for electrons, quarks and the Higgs boson when physicists measure things in the ways that they typically do. Conceptual tools are not inert — they are necessary for the proper workings of science. Whether or not Pluto is categorized as a planet or a 'planetoid' determines whether what is known about Pluto becomes part of the accumulated body of scientific knowledge about planets that is then inductively generalized to form hypotheses about other planets.

So what's the problem when it comes to the science of emotion? For a start, scientists often use common-sense concepts to guide their definition of a functional state, so a mature science of emotion based on natural kind assumptions is at risk of being a sort of fancy folk psychology approach to understanding emotions that won't bring us any closer to improving drug discovery or building emotive robots. More importantly, research shows that the inferred functions for fear (or anger or any other emotion category named in English) vary by context and person. Folk concepts of emotion also differ substantially across cultures. These observations imply that a functional approach may be ill-suited to build a universal science of emotion that applies to all humans, let alone to all creatures on the planet.

Whether or not you agree with the ontological commitments that are offered by Adolphs and Anderson, *The Neuroscience of Emotion* is definitely worth reading. It's the best articulation that I've seen of this point of view in the science of emotion. Just realize that what you take away from the book depends on the assumptions that you bring to it. For me, the book was a thought-provoking journey. (My copy is filled with marginalia.) It is also a reminder that, as scientists, we always view our subject matter through the somewhat foggy lenses of our own, very human experiences, whether we realize it or not. And so, we are never quite as objective as we hope.

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Q & A

Julius Lukeš

Julius (aka Jula) Lukeš is currently Director of the Institute of Parasitology at the Biology Centre of the Czech Academy of Sciences and Professor of the Faculty of Natural Sciences at the University of South Bohemia in České Budějovice (Budweis), Czech Republic. He studied at Charles University in Prague between 1981 and 1986, and he conducted his postdoctoral research at the University of Amsterdam from 1993 to 1994 and at the University of California in Riverside and Los Angeles from 1997 to 1999. His lab has broad interests in functional and comparative genomics as well as in the morphology and evolution of single-celled eukaryotes (protists). He was a Senior Fellow of the Canadian Institute for Advanced Research, is a member of the Learned Society of the Czech Republic, and has been elected as a Fellow of the European and American Societies for Microbiology and the American Association for the Advancement of Science.

Did you have an interest in biology from an early age? I come from a Czech–German family of butchers that used the name Lukeš for Czech customers and Lukesch for the German and Jewish ones. Before the takeover of Czechoslovakia by the communists in 1948, my forebears won several prizes for the best ham in the world. However, since my father knew animals only from this perspective, he was rather surprised by my intense childhood interest in biology and only after some hesitation decided to fully support me. From his perspective, it was an advantage that biology was apolitical (except in the case of Lysenko and a few others) and therefore could function as a meaningful hideaway in the gray and ever penetrating 'real socialism' of my youth. And indeed it was. Although I was not even supposed to be admitted into secondary school, due to my origin from a capitalist family, I was lucky that the regime was already melting by that time. I even made it to the coveted academic destination

of the Charles University in Prague. Later on, after the fall of the Iron Curtain in 1989, my father wanted me to go back to the centuries-old family business, and this made a lot of sense in the years of close-to-zero funding and in view of a generally bleak future for Czech science in the 90s. Yet, by that time, science was already my dream job and I never once seriously considered giving it up.

If you had not made it as a scientist, what would you have become? If communists had not taken over our country, we would have kept our family business. Quite likely, I would not have had any other choice than to become a butcher.

What drew you to your specific field of research? In retrospect, the motivation was somewhat strange: it was the liberal, pro-Western oriented atmosphere of the parasitology group at Charles University in the early 80s. Soon, though, this motivation was backed by a genuine interest in parasites and their hidden omnipresence, complex lifestyles, and the unlimited 'wickedness' of which they are capable. I primarily study trypanosomes, which are responsible for African sleeping sickness. Their vector, the tsetse fly, spits only a few dozen trypanosomes into human blood, yet these parasites virtually always win, despite billions of host cells and sophisticated mechanisms arraying against them.

Who were your key early influences? First, there was Rob Benne, a Dutch molecular biologist who, during my first stay in the West at the University of Amsterdam, confirmed what I had much hoped: that almost unlimited freedom, lack of hierarchy, irony, self-deprecation, and deeply critical evaluation of the data are all indispensable for good science. Second, there was Jiří Vávra, a Czech old-timer who taught me to love single-celled eukaryotes. He remained totally enthusiastic about science until the end and always enjoyed talking about new findings and the bright future of knowledge: this is reflected in the fact that he submitted a paper two days before his death at the age of 86.

