Q & A

Zhonghe Zhou

Photo: Liwang Jin, Xinhua News Agency.

Zhonghe Zhou began his career at Nanjing University in 1982, studying paleontology and stratigraphy. He received a Master of Science from the Graduate School of the Chinese Academy of Sciences (CAS), after which he went on to work at the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) CAS in Beijing, before attending graduate school at the University of Kansas, where he received his PhD in Biology with Honors in 1999. From there, he returned to the IVPP to continue his research on vertebrate paleontology. His main interest is the origin and early evolution of birds, feathers and avian flight. He is also involved in the study of Mesozoic fish, feathered dinosaurs, pterosaurs, and their paleoenviornmental background. He is currently the director and a senior research fellow at the IVPP, a foreign associate of the National Academy of Sciences of the USA and member of the CAS.

How did you become a paleontologist? I grew up in the countryside and had never seen a fossil until I went to college. I first read about paleontology in a popular Chinese science magazine *Fossil* as a senior in high school and had the feeling that it might satisfy my curiosity for both life and earth history. Incidentally, the same magazine is sponsored by the IVPP where I have spent the majority of my career as a paleontologist.

Do you have a hero in your field? Stephen J .Gould is undoubtedly one of my heroes. He was one of the few paleontologists who has made significant progress towards our understanding of the pattern and mechanisms of macroevolution; his best known contribution is the theory of punctuated equilibrium which he developed with Niles Eldredge in 1972. I am also impressed by his great ability to disseminate biological knowledge to the public. He has inspired me as a paleontologist to contribute beyond my own specialized field.

What's so exciting about fossils? When Darwin wrote the *Origin of Species*, fossils were still rare — yet they were one of the key lines of evidence in support of his theory of evolution. To convince the public to accept the theory of evolution, I have always believed fossils are the most direct if not the most important forms of evidence. As a paleontologist, I have the privilege of discovering fossils in the field and studying them before they are known to others, knowing each one of them is unique and part of the history of life's evolution. It is certainly an exciting experience, being exposed to fossilized evidence of evolution at work from the deep time of earth history. I often compare the job of a paleontologist to that of a criminal investigator: you are always trying to reconstruct an unknown scenario from very limited evidence. It is a challenge, but after you discover something it is always a very rewarding experience.

Why are you interested in public science education? To me, one of the best things about the study of paleontology is that the public always seems to be interested in our discoveries, and paleontology can really help the public to understand that evolution is real. As a discipline of basic science, paleontology has a history of less than one hundred years in China, and although the theory of evolution was introduced to China at the end of the 19th century, the theory has unfortunately largely been misunderstood by the public, due to the long, inappropriate use of this scientific theory for political propaganda. The lack of scientific tradition in China and the prevalence of pragmatism in our ancient philosophy and culture challenge the progress of basic scientific research in modern China. For instance, one of the questions I am often asked by the public is: what is the practical purpose of studying paleontology? Therefore, I feel that paleontologists (particularly in China) are obligated to spend more time informing the public of the significance of paleontology with regards to understanding evolution. In the long run, public understanding and support for this discipline are critical to the sustained growth and success of basic scientific research.

What has bothered you the most in your research field? Attempting to obtain a true phylogenetic tree or actual historical lineage of life. Unlike human generational family trees, the family tree of life in earth history is not recorded clearly anywhere. All we can do is to reconstruct the tree (or a hypothesis regarding the relationships among various species of life) based on limited evidence. I often hear people saying that a phylogeny is falsifiable, with which I do not fully agree. Indeed, you may

falsify a molecular phylogeny based on evidence from geographic or morphological evidence. However, a phylogeny reconstructing extinct relationships, which usually did not preserve molecular evidence, is difficult to falsify. When studying paleontology, constructing phylogenetic hypotheses is important, yet we are always struggling in debates over which phylogenetic cladogram is closest to the truth.

