Darwin, 'The Origin' and the future of biology
150th Anniversary of the publication of Charles Darwin's On the Origin of Species

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GERALD LIMOTH: So perhaps I can welcome you all here. And it's great to have such a distinguished audience here for this remarkable occasion on a remarkable day. I'm Gerald Limoth and it's my privilege to chair the British Council.

And it's our great pleasure to have been involved in this occasion today. No one in this room needs telling today is 150th anniversary of the publication 'On The Origin of Species' just down the road here by Joan Murray. And it's a very special day in a very special place. This is the room where T.H. Huxley gave the first lecture. So this is a very memorable occasion. Sadly, as I think you all know, Edward O. Wilson can't join us. He's got pneumonia, which is a real shame. But even off his sick bed, he has agreed to-- he's recorded his lecture and you'll see it up there in a moment. So we're very, very grateful to him for doing that for us, even though as I say, he's got pneumonia and he's really not very well.

But it is nevertheless a great pleasure as it were to have him with us in spirit and a sort of disembodied way. He needs no introduction from me. But his work, his most recent book, which I guess you've read on the creation, is a fantastic read and a defence, more than a defence, I think, a real energizing statement about life and its diversity.

And I think it's right to say that Charles Darwin himself described the 'Origin of Species' as the mystery of mysteries. And we are delighted at the British Council that we have been involved in a large project now going on for many months called 'Darwin Now', which not exactly culminated, but on which we had a big event in Alexandria, which a number of people here were present at to talk about the extremely hot debate around evolution and Darwin, not just in relation to science, but also in relation to philosophy and history and so on.

So we're very pleased at the Council, we've taken to ourselves the purpose of playing a small role, if we can, in public education about science as part of our wider purpose of enhancing Britain's reputation, but also building relationships around the world.

So it is a real pleasure for us to have been involved in this whole effort, not just today. And I want to thank my own team at the British Council for their work on this, but also to thank Professor Almond Laura who's going to chair the panel debate after the lecture. He'll introduce all the other panel members, but perhaps I can thank them in advance for their efforts.

I have one housekeeping thing to say, which is could you please turn off your mobile phones. And if you don't, you'll be fined, and the proceeds will be given to the British Council. You have been warned. So without further ado then, it's my enormous pleasure to queue the video of Professor Wilson. Thanks very much.

[APPLAUSE]

PROFESSOR WILSON: I deeply regret that due to the last lingering effects of pneumonia, I'm not going to be able to be with you physically at the celebration at this place of the most important day in the history of science.

When I was asked by the British Council to give this brief introduction, I considered it, and even by video I always will consider it a high moment of my life. And for that, I'm very grateful. In 1869, 10 years after the publication of the 'Origin of Species', Darwin wrote his close friend the great botanist Joseph Hooker as follows. If I live 20 more years and was able to work, how I should have to modify the origin, and how much the views on all points will have to be modified.

Well, it is a beginning, and that is something. Darwin lived 13 more years after writing that letter to Hooker. And he did manage to modify the theory of evolution by natural selection by expanding it in the descent of man in 1871 to include human origins, and then the expression of the emotion in man and animals in 1872 to address the evolution of instinct.
And thus, if we add his first book, 'The Voyage of the Beagle', was completed, what can be fairly called the four great books of Darwin. Although, he authored many other influential articles and books during his career.

Great scientific discoveries are like sunrises. They illuminate first the steeples of the unknown, then it's dark hollows. The four major books have spread light not just on the living world, but fundamentally the human condition. They have not lost their freshness more than any other work in history scientific canon, they are both timeless and persistently inspirational. The 150 years ensuing after the publication of the Origin has been a time of enormous growth of the Darwin heritage, joined with molecular and cellular molecular biology that accumulated together knowledge that is today the substance of biology.

Its centrality justifies the famous remark made by the evolutionary geneticist Theodosia Stojanovski, the foremost of the modern synthesizers of the 20th century. He said famously in 1973, nothing in biology makes sense, except in the light of evolution. In fact, nothing in science as a whole has been more firmly established by interwoven factual information, or more illuminating than the universal occurrence of biological evolution.

