5-methylcytosine. This specificity is unusual in fungi, but was predicted in prior studies of *de novo* methylation of repeated genes in *C. cinerea*. Recent attention has been focused on an additional modified base, 5-hydroxymethylcytosine, and its role in 'poised chromatin' in stem cells. The *C. cinerea* genome contains 38 copies of a gene predicted to carry out this conversion, and 5-hydroxymethylcytosine has been detected in the *C. cinerea* genome. It appears that this beautiful model organism will continue to contribute to our understanding of important problems in biology, as well as serving as a tractable system to facilitate desired manipulations of other basidiomycetes important for wood biodegradation (responsible for the return of 80 billion tons of carbon per year to the atmosphere), and perhaps bioremediation and alternative fuel production.

Where can I find out more?

Buller, A.H.R. (1931). Researches on Fungi IV (Longmans, Green and Co.)
Burns, C., Stajich, J.E., Rechtsteiner, A., Casselton, L., Hanlon, S.E., Wilke, S.K., Savytskyy, O.P., Gathman, A.C., Lilly, W.L., Lieb, J.D. *et al.* (2010). Analysis of the basidiomycete *Coprinopsis cinerea* reveals conservation of the core meiotic expression program over half a billion years of evolution. PLoS Genet. *6*, e1001135.
Casselton, L.A. and Kües, U. (2007). The origin of multiple mating types in the model mushrooms *Coprinopsis cinerea* and *Schizophyllum commune*. In Sex in Fungi J. Heitman, J.W. Kronstad, J.W. Taylor and L.A. Casselton, eds. (ASM Press) pp. 283–300.
Freedman, T., and Pukkila, P.J. (1993). *De novo* methylation of repeated sequences in *Coprinus cinereus*. Genetics *135*, 357–366.
Kamada, T., Sano, H., Nakazawa, T., and Nakahori, K. (2010). Regulation of fruiting body photomorphogenesis *in Coprinopsis cinerea*. Fungal Genet. Biol*.* *47*, 917–921.
Merino, S. T., Cummings, W. J., Acharya, S. N., and Zolan, M E (2000). Replication-dependent early meiotic requirement for Spo11 and Rad50. Proc. Natl. Acad. Sci. USA *97*, 10477–10482.
Pastor, W.A., Pape, U.J., Huang, Y., Henderson, H.R., Lister, R., Ko, M., McLoughlin, E.M., Brudno, Y., Mahapatra, S., Kapranov, P., *et al.* (2011). Genome-wide mapping of 5-hydroxymethylcytosine in embryonic stem cells. Nature *473*, 394–397.
Stajich, J.E., Wilke, S.K., Ahren, D., Au, C.H., Birren, B.W., Borodovsky, M., Burns, C., Canback, B., Casselton, L.A., Cheng, C.K., *et al*. (2010). Insights into evolution of multicellular fungi from the assembled chromosomes of the mushroom *Coprinopsis cinerea* (*Coprinus cinereus*). Proc. Natl. Acad. Sci. USA *107*, 11889–11894.

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Q & A

Rebecca Safran

Rebecca Safran is currently an Assistant Professor at the Department of Ecology and Evolutionary Biology at the University of Colorado. She received her undergraduate degree from the University of Michigan (Ecology) and her graduate degrees from Humboldt State University (MS, Wildlife Biology in Mark Colwell's lab) and Cornell University (Ph.D., Ecology and Evolutionary Biology in David Winkler's lab). She worked with Daniel Rubenstein as a postdoc at Princeton University from 2005 to 2008. Her work on barn swallows examines interactions between phenotype and behavior and how these shape patterns of variation. She is particularly interested in the role of sexual selection in adaptation and reproductive isolation.

Why did you become a biologist? I think I have been a biologist all my life — I just didn't know it for sure until I was an undergraduate student. I had previously intended to be a writer — I spent much of my childhood dedicated to writing and peddling a magazine of my own creation around the neighborhood. My first independent purchase was a typewriter so that I could set up a little office in my bedroom. The true wake-up calls came much, much later, during my undergraduate days at the University of Michigan. The first 'a-ha' moment was a plant taxonomy class which was absolutely mind blowing! Through this class and its weekly field trips, my eyes were opened to biological diversity in a different way than they had been before. I became quite passionate about identifying plants and eventually all living things. An entire summer spent at the University of Michigan's Biological Station sealed the deal. Here, there were biologists of all flavors — each more passionate and excited than the next. The next question then became: yes to biology, but what kind? I think I am still working on an answer to that question — because I love so many different aspects of scientific inquiry. Still, I don't feel that my time spent on the art of writing was a waste. Contrary to popular stereotypes, I think of science as a very creative endeavor. Thinking outside the box is rewarded and designing elegant experiments requires being resourceful and innovative. Perhaps this is why I so much enjoy a course I teach at the University of Colorado on film-making and the science of climate change.

