

been controlling itself for billions of years and will continue to do so long after we humans disappear.

A 1991 profile in *Science* headlined Margulis as “Science’s Unruly Earth Mother”, “amusing, exasperating, enlightening”. In practising her own brand of science, Margulis routinely dismissed results gleaned from reductionist methodologies in favor of holistic approaches to understanding. Like most scientific ‘rebels’, she simply refused to doubt her own intuition. A prime example is her steadfast belief that the flagellar apparatus of the eukaryotic cell is derived from a symbiotic spirochaete bacterium. A component of her original endosymbiont hypothesis, she spent her whole career trying to prove it. That molecular and genomics-based approaches failed to provide such evidence did not deter her; she preferred to make inferences about how cells might have evolved in the past based on patterns and processes she could observe directly in living organisms. In recent years, and to the dismay of many, Margulis pushed her ideas on spirochaete biology to uncomfortable new extremes: she and colleagues proposed that AIDS and syphilis are in fact one and the same, with the former caused not by HIV but by symbiotic spirochaetes. Swimming against the scientific tide was in Margulis’s DNA.

Stubborn and iconoclastic, brilliant and increasingly dogmatic, Lynn Margulis inspired a generation of biologists to think differently about the evolution of cells. For her dedication to the advancement of evolutionary theory Margulis received numerous distinctions, including election to the US National Academy of Sciences in 1983, receipt of the National Medal of Science from President Bill Clinton in 1999, and the Darwin-Wallace Medal from the Linnean Society of London in 2008. She will no doubt remain an enigma in the eyes of many of her fellow professionals, criticized and praised in equal measure, as she was throughout her career.

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Q & A

Sönke Johnsen

Sönke Johnsen is an Associate Professor of Biology at Duke University, where he is happy to study anything that involves a photon and an animal. His lab is an anarchic collective of people studying, among other things, camouflage strategies in the open ocean, sexual signaling in blue crabs and jumping spiders, the evolution of eyes in mollusks, polarization and UV vision, and the morphological basis of human cataracts. His first love is optics, and he has just finished a book on the topic for biologists.

Did you always want to be a biologist? It never even crossed my mind. My parents were poor but inventive — growing, building, sewing, and scavenging just about everything we needed. For example, we were one of the few families in the early 1970s to have seven telephones, because my dad kept finding broken ones on the curb and fixing them. This gave me a lifelong interest in how things worked and the confidence to tackle any problem. The natural world, however, was farthest from my mind. I grew up in Pittsburgh, which at that time was not the charming museum of the industrial revolution it is now, but instead a functioning factory city with steel mills, soot-blackened buildings, and night skies that were orange with light pollution. Aside from yearly vacations at the beach and occasional trips to national parks, the nature I saw consisted of sidewalk trees, squirrels, and guppies. So, after a brief fantasy of a life in baseball, I always assumed that I would become a physicist like my dad — perhaps an astrophysicist, because I was fascinated by cosmology. I remember once asking my dad where he would live if given the whole universe as a choice, and he said that he liked the earth just fine. At that time, I was gunning for life on a neutron star and was intensely disappointed with his answer.

After a childhood as a math/physics nerd (where I was actually known as a ‘mathelete’ for a time), I entered college and quickly discovered that my Physics classes

bored me. I switched majors to Math, mostly because my favorite teacher at the time — who shared my interest in modern dance and told funny stories about Abel and Galois — taught this subject. This major also gave me time to do what I really enjoyed: dancing, painting, playing practical jokes, and worrying about my personal life. I graduated early, moved to a clothing-optional group house with my girlfriend, and started teaching dance to three-year-olds. I fully expected to never return to academia.

So why did you become a biologist?

Because it began with the letter ‘B’. My dance job morphed into running a daycare center and then into teaching kindergarten. I loved this last job and still believe that six-year-olds have perfect minds. However, I made so little money that I had to steal food from the local college cafeteria. So, I became a self-employed carpenter and eventually ended up sharing a large job with a close friend that involved converting an old barn into apartments. This task, which we did not truly know how to accomplish, dragged on for several months, during which time our employer became increasingly paranoid. One day, she confronted my friend with the idea that he was secretly plotting to murder her. He protested, but she wasn’t convinced. She went back into the house — we assumed to get her gun — so we quickly packed our tools into my friend’s Geo Metro and drove off. During this drive we decided that we needed real careers. Lacking any better plan, we went through the alphabet. For me, ‘A’ meant art, so I considered a career in that for about ten miles and eventually decided that I’d be back to stealing food. Biology then popped into my mind, mostly because I’d had an excellent biomechanics course a couple years before, taught by Rachel Merz. We read and criticized actual papers (a first for me), and Rachel’s love for the beauty and humor of invertebrates was infectious. In contrast, my only other Biology class (when I was 14) consisted entirely of my teacher showing slides of his trips to the American West, set to Pink Floyd music. So I visited Rachel, and she suggested places to apply to graduate school. I also contacted the father of one

of the kids I taught dance to (Scott Gilbert of developmental biology fame), and he got me a job with the theoretical biologist Stuart Kauffman that required no actual knowledge of Biology — so that I could see what I was getting into. Things continued in more or less the same serpentine fashion for the next twenty years, but I'll stop here and be thankful that 'zoology' has become a less common term. Otherwise, I may have become a banker.