Further, few natural processes have been more convincingly explained by evolution through natural selection or as it's popularly called 'Still Darwinism'. The four books of Darwin, when read as a set, chronologically flow as a well-wrote narrative tracing the development of Darwin's thought across almost all of his adult life.

The first 'Voyage of the Beagle' is one of literature's great travel books. It's richly stocked with observations of the kind that were to guide the young Darwin and his evolutionary worldview. Next comes what he called 'The One Long Argument'. There are for evolution by natural selection. Arguably, and I believe, history's most intellectually important book if judged on a global scale of impact.

The 'Descent of Man' then addresses the burning topic foretold in the 'Origin of Species' when Darwin ventures electronically the light will be shown on the origin of man and its history. By the time of the writing of the Descent, Darwin was confident that natural selection would prevail. And he delivers his conclusions forthrightly.

And finally, in the expression of the emotions in 'Man and Animals', Darwin draws close to the heart of the matter that concerns us all as a species, the origin and nature of mind, what Darwin call the citadel that he could see, but knew the science at the time could not conquer. The chronicle Darwin's life in the four great books was a script for genius. It began in 'The Voyage of the Beagle'. The ship was commissioned by the British government to conduct a coast and geodetic survey around South America. It took five years from 1831 to 1836, and ended up circumnavigating the globe.

I ask you to imagine for a 21-year-old man newly escaped from Cambridge University to leave for 5 years and suffer no television, no radio, no newspapers, no contact of any kind, except months old letters delivered at infrequent ports of call, now set before him is something far better, an unexplored world to navigate and record for history with unimaginable discoveries awaiting at every turn.

For a young naturalist launched upon such a great voyage, and the vast majority of the plants and animals on Earth still unknown in science. With all of the specimens, he could collect valuable to science, and with all of the observations he made worth recording, and not less,

not least with no duties, except gentlemen companions of the captain and the ship's naturalist the world was Charles Darwin to possess.

Then after a long gestation came on the 'Origin of Species'. Evolution by natural selection is perhaps the only one true law unique to biological systems, as opposed to non-living, physical systems. And in recent decades, it has taken on the solidity of a mathematical theorem.
It states, to put it an extremely simple terms, that if a population of organisms contains multiple hereditary variants and some trait, say red eyes versus blue eyes in some bird population, and if one of these variants succeeds in contributing more offspring, breeding offspring to the next generation than the other variants, the overall composition of the population changes, and evolution has occurred.

And if new genetic variants appear regularly in the population by mutation or integration, evolution never end. The full importance of Darwin's theory can be better understood by recognizing that modern biology is guided by two overwhelmingly powerful and creative ideas. The first is that all biological processes are ultimately obedient too, even though far from fully explained by the laws of physics and chemistry. The second is that all biological processes arose through the evolution by the process of natural selection. The first principle is concerned with the how of biology, how the machine of the organism works.

The second is concerned with the ways the system is adapted to the environment over periods of time long enough for evolution to occur. In other words, the why of biology. Knowledge addressing the first principle is called functional biology, and that addressing the second principle is called evolutionary biology.

If a moving automobile were an organism, functional biology would explain how it is constructed and operates. By evolutionary biology with reconstruction reconstruct its origin and history how it came to be made and its journey thus far.

The impact of the theory of evolution by natural selection nowadays grown very sophisticated at all levels of biological organization from molecules and cell up to ecosystem has been profound. And its implications have reached to all of life and all dimensions of human existence, to the extent that it can be upheld. And the evidence to date has done so compellingly.

We must conclude that life has diversified on Earth autonomously without any kind of external guidance. Evolution in a pure Darwinian world has no goal or purpose external to itself. The exclusive driving force is random mutation sorted out by natural selection from one generation to the next.

