Take off: The northern flicker (*Colaptes auratus*) also changed its habitat use during lockdowns. (Photo: Holly Hauser.)

Some thought is being spent on how cities of the future are to be made sustainable with respect to their environmental impact as well as liveable for their human residents (Curr. Biol. (2019) *29*, R947–R949). In this context, a better understanding of how the built environment accommodates and affects wildlife will be crucial.

Observations of city life have a long tradition and can be readily expanded with the help of the human residents of the same cities. A detailed understanding of the incipient evolutionary change happening in the urban jungle is only just beginning to be sought and will be harder to attain. In a roadmap published in 2019, Ruth Rivkin and colleagues formulated six questions to guide research, addressing how urbanisation affects non-adaptive evolutionary processes, natural selection, and convergent evolution, as well as the influence of environmental heterogeneity on evolution, the roles of plasticity, ancestral traits, and contemporary adaptation for the ecological success of urban species, and finally the evolutionary diversification of novel traits, genes, and species (Evol. Appl. (2019) *12*, 384–398).

The authors call for the insights gained to be applied in city planning, conservation, pest management and public engagement. The hope is that application of deeper understanding will reduce the impact of urbanisation on biodiversity and make cities more liveable for humans as well as for other species.

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Q & A

David Kleinfeld

David Kleinfeld graduated from Abraham Lincoln High school in Coney Island, Brooklyn, in 1971. He attended college in the Midwest where, after various false starts, he majored in electrical engineering. As a work-study student at Argonne National Laboratories, David realized a passion and an aptitude for experimental physics. Back at university, a seminar by John Hopfield on electron transfer in proteins, and some prodding from David's professors, convinced David to make his way west and take up an offer to join the laboratory of George Feher in La Jolla. David graduated in 1984 with a thesis on the conversion of light to a pair of separated electrical charges during the first step of photosynthesis. Motivated again by work from John Hopfield, this time on neural networks, David moved back to the east coast and began a decade-long stretch at AT&T Bell Laboratories. He then returned to La Jolla in 1996, now with a family, where David leads the "Neurophysics" laboratory as a distinguished professor of Physics and of Neurobiology at UC San Diego.

What turned you on to biology in the first place? I am not a biologist. I don't think in terms of evolution, although I will return to this point. I also don't think about how nature tries to fill every niche, inhospitable as some appear, with life. I am enthralled with neuroscience, which is as much about computing and the ability to sustain abstract thought as it is the mechanics of cells and biochemicals. I suspect that my interest was sparked when I was an undergraduate and had a wonderfully insightful professor, Petar Kokotovic, for my classes in control theory. Petar recommended that I read *Cybernetics: Or Control and Communication in the Animal and the Machine* by Norbert Wiener. The material stuck with me. The Cybernetics movement is a blueprint for how we should think about neuroscience research today; at the time that Weiner wrote his book, there were simply no experimental tools to test the ideas that he and colleagues proposed. Anyway, much as I was moved by the book, it would be a decade before I acted and moved toward neuroscience. That's just the way things work — you get an inkling that something is new and exciting, but time goes by before you make your move.

And what drew you to your specific field of research? This is more of an issue of random drift than I should admit. But I parked myself studying two problems, more or less, over the past two decades. And they enjoy some amount of synergy. The first problem concerns active sensing, or how nervous systems both optimize their search strategies and compensate for self-motion. This forms a clear bridge between ethology and engineering, and requires a holistic view in terms of neuronal circuit analysis. And finally, after this many years, my colleagues and I can describe what we measure in terms of physical models that balance biological realism against physical simplicity. This recent turn of events has been a source of great intellectual satisfaction.

The second problem is how the brain controls its own blood supply, which is both a matter of static plumbing and vascular dynamics. This connects bioenergetics and computation, and also benefits from an engineering perspective, this time in terms of the logic for the control of flow. My work on blood flow started as a result of a compromised experiment, in which the motion of red blood cells added an unanticipated noise to optical measurements of neuronal function in rodent brains. My friend, the great experimentalist Winfried Denk, later suggested that we just look at flow of blood cells directly. Things quickly took off, with one surprise after another over the years, albeit with a lot of technology development in between. Here too, we seem able to understand our results in terms of physical models that balance biological realism with physical simplicity. Quite the ride.

If you had to choose a different field of biology, what would it be? From one perspective, neuroscience is the study of how matter gained intelligence at a level sufficient to understand itself. I don't know how much more profound you can get. But one nascent field that caught my eye back as a graduate student, and now seems to be coming into its own, is the statistical mechanics of evolution. Perhaps naively, I envision this in terms of large-scale experiments on mutable, rapidly reproducing single-cell organisms. It touches on all aspects of biology — brains are just a means to improve adaptation!