Which challenges have you met in your research in China? I feel the current biggest challenge facing paleontological research in China is the lack of appropriate management of fossil resources. More specifically, scientific collecting and excavation of vertebrate fossils has become increasingly difficult due to conflicts of interest with local governments, while illegal fossil collecting by farmers has not been stopped. Although the central government has issued regulations for the protection of fossils, there remains a long way to go for important fossil sites to be free from illegal collecting by farmers, which is stimulated by fossil black markets and dealers who benefit the most from the situation. As a result of non-scientific collecting, we must deal with the loss of information on the locality and horizon of the fossils and be wary of fossil forgeries, which pose another major threat to paleontological research.

What do you do for fun? While studying fossils is fun for paleontologists, I also enjoy reading books on history (in particular while traveling) and playing basketball, table tennis or badminton. I also like to spend some time watching the news on TV or on the web in order not to be left behind by the internet age. While traveling, I enjoy visiting forests, seeing wild animals in their natural habitats, and experiencing the diversity of culture different parts of the world have to offer.

What is the most useful advice you have heard? The most useful advice I have heard is probably from my former professor the late Larry Martin "Never worry about things that are out of your control", which has since become a motto for me. With this in mind, I can always make myself more patient and ease difficult situations.

Do you agree with the statement that dinosaurs are not extinct? It is true that there is compelling evidence indicating that birds are descendants of theropod dinosaurs, and birds are undoubtedly nested in the phylogenetic tree of dinosaurs, yet can we really say dinosaurs are not extinct? Or do you agree with the saying that the smallest living dinosaurs are humming birds? Admittedly there is nothing wrong with this in a strict cladistic sense, yet I personally would not like to say so because there is a distinction between phylogeny and taxonomy. Phylogeny is about natural phylogenetic relationships, yet taxonomy in general is about the practice and study of the classification of organisms for conventional purposes. Scientifically, all birds can be referred to Dinosauria, yet as long as we are still using amphibians, reptiles and mammals in their conventional definition, there is no point in changing our conventional concept of dinosaurs, which does not include birds.

Why do you think chance has played a big role in evolution? Although natural selection is the main driving force in biological evolution, there is no doubt chance has played a big role as well. As a paleontologist, I always try to understand 'chance' from both the biological and environmental/geological perspective. Mutation provides the fundamental basis for the phenotypic variation on which natural selection acts, thus the first category of chance is derived from genetic changes. The second category of chance is from the environments where the organisms are living. The environmental changes to a specific species or population comprise a complex background including the physical environments and lives of other sympatric individuals or species. From a geological perspective, these 'chances' of selection or adaptation in the past are overwhelmingly numerous, and are critical to our understanding of macroevolution (such as extinctions) in earth history.

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Quick guide

Badgers and bovine tuberculosis

Robbie A. McDonald

What is tuberculosis in badgers? Tuberculosis in European badgers *Meles meles* is caused by *Mycobacterium bovis*, the same pathogen that causes bovine tuberculosis in cattle. Pasteurization of cows' milk and childhood vaccination have greatly reduced human cases of bovine tuberculosis infection in the developed world, though it remains a public health challenge in many developing countries. In parts of the UK and Ireland, where bovine tuberculosis is a large and growing animal health problem, badgers are a wildlife reservoir and an important source of infection for cattle.

How does bovine tuberculosis affect badgers? Badgers infected with *M. bovis* can live for several years without showing any adverse effects. It is not possible to diagnose infection in badgers by outward physical signs, except in very occasional individuals with gross external lesions. Diagnosis can be made on the basis of bacterial culture of clinical samples, serology or interferon gamma release assays (IGRA). Infection affects badger survival, particularly as the disease progresses. Animals with more advanced infection, especially where they are shedding bacteria from lesions in multiple organs, have considerably higher rates of mortality. Male badgers appear to experience more adverse effects of infection than females, perhaps related to differences in their behaviour and/or their immune function, related to reproduction.

Do badgers give bovine tuberculosis to cattle or vice versa? Yes, both. Badgers give bovine tuberculosis to cattle, and cattle give bovine tuberculosis to badgers, but we don't really know how or where. It could be direct, nose-to-nose, contact between animals, or indirect, via contamination of the environment with infectious excreta (Figure 1). It could be in farm buildings, which