

# Discurso de Antoine Kremer

*Doctor honoris causa por la UPM*

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I am deeply honored and humbled to receive the doctor 'honoris causa' distinction of the Universidad Politécnica de Madrid. I would like to express my sincere appreciation to the University for this honour. I am moved by the solemnity of this ceremony and feel somehow embarrassed to disrupt this solemnity by continuing my presentation in a different language. Sadly I am not fluent in Spanish, and prefer to continue in the so called international scientific tongue, English.

Before I start my talk, I would like to thank Dr Luis Gil for the introduction and the laudatio, and all those that were instrumental in my nomination. I would like to mention that this ceremony today celebrates also years of transeuropean cooperation. My research and own accomplishments have their roots in collaborative research, and we would not be here today if I had not benefited from continuous collaboration with colleagues of different European countries that joined their efforts and resources to study the evolution and fate of forest trees across Europe. In this regard, I am pleased that colleagues from Spain were able to attend this ceremony, and I like to take this opportunity to acknowledge their contributions to this research.

My talk today is about the « Greatest Show on Earth». I am quoting a famous popular science writer in Biology, Richard Dawkins, by using the title of one of his book, published in 2009. So what is the "Greatest Show on Earth"? The show takes place everywhere on Earth, within each society, community, living organisms at every minute and yet we will not see it in most cases. So what can it be? The reason why we do not see it is that it develops in slow motion in most cases, or when it is rapid motion it occurs at such a small scale that human eyes cannot notice it. Yet we are all actors of the show, when I say WE, I mean we as human beings or more generally we as living organisms. So what is it??

The title of the show is "Evolution", I mean biological evolution sensu Darwin. The scene of the show is the planet and the actors, as already mentioned are all living organism. And the show is continuously going on. Lets just take a very short glimpse on it. At the second I am talking, there is more than one mutation that occurs by chance in the DNA molecule of a given individual in a given species. This mutation has some additional chance to be propagated by reproduction to other individuals within the same

species, and it might well be that the mutation will invade the whole species and transmit a given attribute. To make it short, a mutation is a random error during DNA replication that may have some effect on the individual carrying it. It is also a new variation in the genetic make up of a species. And mutations are steadily being produced, admittedly at a very slow rate, which we call a molecular clock. There are of course other sources for genetic changes in a species, like gene communication via dispersion, hybridization among species etc. Taken all together, these subtle changes are the necessary ingredients so that the show takes place. Let's just imagine that there is an environmental crisis, or some changes in the outside world, not all individuals in the species will be able to survive or sustain the environmental crisis. But if the species has accumulated many mutations, then the chances are much higher that at least some individuals will survive, and will be the source for the next generations. And if these survival individuals share some specific attributes, the next generation will share these attributes and your species has changed has evolved and in some cases has adapted. So these are the sequences of the show, each time there is major event occurring as a result of evolution: a new species, a new attribute in a populations that is acquired, we got a new sequence of the show!! Now we may better understand why the show is universal, and why in most cases we do not see it. It is going since million of years and has produced the overwhelming biodiversity that exist on earth. Now we may raise the question on the ultimate aim of the show? Whether I am a frog, whether I am virus, whether I am a whale or a tree, we are all playing the same show. Why are all the living species on earth playing this show? And we all share one single goal: to survive, to maintain the species we belong to, to ensure demographic success regardless of the constraints , stresses that the species may face during its lifetime, to exist for ever!!

I spent my career understanding the show of the oaks (*Quercus*, Roble, Encina), and tried to get some sense out of their show. I tried to understand the peculiar strategies that allow this tree species to achieve its goal, to survive and to sustain environmental crisis since they exist since more than 60 million years. A simple glimpse to where the oaks exist today sets the scene very rapidly: they are all over the place across the northern hemisphere, more than 400 species, growing from the equator to the boreal region, from the sea level to high altitudes in the tropics, from deserts to wetlands. This picture corresponds to what we can call an "evolutionary success". Surely they would have received an Oscar!! So my scientific queries were quite obvious: how did the oaks achieve their success? And will they be able to continue the success story, today and in the future?

To understand the causes of their success, I will employ a metaphor. I will try to make a comparison between their show and ours, I mean the show of the human species. Working during decades on the same species, it becomes almost unavoidable to compare the species one is studying with the species one belongs to. As I did just indicate, all species play their show having the same aim. So let's make a comparison between *Quercus* and *Homo*. At the first glance the comparison may seem awkward, isn't that comparing apples and oranges. It makes sense from an evolutionary standpoint, since all living species share the same ultimate goal. Let's see how two of them manage to complete their goal. This comparison very nicely illustrates the different evolutionary strategies that different species adopted to ensure survival and demographic success.

Let's start with the ingredients of the show, the fuel that's feeds evolution: Diversity, I mean genetic diversity. Recall that it is the genetic differences that exist within a species that allow evolution to occur. The more differences there are the higher the

chances that a species evolves. Now how much genetic differences are there between oak trees, and between human beings. It was impossible to answer this question some years ago. How do you compare differences between two persons, and differences between two oak trees? But now we are able to compare the universal genetic information that codes for our morphology and physiology. All living beings share a universal code which is within the DNA molecule. And since recently we are able to measure the differences between any living beings, between two trees as well as between two human beings by using the same universal metric, the DNA sequence!! So if I compare two trees taken at random in a given population, they have 4 to 10 times more differences in their DNA than two human persons taken at random for example in our assembly. Nobody would ever have guessed that? Trees look all alike. But that is not the case. They exhibit enormous diversity. It is of course a heritage of their history. As I just indicated earlier diversity accumulates over time as mutations occur at a constant rate. The differences between oaks and humans, is that oaks do not lose their diversity, and they have more means to enrich it. So based on the level of diversity, trees would be more prone to evolution than human beings.