Do you have a scientific hero? Michael Faraday, the earthly god of experimental science.

Which historical scientist would you like to meet and what would you ask them? The real question here is: who was a great conversationalist? Many people write about their long walks and discussions with Enrico Fermi, who is universally considered to be one of the greatest experimental as well as theoretical physicists. I would have loved to discuss quantum mechanics with Fermi. He was there at the beginning of wave mechanics and matrix mechanics and became a self-taught expert and ardent practitioner. How did Fermi come to imagine the world of atoms and fields?

Do you have a favorite paper? In neuroscience? What else could it be other than Jerry Lettvin's 1959 paper *What the Frog's Eye Tells the Frog's Brain*, reporting that high-order sensory neurons respond to very specific spatial patterns, which he called feature detectors. Jerry added ethological relevance to Hartline's mechanistic notion of the receptive field of a neuron. Simply brilliant.

What is the best advice you've been given? Fight for your ideas. Seek criticism, understand and respond to criticism, and correct your falsehoods. But always fight. No one actually said this to me, but the people I admire appear to follow this dictum. The best ones do it so smoothly that you barely notice.

Was it difficult to combine a career in teaching and research? It has become less difficult for me, as I'd underestimated the challenge of teaching lower division physics to undergraduates when I first started at the university. I feel that teaching seniors and graduate courses in my specialization, and especially teaching in postgraduate schools, remains a potent means to refine my trade and sharpen my intellectual arguments. And these experiences led to some extensive pedagogical publications that were written with my colleagues. But clearly there are scientists at research institutes and medical schools that barely teach and do great science.

If you would not have made it as a scientist, what would you have become? Plan B? This is a loaded question. When I grew up, no one in Coney Island or Brighton Beach was thinking about entrepreneurship, at least the legal kind. Nor was it particularly in the air, at least in my circle of friends, when I was in graduate school. So I probably would have drifted off to an engineering company. These days I would apply physics to new areas: my daughter and I are thinking in terms of differential geometry and the fit and design of dress pants! Imagination and technical skill can set you free.

What's your favorite experiment? This needs bounds. As an observer in my lifetime — the Laser Interferometer Gravitational-Wave Observatory (LIGO). A simple idea. A mind-boggling realization. Nothing I can build can begin to approach the sophistication of LIGO; this interferometer has quantum coherence between 40 kg mirrors! It blows my mind. No data that I will generate are likely to have anywhere near as much impact on mankind.

What has been your biggest mistake? So many. I keep thinking that my career could have gone further if I was smoother — better behaved and less neurotic — in my interactions with colleagues. I am also inconsistent with time management; the one saving grace is that I can be captivated by a problem and obsess until I solve it or I'm exhausted. Sometimes this is essential for progress. Sometimes it leads to strife.

What is your favorite or least favorite conference? It's an issue of style. I enjoy meetings with an intellectual focus but a wide range of experimental approaches. In this regard, boutique meetings on *Engineering Principles in Neuroscience* that were held a decade ago at the Banbury Center were illuminating for me. I have mixed feelings about the annual Society for

Neuroscience meeting. It is a great way to catch up with people you know, meet new people, and learn about new results during the give-and-take of a poster session. But the overarching organization seems wrong; sessions are sorted largely by anatomical region of the nervous system rather than by function or computation. In this regard, the more intimate and focused BRAIN meetings are a vast improvement.

What is your greatest research ambition? I have been too diffuse in my career. Going forward, I want to solve one simply stated problem that all reasonable parties agree is nontrivial. I think a quantitative link between brain arteriole oscillations (vasomotion) and brain neuronal dynamics, an issue in brain energetics that will also place the interpretation of fMRI on a firm footing, is something my laboratory can pull off in the near term. Maybe!

Do you feel a push towards more applied science? There is nothing wrong with applied science; it is a sign of the maturity of a field. The problems occur only when people try to develop technology, or medical procedures, in cases where fundamentals are lacking.

I have had the luxury and great fortune of focusing on fundamentals. I feel, and I suspect that almost all scientists agree on this, that understanding fundamental aspects of a scientific problem are critical for progress. Otherwise technology will grind to a standstill. Nonetheless, I also feel that one should pursue applications if they come your way. It's a payback to society. I am very proud that we discovered a class of arterioles in the brain that lead to brain injury when blocked, a basis for microstrokes. This would not have come out of neurology any time soon, as one such physician gleefully announced “I don’t see them so they cannot exist” when I presented our data at a past NINDS meeting.