We are on our own, it implies. We are one with a biosphere, but we are also free, thus wholly the masters of our own fate. That is the central philosophical contribution of the 'Origin of Species'. 12 years after on the 'Origin of Species' was published, Darwin in the 'Descent of Man' dropped the other shoe.

Victorian society whose wrath Darwin had so feared as to hold back the publication of the Origin until 1815 mine might not have been entirely scandalized by the descent of plants and animals, but they were quite unprepared to accept the descent of man from, as Darwin put it, delicately put it, some pre-existing form.

And they were most certainly scandalized at the idea of apes as ancestors, as the evidence unfortunately for Victorian society suggested from the very start, yet Darwin had to take that step. It was implicit from the premise that evolution is universal.

The indelible stamp of evolution, as he called it, is everywhere to be seen in human anatomy, and all we know is its evolution. In 1871, Darwin and other evolutionists lack the smoking gun. There was no fossil evidence. A century of research, however, has turned up an abundance of pre-human and early human remains enough to establish the broad outline and many of the early details of the origin of our own species.

The family of man, as it turns out, and Darwin guest originated in Africa and spread out over the rest of the world in successive waves. The line antecedent to the human clade evidently split about six million years ago from the separate line, leading to our closest living relatives, the chimpanzees.
The expression of the emotions in 'Man and Animals', the final piece of Darwin's tetralogy, is both an old-fashioned, descriptive treatise, and the most modern of Darwin's major works. On the one hand, it provides a straightforward catalogue of human postures and facial expressions that might have been written in past centuries.

On the other hand, this book is rich and accurate enough in interpretation to serve as part of the foundation of modern psychology. Darwin is, in Conrad Lawrence's words, the patron saint of that discipline. His pioneering contribution was this. He treated emotions and their manner of expression as products of evolution, the instincts, and as such, they have evolved by natural selection, and essentially the same manner as traits and anatomy can be studied in the manner of analytic and synthetic biology.

In one sense, reaching to the heart of human self-esteem that was a move as daring as the 'Origin of Species' itself. The four great books of Darwin, and especially the pivotal one we celebrate today, were put together by another innovation of the master naturalist.

He gleaned information not only from existing literature and his own experience, but also from a global network of correspondence. In an effort worthy of the purposes of the British Council, he drew information and concepts from around the world, organized them, and distributed them back to the global culture. No one has pulled that feat off in biology since.

At its foundation, biological knowledge conforms to the two principles I just mentioned or laws arguably with enough firmness to be cited routinely as scientific laws. That is, they are all inclusive, and with no proven exceptions, and their consequences can be followed wide and deep.

The first law says that all the entities and processes defining life are ultimately obedient to the laws of physics and chemistry. The second law still in contention due to claims for counterexamples is that all of the entities and processes that define life in all of the diversity of life have evolved by natural selection.

Modern evolutionary theory rooted now in molecular genetics and thereby consistent with the first law of biology begins with a distinction between the units of heredity and the targets of natural selection. The units or the genes, respectively the base pair sequences forming their codes, their degree of duplication in the genome by tandem repeat sequencing, their location in the genome and the interaction of their products during epigenetics.

The targets of the natural selection process are the phenotypes. That is, the outward traits prescribed by that genetic infrastructure. Natural selection is also multilevel-- operates at different levels. That is, a phenotypic target of natural selection can exist at any level of biological organization, from macromolecules to chromosomes to eukaryotic cells to multicellular organisms, and even to organized social groups and populations of groups and individuals. And finally inarguably, entire ecosystems.

I make this rather technical point to lead into what I believe is the future pathobiology. Multilevel selection typically places selection at adjacent levels in opposition to go on up to say a multicellular organization organism or a complex society requires some degree of altruism on the part of individuals at the lower level.

It's promoted by selection at the level of organisms that make up the groups. Such major transitions across levels of organization have occurred very rarely in evolution and taken long periods of time to be achieved even once. And this is a phenomenon that we evolutionary biologists have not yet explored in enough depth.

