Illegal goods: Confiscated ivory items displayed ahead of the first official ivory crush held by the US Fish and Wildlife Service in 2013. (Photo: Gavin Shire/USFWS.)

harvested from African elephants, we cannot see a way by which ivory harvesting can resume and be sustainable," the authors state. However, they also acknowledge the failure of existing trade bans, admitting that "we cannot brush aside the fact that poaching has reached industrial scale fuelled by an increase in consumer demand driven by the rise of the middle class in countries like China." Ultimately, consumer behaviour is the root cause of the problem that needs to be changed.

In a drastic attempt to demonstrate that illegal ivory objects are not a good investment, several countries have staged large-scale public destruction of confiscated ivory objects. In the US, the hashtag #ivorycrush was used in a social media campaign to publicise several such events. In the first official ivory crush held in 2013, the US Fish and Wildlife Service's National Wildlife Property Repository near Denver used rock-crushing machinery to destroy a six-ton stock of confiscated elephant ivory. Since then, similar events have also been held in Times Square, New York and elsewhere in the US. Kenya has demonstrated its resolve by burning its stockpiles of ivory.

A world without megafauna?

The current poaching crisis may well be an important watershed for the surviving terrestrial megafauna, including elephants and also rhinoceroses, which are facing similar problems. In the opening speech at the Inaugural Giants Club Summit held on 29th April 2016 at Laikipia, Kenya, Save the Elephants founder Iain Douglas-Hamilton laid out his hopes and fears for the future of the animal species for which he has worked for more than half a century.

In the worst case, Douglas-Hamilton concluded, corruption and criminality could prevail over all conservation efforts, causing great damage both to wildlife and humans. In this case, he said, "I fear if killing elephants for ivory continues at the present rate that the surviving elephants become fierce and dangerous, reduced to small isolated populations, living in dense thickets, a danger to human beings and with no long-term viability. This could be an eradication of the wonderful, peaceful animals that are viewable by thousands of people from Africa and overseas who come to see them."

However, he ended on a positive note expressing that his hopes were stronger than his fears, and highlighting the case of Botswana as an example of a successful conservation programme, concluding: "I have hope that through intelligent planning, based on sound knowledge, elephants can continue to play their role in preserving Africa's great forests, and with them the water, climate and other ecosystem benefits that result from their survival."

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Q & A

Venkatesh N. Murthy

Venkatesh Murthy is Professor of Molecular & Cellular Biology and the Head Tutor of the Neurobiology concentration at Harvard University in Cambridge, MA. He has a Bachelor's degree in Mechanical Engineering from the Indian Institute of Technology, Madras (Chennai), India, a Master's in Bioengineering and a Ph.D. in Physiology & Biophysics from the University of Washington, Seattle. His doctoral work involved concerted activity in the sensorimotor cortex of behaving animals. His postdoctoral work at the Salk Institute focused on the biophysics and cell biology of synapses, a subject that occupied him in the early years as a faculty member at Harvard. In the past decade, his research group has sought to understand the algorithms and neural circuits underlying odour-guided behaviours.

What turned you on to biology in the first place? I am afraid I don't have a nice "I was always fascinated by nature and creatures from childhood" backstory. In fact, growing up in India, I don't recall having differentiated interests — I liked all subjects in school, and played music and cricket outside it. I did very well in all exams in high school and got into a very competitive engineering college, from which I graduated with zero coursework in biology. It was very common for engineering students to come to the United States for graduate school, and with a vague idea of combining biology and engineering, I ended up in Seattle. After a Masters' degree in bioengineering, I got very excited about artificial intelligence and neural networks. After a period of tinkering, I decided to study the brain and got my PhD in systems neuroscience. My introduction to biology really came during this period, and much of it was through reading and interactions with other scientists in a non-classroom setting. So, you can see that I turned to biology from an interest in intelligence in a more abstract computational sense.