Do you think there is an increased need for scientists to market themselves and their science as ‘a brand’? I think science, and the role of scientists and their culture of self-doubt and re-evaluation, should be constantly and even meticulously explained to the public. We need good spokespeople for this task and to hawk the verifiable impact of scientific progress on economic expansion. Science is a fragile business and needs to be appreciated if it is going to continuously blossom. At the level of individuals, I would like to think of scientists as being above the fray, as an honorable profession that is only hurt by individual advertising and branding. But the age of Twitter may crash this illusion. Twitter is here to stay, so we need to fight and transform it into something positive.

Do you believe there is a need for more crosstalk between biological disciplines? Always. I think all laboratory buildings should be designed to almost force individuals to cross paths and to come together to talk. Common staircases, central hallways, lots of whiteboard space, common cafeterias with good food and limited hours, and so on. These are ways to increase the likelihood that people will interact; Bell Laboratories, Janelia Research Campus, and others all did this. What could be more natural than discussing an old problem with a new group of people over lunch?

Which aspect of science would you wish the general public knew more about? Applied probability, which is mathematics as opposed to science per se. Humans, as we know most definitely from the work of Tversky and Kahneman, are poor at assigning probabilities — even relative probabilities — to events. So as a society we focus on the rare events and many tangential issues. Probability should be taught in high school, which it is currently not as a rule. Probability is of far more general utility than calculus, which makes up the bulk of “advanced mathematics” in high schools. I would also push for physics to be integrated into the scientific curriculum. The key points are abstraction, so people learn to see simplicity and beauty under the layers of complexity, and action at a distance, so fields and radiation are understood and not immediately associated with evil.

Do you think there is too much emphasis on big data-gathering collaborations as opposed to hypothesis-driven research by small groups? Yes. I appreciate that some insights only come from examining trends that appear in large datasets or extensive surveys. But, as I see it, all of the theoretical insights that have occurred in systems neuroscience — from coupled oscillators for locomotion, to attractor networks for the control of heading, and to balanced inhibitory/excitatory feedback as a means of stabilizing neuronal activity — have come from quandaries posed by the results from single or in some cases dual investigator experiments. So let’s augment, but not replace, “hypothesis-driven research by small groups”.

What do you think are the big questions to be answered next in your field? We have so little idea of the principles of computation used by the brain that I am not even sure how to ask the big questions. I’m going to narrow this to “What is different between electronic circuits and the nervous system?” and use this to define “the big question”, since the nervous system accomplishes tasks that are outside the realm of conventional circuits. One set of questions concerns the profound role of plasticity in all things neuronal. We know little about plasticity, except for what happens with pairs of spikes. Yet here is where the genetic tools and molecular probe and imaging technology are such that we can already ask hard questions in a proper, reductionist manner. If I were starting out and I were to take advice from my older self, I would dive into the physiology of plasticity.

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Quick guide

Soybean

Chao Fang and Fanjiang Kong*

What is soybean? Soybean (*Glycine max* (L.) Merr.) is an annual species belonging to the legume/Fabaceae family within the Rosales order. It has ternately compound leaves, small white or purple flowers, and curved seed pods usually containing between one and four seeds. The typical height range for cultivated soybean varieties is 0.2–1.5 m. It is widely accepted that cultivated soybean was domesticated from its wild progenitor (*Glycine soja* Sieb. & Zucc.) (Figure 1A) over 5,000 years ago in the Huang-Huai Valley of China. The subsequent expansion of cultivation worldwide saw soybean introduced to Korea, Japan, and South and Southeast Asia approximately 2,000 years ago, to North America in 1765, and to South America at the beginning of the last century. Over 60,000 accessions (varieties/cultivars) of soybean adapted to different regions have been developed, and soybean is now one of the most economically important legume crops in the world. The global production of soybean is concentrated in the United States, Brazil and Argentina, with China and India ranking fourth and fifth but far behind. The top three countries together accounted for approximately 82% of global soybean production in 2021, with China being the largest importer. Besides its economic value, soybean also has academic value as a model system to study photoperiodism and nodulation by symbiotic rhizobial bacteria for nitrogen fixation.

What makes soybean special? Soybean, also known as ‘king of beans’, is the main source of plant protein and vegetable oil for humankind. Approximately one-fifth of global soybean production is used for direct human consumption and three-quarters of production is used for livestock feed. Due to its high protein content and quality, soybean is one of the most prevalent and cheapest sources of protein and is the only