The origin of eukaryotic organisms, for example, took over half the known history of life to be reached. From the beginning over 3 and 1/2 billion years ago to 1 and 1/2 billion years ago,

multicellular organisms and animals in particular were not added for more than another half billion years.

The origin of insect super organisms, in particular the tightly knit colonies of ants and termites or their equivalent was not attained until well into the late Jurassic to very early Cretaceous periods 200 to $140 billion years ago.

I believe that in this century, it is in the major transitions of evolution that biology will predominantly dwell. The age of reduction in biology has largely passed. While enormous amounts of new information will continue to be yielded by the cleavage and analysis of complex systems, the big problems in each discipline are those that require an exactitude of synthesis, or more accurately, recreation of reduced system broken down by analytic research.

As more biological systems are understood, and with them the major transitions, common principles of emergent evolution should become apparent. There appears to be no a priori realistic way to create such a unified theory of biology at the present time. It awaits far more empirical information than we now possess, requiring immense amounts of hard work with real organism.

Contemporary biology has long been addressed by two very different strategies of research. The first strategy follows the dictum that for every problem in biology, there exist an organism ideal for its solution. The bacterium E. coli has thus triumph for molecular genetics, the nematode C. elegans for the neuronal basis of behaviour. The honeybee for the instinct and self-organization of animal societies, and human beings for the conscious mind.

If those scientists faithful to this dictum are called the problem solvers, the second tribe of scientists may be called the naturalist. The research strategy of the naturalist is the inverse of a strategy of the problem solver. It is that for every organism, there exists a problem for which the organism is ideally suited.

The procedure of the naturalist is to adopt a group of species, such as conifers diatoms or weaving spiders, and fall in love with those organisms, and learn as much about them as possible across all levels of biological organization, from the genes to its place, their place in the ecosystems.

Problem solvers at work mostly in the laboratory explain the approximate causes of biological phenomena, usually those visible only at a microscopic level. In other words, they discover how the system works. Naturalists, their counterparts working typically in the field, but experimentally in the laboratory also stress those adaptation of biological phenomena to the

environment, the why in its attempted full explanation, although the two approaches have seemed at times to represent independent cultures.

In fact, they are complementary, and can with more information, be fitted nicely together. The boundaries today are, in fact, being erased. Scientific naturalist working as organismic and evolutionary biologists use the methods of molecular and cell biology, while molecular and cell biologists grow more prone to address patterns of diversity and evolution.

With increasing frequency, the two tribes of biology collaborate in research project. Now, at the risk of oversimplification, it can be said that the naturalists discover the problems in nature that the problem solvers problem solve.

The trajectory of a unified biology can therefore be visualized as T-shaped. The horizontal arm is biodiversity at the level of species, and genetic strains within each species. One vertical arm is the model species of the problem-solver, reaching from the populations that constitute the species or strains down through the levels of biological organization.

At the present, perhaps fewer than 100 such model species are in full practice of examination. In a decade or two, there will be thousands, and then tens of thousands. The process will accelerate as DNA sequencing grows ever faster and cheaper.

The more the two-dimensional array of knowledge is filled in, the more of the gaps in knowledge, and the most promising new directions of research will become apparent. At the same time, paleontology and phylogenetic analysis will add the dimension of time.
A unified biology, to conclude, is a goal worth thinking about. Even if it may still be far from our grasp, biologists are stretching causal explanations across wider segments of the levels of biological organization, and then broader arrays of species.

In so doing, they are melding together explanations of function and adaptation, as well as molecules and cells with organisms and species. As a result, the emphasis on research is shifting from one or two levels of biological organization to the transition between these several levels.

The unified biology that Darwin made possible will in the 21st century be the one that maps the pathways from the molecules to ecosystems in unbroken transit of causal explanation. It will disclose the still unimagined commonalities, if such exist, among the evolutionary transition.

It will also provide insights into whatever different genetic codes and transitions are possible, and even which of these might exist on other worlds. The 'Origin of Species' define the path of

a unified biology. This great book led to a renewal of the environment, and that last brought within reach and authentic science of man. Thank you very much.