Do you have a favorite science book? I love reading Stephen Jay Gould's books. His stories are smart, witty and written in a colorful language. I particularly enjoyed *Wonderful Life*, *Eight Little Piggies*, and *The Lying Stones of Marrakech*.

What is the best advice you've been given? It was from my father. He told me to never go with the crowd, with one exception: when you are facing a firing squad down the road.

What would be your advice to young scientists? The long experience of living in 'real socialism' has taught me some lessons. One of them is to avoid any dogmatism or populism: in other words, simple solutions usually don't work, both in life and science. Be scientifically correct but not necessarily politically correct. A world where scientists are not 'being defined' and are instead 'defining' is the better one.

Which aspect of science, your field or in general, do you wish the general public knew more about? I am trying to popularize science as much as I can and encourage my colleagues to do so as well. There are so many things that the general public should know (and, surprisingly, is eager to know…). For one, protists represent ~70% of all extant eukaryotic diversity, yet a large majority of what we know about eukaryotic cell biology comes from just one group of mostly macroscopic eukaryotes: the Opisthokonta. An almost untapped fountain of biological diversity is still hidden in these unicellular forms of life. And even more importantly, they contribute to the well-being of our planet much more than we had previously anticipated. Some are extremely abundant, literally in every milligram of soil and milliliter of sea water, yet you could easily count the number of labs that study them on one hand. Indeed, marine protists produce a substantial amount of the world's oxygen. We know close to nothing about them, and the number of scientists that study them is still very small. So it is simple: protists have to be studied much more! And the public should be more aware of their importance.

What do you think is the big question to be answered next in your field? Previous generations (as well as my own) of parasitologists, epidemiologists, and medical doctors virtually eradicated human intestinal parasites from the economically wealthy countries, and this was, until recently, regarded as a great achievement. Yet, in the meantime, our intestinal microbiomes became unobtrusively altered, as nicely described in Martin Blaser's *Missing Microbes* and by current, intense research on bacteria inhabiting our bodies. I believe that, in the future, some of those wiped-out human intestinal parasites should be brought 'back', but the big question is how to achieve this goal. It is already pretty clear that, in the new context of well-fed, immunologically naive and microbially deprived Westerners, the benefits of these parasites will easily outweigh their drawbacks. I am doing my share in this effort by infecting myself with different parasites, which in the context of my body indeed behave (so far…) as commensals.

What do you think are the biggest problems science as a whole is facing today? In the 21st century, science is having a larger impact on humankind than ever before. Scientists have better conditions for their work, and there are more scientists now than there have been throughout history. And this is all great. However, with all the exponentially growing knowledge, and with the well-being of humankind and this planet more dependent on that knowledge than ever, we face one unexpected (at least for me) development: the relativization of demonstrable truth and 'alternative facts'. I believe that the rigorous methodology of science has a lot to teach society as a whole. If you cheat, you will be caught more efficiently in science than in other endeavors. Thus, it is imperative — now more than ever — that scientists engage with the public by going on television and debate with and write for the public. If scientists will not provide space for qualified discussions, others will do it for us.

Another danger is the spreading of bureaucracy, with ever expanding rules, laws, measures, precautions, and 'recommendations'. There is a fast growing business of regulators watching over scientists — rules around GMO, radioactivity, dangerous chemicals, transportation to and from developing countries, gender, race, age, and other 'equalities', and the increasing complexity of using animal models to the point when people give up, even in cases where there is no replacement for them. This all gets to the point when a supervising or regulatory body begins to steadily issue new rules. Young scientists don't want to risk a conflict, usually owing to feelings of vulnerability and because they have to fight so many other battles just to stay afloat, and senior investigators don't care or don't want to bother, so useless regulations pass and sooner or later become accepted. Yet we as scientists should question the value of these regulations and not just complain about them to colleagues over a beer at a meeting when the regulations seem silly. Rules and recommendations are of course important and unavoidable in our increasingly complex societies, but I am perhaps more sensitive to them because of my years spent in 'real socialism'; there were plenty of stupid rules and, to retain self-respect, one had to disobey some of them.