Are you happy with your choice?

Very much so. No other field has given me so much in so many ways. Aside from its beauty and elegance, the natural world never fails to make me laugh. As I like to tell my students, if something looks ridiculous, it's probably due to sexual selection. But even natural selection comes up with some whoppers. Scallop eyes, for example. Why give a clam 100 big, blue eyes? Or why are the sea urchins in my tank wandering about with carrots stuck to their heads (which of course aren't even heads)? Or tardigrades? Who ordered them? Also, Biology, for me at least, provides a spiritual connection to the world that religion never did. I wouldn't call myself a druid, but the natural world does impress and awe me, and the fact that I was formed via the same process that gave rise to pelagic snails, corals, and oak trees gives me comfort. I've always been drawn to family sagas and nature is the ultimate extended dynasty, complete with weird Uncle Wiggly. Getting paid to study this is really too good to be true.

What do you like most about your job?

Two things. First, I love to go to sea. My first trip in 1997 was with Edie Widder, Tammy Frank, and Justin Marshall. I was so excited that I nearly passed out, and things haven't changed much since then. Seeing the animals in the water, via submersible or scuba, or seeing them on the ship after being collected, never fails to amaze me. Shipboard life is also interesting in itself, being a self-contained community of often odd people made even odder by extended isolation. And where else do professors get to play with hydraulic winches and 30 meter fishing nets?

My other main love is mentoring graduate students and postdocs.

I've always enjoyed teaching, but with undergraduates I hardly ever get to see whether I've succeeded, because they've moved on. Graduate students, from what I can tell so far, never truly leave, so you can see them grow. It's been wonderful to watch my students develop from relatively shy, hesitant people to forces of nature that lead entire expeditions. I'm not sure how much of a role my mentoring played in this, but it's still wonderful to watch and does make me proud.

Do you have anything useful to say to students and postdocs? In the US, I'm known as an advisor, so I suppose I should give advice. Most of it is only relevant to people pursuing a research career, but here goes:

For graduate students: choose your advisor carefully. You will be stuck with him/her for the rest of your life. Even after you get your PhD and no longer require reference letters for a job, people will still see your advisor floating behind you like a shadow and assume that you two are somewhat alike. Wonderful research is not always performed by wonderful people, so make sure you choose a person that you like, work well with, and — most important — trust. As my first student, Alison Sweeney, said, selecting an advisor is like choosing a spouse after one date. Learn all you can on this date and follow your gut. Aside from that, work on something you like, in a place you like, with people you like. Happy people (within limits) are more productive and creative, so being miserable in Famous-Guy's lab at Cutthroat University to further your career is a false bargain. Similarly, while it can be inspiring to talk with the older heroes of your field, it's not as useful a career move as you might think. Instead, develop strong ties with other students — they're the ones who will still be with you in forty years. The heroes will be dead.

For postdocs: you will get a job, you will get a job, you will get a job. You may not get the job you thought you'd get when you entered graduate school, but you will likely get a job that you like. I did not go to an ultra-elite graduate program, but nearly every one of my fellow students now has a job that makes them happy. Also, worrying about getting a job will not make it easier to get one and



will blind you to the fact that — as a postdoc — you have more freedom, ability, and opportunity to do research than you will ever have again. I know it's easier said than done, but try to enjoy it.

What about advice for professors?

For early-career professors: Pick your students carefully; they are part of your life for a long time. Be especially choosy about your first student, since they set the tone for so much that follows. I've seen careers rise and fall on the relationship with the first student. Choose students you care about, otherwise the effort simply isn't worth it. Be generous with them and in your collaborations with others. Aggressive competition may buy you short-term gain, but will eventually leave you bitter and alone, stamping your foot in an empty office.

For mid-career professors: At some point, you will discover that your mental resources are finite after all — try not to be too disappointed. Avoid administrative duties like poison. I suppose everyone should do their part, but the initial glow of being asked to join the university honor code reform reversal committee wears off quickly. When the mid-life crisis comes (which it will if you are male), and you are choosing between the marriage-ending affair and a shiny little car — get the car. That's as far as I've gotten.

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