Who were your key early influences? My graduate and postgraduate mentors, in different ways, have been the most influential people. My Master's thesis advisor, David Foster, took me in as I arrived from India with no clue about science, and facilitated my jittery entry into quantitative biology. He also eased my cultural transition, including me in many social events! My doctoral dissertation advisor, Eb Fetz, introduced me to computational and systems neuroscience. With his eclectic interests and enthusiasm for all things related to the brain — I recall talking to him about meditation and psychedelic drugs, in addition to brains, neural networks and motor control — he opened my eyes to the excitement of neuroscience. Finally, my two postdoctoral mentors, Chuck Stevens and Terry Sejnowski, catalysed my metamorphosis to a scientist in different ways: Chuck through long, one-on-one discussions and his elegant way of building a logical sequence of quantitative arguments starting with axiomatic assumptions (essentially a theoretical way of thinking about biology), and Terry through his encyclopaedic knowledge, his lightning-fast thinking, and his knack for gathering vibrant, sharp young scientists in his group. I feel lucky to have serially stumbled into each of these wonderful scientists. Looking back, it's interesting that all my mentors had a mathematics or physics background — perhaps not a coincidence.

Do you have a scientific hero? I am not sure I have a scientific hero in a 'love-at-first-sight' sort of way. Like so many others, I am awed by the stories and contributions of Alan Turing. If I restrict myself to my own research field, I have always been drawn to Alan Hodgkin. I admire the fact that, without fussy advertisements about interdisciplinary research, he used a wide variety of skills (physics, chemistry, biology, designing and building measuring instruments, mathematical modelling) in the service of figuring out a fundamental biological phenomenon.

Photo by Rick Friedman.

Do you have a favourite paper or science book? I am very fond of Valentino Braitenberg's little monograph "*Vehicles*". I read it for the first time around 1989, when I was just getting interested in intelligence and brains. In this plainly-written and simply-illustrated book, Braitenberg builds (conceptual) toy vehicles to show how complex behaviours can arise from rather simple design principles. You may come away thinking it's all obvious, but you will come away thinking.

If you would not have made it as a scientist, what would you have become? Sadly, I am not sure. I shudder to think it might have been some unimaginative, white collar job in software or tech. I feel lucky to make a living doing what I do!

What has been your biggest mistake? Taking myself too seriously on occasion.

Do you feel a push towards more applied science — if so, how does that affect your own work? Yes, but for me, it has been mainly in terms of getting research support. I have felt very little external push in that direction when I actually do my work, or when publishing it. I get the sense that this might change soon, since so much funding in biology is heading towards biomedical applications. My own infrequent involvement in translational projects has been educational and rewarding. I have no doubt that the newer generation of biologists has to face greater challenges in balancing basic and applied science. Hopefully, each scientist can find her own balance, without deriding either aspect.

Do you think there is an increased need for scientists to market themselves and their science as 'a brand'? I am not sure there is a need, but there is money (grants or gifts from private sources) and exposure (publicity from popular science pieces and social media) to be had, and scientists that are alert to this availability seem to benefit in many ways. The idealist in me cringes at this marketing idea, the realist in me accepts it, and the cynic in me smirks.

Do you believe there is a need for more crosstalk between biological disciplines? Of course yes, but I am a bit puzzled that this issue comes up at all. I have always thought that everyone should learn as much as possible to answer the questions they are interested in and talk to others as needed. Alan Hodgkin, mentioned above, is a case in point. Shouldn't the focus be simply on questions, which then are addressed using the best methods and tools available? I feel that true interdisciplinary work just happens naturally, without any top-down enforcement.

What do you think about post-publication peer review of papers? We should definitely do more to encourage post-publication peer review. There are now enough examples of this method working to rapidly uncover problems or confirm important findings. There is some worry that a small group of narcissists with time on their hands and axes to grind will overwhelm any 'comments' section for a published paper — but I hope this issue will get sorted out communally. A different worry that nags me is this: if publicity starts right after a preprint goes live, before any peer review has occurred, how can one reverse or retract media attention if problems arise with a preprint? Perhaps this is a larger issue of the relation between the press/media and science.