If you were so excited by plants initially, why study birds? Aren't they really difficult to work with? I will admit to being fairly pragmatic in my choice of study organism for my dissertation work. Before starting my Ph.D. (and not knowing where I would end up), I thought about a system that was common, tractable, typically abundant, in which it would be easy to measure relevant features of ecology, behavior and evolution. I had a checklist of 'key features' and several field guides to thumb through. Everything kept pointing to the birds. Their nest sites are discrete locations where a lot of important measurements can be collected quite easily and they are more tractable than one would think, especially if you are interested in reproductive behavior.

What is the best advice you've been given? Something my graduate adviser David Winkler once said to me has stuck: "*biology is 24–7, not 9–5, so you have to really live and breathe it.*" This came from someone who works hard and has also never lost a child-like curiosity for all things biological. I took this advice to mean something like: embrace this job as your lifestyle. If it feels like 'work' or a 'job', it is probably time to think about doing something else. I still feel like I learn something new and fascinating about biology each week; and things that I have now experienced dozens of times — marked birds returning to breed in the same locations year after year — never cease to fascinate me.

Speaking of lifestyles, what about work–life balance? As a female scientist with two young children, I get asked this question a lot. Lately, I have come to realize that there is no such thing as a work–life balance. You do what needs to get done. Sometimes that means picking up a sick child from school and canceling work plans and sometimes that means staying late at work to meet a

Photograph: Kevin Stearns.

deadline. My husband Sam Flaxman is also a young faculty on the tenure track and we are fortunate enough to be in the same department. Our schedule is highly orchestrated, down to a very fine scale. Surprises wreak havoc on our beautiful plans. Then, a sense of humor helps. I am lucky to be completely in love with my job and with my family, so the entire package is my lifestyle. But, there is not much room for anything else just now.

Do you have a 'scientific hero'? This is a timely question because one of my many scientific heroes has recently passed away. Thomas Eisner's office was just next door to the graduate student office that I occupied for nearly six years at Cornell. Tom was inspirational in so many ways — his love and understanding of natural history, his elegant way of unfolding a lecture, his insatiable curiosity. Tom was an elegant and creative experimentalist, an artist, and a true pioneer in integrating across disciplines. I have to also thank Tom for encouraging me to get back to creative writing. He edited a small piece I had written about the natural history of migration. I hope to someday get back to the writing, when the time is right. Thinking back, I also found great inspiration by many of my peers during graduate school. Winters in Ithaca can be dark and long. With so few distractions around, our social networks were very much intertwined with our research. For example, one of my first collaborators was an office mate with an impressive mathematical ability. So impressive that I agreed to marry him!

What are the big questions in your field? First, another question: what is my field? My group works at the interface of behavior, genetics, ecology, evolution and physiology, so I have a hard time sorting out how to define my field. Most of what I end up doing is tied to animal behavior. I think many of the big questions in behavior, evolution and ecology are related to technological advances and integration: advances in genomics and computational biology are opening up ways to look back in time — something evolutionary biologists are obsessed with. We are getting ever closer to understanding the molecular basis of phenotype and behavior — something that will enable a closer analysis of how evolution shapes phenotypic variation within and among populations and how populations split off from one another into separate species.

Finally, what advice would you give to those just entering your field of research? The job market is grim, getting funding is extremely competitive and publishing requires endurance and patience. If you love biology, however, then pursue it fully and I mean *fully*! Hard work does pay off and this can mean working hours that would look unreasonable to someone used to a 9 to 5 position. Embrace your career as your lifestyle rather than a job and do absolutely make sure you enjoy it (or at least, most of the time). Get out of your comfort zone, talk to a lot of people in and beyond your field, read widely and make time to let your mind wander. Keep a diary so you can track your ideas and goals for the present and future. Ask: what can I get done this term? This year? What is the next set of experiments now that I have this result? What would I love to be doing within the next five years? Be open to ideas that turn your world view upside down and inside out. Keep your eyes open — in the field or lab, when you are at a conference, or just walking to get a coffee.

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Primer

Neural basis of mathematical cognition

Brian Butterworth and Vincent Walsh

The human brain has remarkable capabilities for encoding and manipulating information about quantities. Understanding how the brain carries out such number and quantity processing is a problem not just for those interested in numerical cognition: it raises important questions that are relevant to understanding development, action, vision, language, executive function and cortical organisation. It is also a clear case of research into a core human psychological function having indisputable everyday relevance; hence the emphasis in early education on numeracy and later on mathematics.

The neural system for the arithmetical aspects of mathematics has its roots in the numerical capacities of ancestral species. There is evidence that we share with a wide variety of species a capacity to respond discriminatively to numerosities. This has been demonstrated in bees, fish, reptiles, birds, rodents, elephants, monkeys and apes. Electrophysiological recordings from monkey parietal cortex suggest that there are neurons in the lateral intraparietal cortex (LIP) that respond more the more objects are presented, and neurons in the fundus of the intraparietal sulcus (IPS) that are coarsely tuned to specific numerosities. That is, one neuron will respond more strongly to, say, four objects, but also, though less strongly, to three or five. These neurons are in areas in which neurons also respond to space, time and object size; it has not been demonstrated that numerical responses are distinct from responses to these dimensions, and it has been suggested that these numerical responses are one of multiple duty responses that may be made by the same neurons.

Of course, there is much more to arithmetic than being able to