Perhaps the last example is an unwise (to put it politely) decision of

the European Court of Justice from summer 2018 that all plants prepared by CRISPR–Cas technology have to be treated as GMOs and are subject to all corresponding draconic rules from 2001. Traditional breeding methods, which induce thousands of random mutations, are just fine, while the surgically exact and controlled method is wrong: a decision with enormous consequences, made by ignoramuses. Experts on the subject — and Europe has so many of them — had apparently little influence in this ruling and started fighting it only recently, in what will be a protracted battle with a highly questionable outcome.

What is your greatest research ambition? My ambition is to help take Czech science back to the position it used to occupy before the communists took over, with respected, competitive, and internationalized research that is happening not only in Prague but also across the country and comparable with that of similarly sized countries, such as neighboring Austria. I am glad to see that it is slowly and steadily happening. I had just hoped that it would happen faster.

There is another one: to help protect disciplines in which Czech science is historically strong, such as classical taxonomy, microscopy, training in field work, and so on. Many of these disciplines have almost been wiped out in the West as obsolete, yet, now when the technology makes a complete genome of an organism relatively easily available, there may not be a specialist around that can connect the new data with known biology of that organism from the pre-molecular era. This may actually prove to be a benefit to Czech scientists, as long as there is a delay in adopting such general trends.

What's your favorite experiment? Probably the one performed by Matthew Meselson and Franklin Stahl in 1958 in which they showed by an ingenious approach that the double helix is always composed of one old and one newly synthesized strand. This was a true milestone in molecular biology and, based on his memoires, one that kept Richard Feynman at Caltech, as he thought "there is no way this can happen anywhere else". Sadly, at the same time in my country and elsewhere in the Soviet camp, the communists banned the teaching of the key laws of heredity formulated by Gregor Mendel; the irony being that Mendel's theories were formulated a century earlier in Moravia in the Czech Republic.

What are your passions in life? I have many. These include classical music and classical paintings, jogging, and most of all travelling. So far, I have visited 99 countries and have enjoyed putting into context what I have read about them in decades-old accounts. In the often forgotten travel journals of Leigh Fermor, Moorehead, Thesiger, Naipaul, Gunther, Theroux, and others, one can find not only a lot of wisdom but also explanations of why some countries now look the way they do.

Do you feel a push toward more applied science? How does that affect your own work? When I finished my PhD in 1991, science in Czechia was moribund; most young people left it for jobs in pharma and other companies that payed several times better. Things improved significantly around 2000 and even more after we joined the EU in 2004. At that time there was little competition: as long as you had decent publications and had taught some students, your chances of getting funding were pretty good. There was also complete freedom to study whatever we chose. No one regulated science and in hindsight it was perhaps quite similar to science in the US in the 60s and 70s. This is changing. All the current trends, including the push toward applied science, that occur in Western Europe eventually reach us with some delay. Fortunately, we are still enjoying a lot of freedom and increasing funding, and I am pleased to see more beautiful papers coming out of the Czech labs.

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Quick guide

Appressoria

Nicholas J. Talbot

What are appressoria? Appressoria are specialised infection structures used by many disease-causing microorganisms to breach the outer surface of a host plant or animal, and thereby gain entry to internal tissues. Appressoria are made by a wide range of disease-causing microbes — and even by parasitic plants — and they come in many different shapes and sizes. They are, however, best known in plant pathogenic fungi, in which appressoria have been most intensively studied because of their importance to some of the most devastating diseases affecting world agriculture. Appressoria are necessary for rusts, powdery mildews and blast diseases, which affect the major cereal crops of the world, as well as devastating oomycete diseases like potato late blight.

The term *appressorium* was first introduced in 1883 by Frank, who described "spore-like organs of the fungal pathogens of plants". Frank believed that appressoria were adhesive discs that allowed a fungus to attach tightly to the leaf surface, but it later became clear that appressoria were actually required by many pathogens to break through the tough outer layer of plants.

Appressoria can be unicellular (often swollen or hemispherical cells) or more elaborate multicellular structures, sometimes called 'infection cushions' (Figure 1). In all cases, appressoria adhere tightly to the host surface, using adhesives or mucilage to hold them firmly in place. Attachment is followed by enzymatic action, physical force — or a combination of both — to rupture the host surface.

In fact, some appressoria can apply enormous physical force to breach the outer surface of plants. This was first predicted in 1895 by Miyoshi, who calculated the forces required to invade plant tissues, Miyoshi's estimates were confirmed experimentally by the classic 'gold leaf experiment' performed by Brown and Harvey in 1927. Ingeniously, they wrapped the leaf of a plant in a thin layer of gold leaf (the same material