Symposium report

How does plasticity shape evolution?

Now for the 6th time, the meeting of the European Society for Evolutionary Developmental Biology (EED) was held in Uppsala, Sweden, from July 26-29, 2016. For four days, scientists from disciplines as diverse as palaeontology, genomics and philosophy came together to take up the challenge of bridging the fields of evolution and development. Thanks to its interdisciplinary nature, the field of Evo-Devo is very dynamic, and each EED meeting has its own character with new research areas appearing. This year's meeting included several novel topics, such as the role of Evo-Devo in domestication or reproductive medicine, but also familiar ones, such as the evolution of the vertebrate limb or the evolution of gene regulatory networks. Four concurrent sessions gave all participants a lot to choose from.

Antonio Cordero and I – both postdocs in Professor Tobias Uller's group at Lund University – decided to use this conference to showcase a topic that has been puzzling us for a while, namely the role of plasticity in evolution. Plasticity describes the ability of an individual, often represented by its genotype, to produce alternative phenotypes in different environments. For example, due to years of mechanical stress through training, the playing arm of professional tennis players is measurably longer than their non-playing arm. Plasticity is often an adaptive outcome of natural selection, but the question we posed was if and how plasticity may shape future evolution. Plasticity may retard genetic evolution if plasticity makes individuals sufficiently fit for selection to be weak. But plasticity may also direct evolution in a particular direction if responses are non-random with respect to function and the ability to respond itself is heritable. This, then, is the idea that phenotypic plasticity takes the lead in adaptive evolution, followed by changes in the genetic regulation of development.

There was an excellent line-up of speakers for our symposium, which was held at the main hall of the Uppsala Congress Center and well attended. The first speaker was Dr Arkhat Abzhanov, who recently moved to the Imperial College London from Harvard University. He presented new research expanding his highly celebrated work on the evolution and development of the beaks of Darwin's Finches. While beak shape is quite inflexible in Darwin's Finches and shows high heritability, beak shape in other birds can be highly plastic and develop according to the type of food young birds consume. Abzhanov's work attempts to unravel the causes, mechanistically and evolutionarily, for these differences and his work may suggest that plastic beaks are the ancestral state in birds. In the following talk, Professor Armin Moczek, from Indiana University, USA, presented three different aspects of his comprehensive work on horned beetles. An illustrative case of how evolution may proceed along trajectories set by developmental plasticity comes from comparative analyses of environmental sensitivity of horn development. Intriguingly, gene expression profiles are largely similar between nutritionally caused horn deformations and naturally occurring horn types of other horn beetle species, thus demonstrating parallelism between a plastic response within species and evolved divergence between species. Dr Ingmar Werneburg from the University of Tübingen, Germany, presented his innovative work on comparative embryology and challenged the "early equals important rule" of development. This rule posits that the earlier an element occurs in ontogeny, the larger and/or the more complex it will be in its final form in adults. In a detailed ossification series of a wide range of squamate reptiles, he demonstrated several notable exceptions to this rule, suggesting that evolutionary diversification involves substantial tweaking of developmental processes. In the final talk of the main symposium, Dr Jacqueline Moustakas-Verho from the University of Helsinki, Finland, presented her work on the scutes of the turtle shell (scutes are the little ‘tiles’ making up the surface of the turtle shell). In the true spirit of “eco-evo-devo” Jacqueline combined gene expression analysis, *in silico* modelling, and field studies, to show that scutes develop from placodal signalling centers. This was previously overlooked because of the transient nature of gene expression patterns, but the arrangement of scutes is well predicted by the reaction-diffusion dynamics that Jacqueline and her co-workers have modelled.

The session consisting of the talks of the four invited speakers was followed by a session of five shorter talks given by junior scientists. In the same vein as the main session, these five talks demonstrated the role of plasticity in shaping and changing skeletal elements and highlighted the many different aspects of the topic. If I should single out one conclusion from the symposium, it is that there are many insights to gain about evolution from studying the context-sensitivity of developmental processes. Vice versa, understanding the evolutionary past can help us to fully embrace the organism as an evolved system and to understand why this responsiveness exists. Studying both aspects may even allow us to project the path evolution may take in the future. The evolutionary history of organism ensures that responses to new challenges are not random and that organisms are not bound to passively wait for beneficial mutations to occur. Their responsiveness may guide evolution, at least to a certain extent. This symposium has highlighted fruitful avenues of research in the interface between evolution, development and genetics, and I want to thank the Genetics Society for the generous support.

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