Any strong views on social media and science — for example, the role of science blogs in critiquing published papers? I think scientists really ought to embrace these and participate in them. I would only beseech the participants to avoid conveying and accepting superficial impressions, and force themselves to be as careful as they can be in their writing.

Which aspect of science would you wish the general public knew more about? I wish there would be sustained emphasis on science as a process and as a way of understanding the world, rather than simple advertisement of applications and cures. I realize the inherent difficulty of the endeavour, but I think it should be brought up more often. I suspect the public is much more eager to share the excitement of science than we give them credit for — if we can get them to be so excited about black holes and gravitational waves (which have no immediate practical value, but are of immense value in understanding nature), why not also about the basic discoveries in biology?

Do you think there is too much emphasis on big data-gathering collaborations as opposed to hypothesis-driven research by small groups? Like everything else, it is a question of balance. I think coordinated large-scale data collection is clearly important for some things. But which things? Almost any question can be rephrased to set us off on a voyage to collect big data. Prominent biologists that advocate such huge projects have been commanding attention because they appear to have big ideas and are tackling big questions. With finite resources, a balance must be set between such large scale efforts and support for projects that are commensurate with smaller individual groups. I would be very sad if small scale, individual labs go out of business. It is always dangerous to make analogies, but a healthy middle class seems important for the intellectual economy, where ideas and knowledge are the commodities.

What about theory in biology? Several disciplines in biology have warmed up to theory, including my field of neuroscience. I think having smart people thinking full-time about theory is incredibly important. Theories are always going to be imperfect or wrong, but they offer explanations and drive experiments. It is also important to distinguish theory from computational work done in the pursuit of data fitting or analysis. The most pressing step in integrating theory into biology, in my opinion, is creating more faculty positions for pure theorists (and not just for those that do both experiments and theory). We should value theorists with broad interests, without expecting them to only work on a single theme or subject.

What do you think are the biggest problems science as a whole is facing today? I think a big challenge moving forward is to find ways to reward and sustain sheer curiosity and ingenuity, even if the problems being addressed may not seem big or broad at present. Not everything needs to be overtly about saving the world or making money.

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Quick guide

Tetrodotoxin

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What is tetrodotoxin? Tetrodotoxin (TTX) is a potent neurotoxin known from a wide array of taxonomic animal groups from almost all over the world. This toxin was first detected in puffer fishes of the family Tetraodontidae, which is where the name tetrodotoxin was derived from more than 100 years ago. However, the effects of TTX have been known for over 5,000 years in some cultures, largely due to human consumption of species with TTX, like puffer fishes. In Japan, puffer fish is considered a 'delicacy', called *fugu,* which occasionally causes serious intoxication, and even death if not prepared for consumption correctly. TTX can enter the body by injection, ingestion, inhalation, or via abraded skin. The oral LD_{50} (i.e. the median lethal dose in test organisms) in mice is 334 μg/kg; in a 75 kg human this would be equivalent to 0.765 mg, thus making TTX 10,000 times more poisonous than cyanide. TTX blocks the pore region of fast voltage-gated sodium channels, thereby blocking stimulus conduction and causing general paresthesia with neuromuscular and pulmonary symptoms.

Which animals contain TTX? TTX is known from almost 140 animal species, belonging to various groups of both protostomians and deuterostomians (Figure 1). In most of these species, TTX has only been detected in recent years. The protostomians account for about one third of all TTX-containing species, and TTX is found in all of its three main groups: lophotrochozoans, ecdysozoans, and arrowworms (Chaetognatha). In the Lophotrochozoa, TTX mainly occurs in mollusks (snails, bivalves, and octopuses), but it has likewise been detected in flatworms and ribbonworms. Most of the ca. 10 ecdysozoan species with TTX belong to the Pancrustacea, of which most are nominal 'crustaceans'; a caddisfly