spans borders, departments, and disciplines, unifying curious minds steeped in rigorous logical, mathematical, and computational reasoning. As we reveal the unseen mechanisms and processes that shape these evolving worlds, we seek to use this understanding to promote nothing less than the wellbeing of humankind and of life on Earth.

SFI is an independent, nonprofit research and education center that has been leading global research in complexity science since 1984. For more information, visit our website at santafe.edu.

The Santa Fe Institute: Searching for Order in the Complexity of Evolving Worlds

... one really important thing
is to choose a problem that
you feel is both interesting
and important.
Both are necessary.
VENKI RAMAKRISHNAN

Everything that we have taken
for granted since the French
Revolution — that we have
political rights, that we can
form our own opinions —
all of that is hollowed
out at the moment.
ANDREA WULF

We are all awash in a sea
of mimicry and simulations
and feedback loops.
We live in a giant novel.
TOM MCCARTHY

There's this big cut
between us and nature,
and the Romantics
bring that together.

ANDREA WULF

Of course a camera or a
typewriter is technology...
but so is taking a crayon and
drawing on a wall of a cave
— or speaking, for that
matter. Language would be
the ultimate technology.

TOM MCCARTHY

They put the self
at center stage and
it has remained
there ever since.

ANDREA WULF

You only have one life
to live. So why not do
the thing that actually
matters more?

VENKI RAMAKRISHNAN

BOUNDARY

INDEFINITE