This brings me to a second feature or property that differentiates humans and oaks: gene exchange between living beings, as a mean to enrich diversity. It is intuitively understandable that the more interbreeding there is between individuals of a species, particularly if the two individuals come from two different populations, the more diversity is enriched. The enrichment will be highest when the interbreeding takes place between two species, in other words when species hybridization takes place. It is well known, and I have been studying this over the years, oak species can easily cross with other related species, and this is so common in oaks that it became a nightmare for oak taxonomy. From an evolutionary stand point, hybridization is a way to overcome severe stresses, by benefiting from genes of another species. Not only that, we have also shown that hybridization is a mechanism accelerating the spread and dispersion of the species. Now let's examine hybridization in the human species. This may seem incongruous. Well there is only one species nowadays in the genus homo. So by construction, we are out of the play, the human species is ill equipped here. But it might be our own fault. It wasn't like this in earlier times. There were more human species long time ago, and there are studies and reports indicating that intercrosses among species occurred indeed by Homo sapiens and Homo Neanderthal. So here humans are clearly missing a mechanism facilitating adaptation and evolution. I am not raising the issue of why our companion species disappeared, and actually if homo sapiens was responsible for that. It is out of the scope of this comparison. But we have certainly lost a very efficient evolutionary mechanism to escape or adapt to severe environmental crisis, which is interspecific hybridization.

Now let's make a third comparison between Homo and Quercus. Let's consider demography, and population size. It is useless to raise here the evolutionary benefit of being very many. The more numerous a species is, the higher the chances to survive. I made a very rough comparison considering oaks and people living in France: we are currently 66 million French people. And there are approximately 9 billion oak trees in France. The difference here is obvious.

This was a very crude comparison on the different strategies that species may adopt, or that they have acquired during their history to overcome environmental crisis and ensure species maintenance. It is a bit unfair as I have only considered properties that are at the advantages at the oak side. To be completely fair I should also consider properties that are more at the advantage to the human side, particularly its

outstanding capacity to make use of natural resources or domesticate other living organisms to its own benefit.

But yet overall, I am not sure that homo sapiens would be the winner in this comparison regarding their evolutionary success. There are probably more chances that oak trees would survive longer than our own species, given the evolutionary strategies and resources they are equipped with. While we, eg human scientists, organize workshops and meetings on the “conservation of oak genetic resources”, it would probably be preferable that oaks get together and discuss on how to “maintain the human species”. This may sound like a funny and awkward statement, but it did already occur during history. Not that oak trees organized conferences about the future of the human species, but it happened that oaks saved the human species from starvation; it happened that oaks contributed to the survival of the human species. Indeed there were times back in history when acorns were the main component of the human diet in Europe.

This comparison between oaks and humans was a nice metaphor to illustrate the universality of Evolution, and ways to achieve evolutionary success. Evolution is best known for what is called “Macroevolution”, the birth and death of new species over ages and biological history. But it proceeds every second, every minute at a narrow time scale which is also called “microevolution”, e.g. the changes that occur within one species, or within different populations of a given species. This is the scale at which I have been following the “oak show” since a few decades, by looking backwards in time but also by considering future times. Although today’s picture clearly suggest that oaks were quite successful by colonizing most of the northern hemisphere, times were much more difficult in the past. Indeed extinction occurred some 2-3 million years ago when the first glacial-interglacial periods came into place. Not all species were able to migrate back and forth along glacial-interglacial periods, and some tree species and oaks just disappeared particularly in Europe. Today there are only 20 oak species in Europe, whereas there are several hundred in North America and Asia. Europe has clearly been depauperated in diversity. And this might be of some concern for the future. So let’s examine today’s show to make some prediction about the future. More than ever the “show goes on” even a much rapider speed than at any time before. Ever since Christoph Columbus, biological diversity has been reshuffled around by human transport and communication. We grow more plants from other continents that ever before. And this is the case also for trees. We have imported oak species from North America and Asia. And some of our species have also been planted in other continents. I have seen oaks in Australia and New Zealand where there is no natural growing oak species. Of course this reshuffling has not been conceptually designed for feeding Evolution. But these are the facts. The facts suggest also that natural “migration” has been accelerated due to environmental changes. Trees and particularly oak from southern Europe, from Spain will progressively migrate northwards as the climate gets warmer and meet some of the temperate local oaks. And guess what’s gonna happen ? Temperate oak trees will mate with mediterranean oaks, and benefit from the genes that will facilitate adaptation to drier climates. By predicting these outcomes, I am coming to a critical point of my talk, which is precisely the prediction of the next steps of the show. It would be highly risky to predict the next scenes of the show. We know some of the ingredients that I just recalled, which are the natural and human mediated redistribution of diversity across the globe. In the same time a new diversity builds up, new environmental crisis have occurred as well. Human activities during the past centuries have induced climate change and generated new selection filters for trees, and we already know some of the extreme outcomes as species extinction for some species. This has not yet occurred in the case of tree species, in

Europe. And hopefully it will not. But I will not be able to tell who will be the winner during the ongoing environmental crisis. I am not talking winner between oaks and humans as I did earlier in my talk, but between temperate and Mediterranean oaks, between broadleaves and conifers, between fir, spruce, beech etc. Depending on where you are, there will be one or more winners, but you have to follow the show today, tomorrow in ten or several decades from now to understand the secrets of the "Greatest Show on Earth".

Thank you again for giving me the honor to be here today. I am deeply humbled to receive the recognition and distinction from your University.