New thesis maps the origin of colour vision

March 26 2015

Roughly 500 million years ago, the genome of vertebrate animals' early ancestors doubled in size, not just once but twice. This meant that suddenly there were several gene copies which were free to develop new functions. Many of them came to use at different points in time or in new cell types. Then, about 350 million years ago, another doubling of the genome occurred in the ancestor of ray-finned fishes. These ancient events were of dramatic consequences to the evolution of eye-sight.

The cone and rod cells of the eye are what enable us to see, with cones being sensitive to colour while rods only see in 'black and white'. Rods and cones use different, but related proteins for their response to light. In his thesis, David Lagman shows that many of the genes that give rise to differences between rods and cones originate from the early doublings of the vertebrate genome.

'Key components of the eye are the proteins which collect the light and start the response chain in rods and cones. The primordial vertebrates had as many as five types of light receptors, four of which were used for seeing colour. Two of these were later lost in the ancestor of mammals, but still exist in for instance birds and fish, giving them at least to a certain degree better colour vision than humans', says David Lagman.

The components in rods and cones that transmit the signal also became more numerous in the early vertebrates. And in ray-finned fish there were subsequently even further duplications of the genome, resulting in even more components than in mammals' rods and cones.

The research group has furthermore studied how these extra genetic copies have changed during evolution in zebrafish, which is commonly used as a model organism in both physiology and developmental biology. The thesis shows that genes coding for eyesight in zebrafish are used in the same cell types as their counterparts in mammals. This indicates that the specialisation is very old.

'A surprising find was that certain genome copies in zebrafish were used in different parts of the retina. Some of them are even used in the pineal gland, which resembles the eye but primarily regulates our biological clock. Some eyesight genes turned out to have different levels of activity during the course of the day, which is yet another example of specialization that has occurred thanks to the existence of extra copies of the genome. So we have discovered that duplication of genes hundreds of millions of years ago has led to several different types of functional differentiations. This means that much of evolution can occur thanks to genetic duplication followed by change', says David Lagman.

The thesis also shows how important it is to research how genes are used. This knowledge makes it easier to use zebrafish as a model organism to increase our understanding of the eye's mechanisms even in humans, opening new possibilities to develop treatments for diseases which affect our eyesight.

More information: "Evolution of Vertebrate Vision by Means of Whole Genome Duplications : Zebrafish as a Model for Gene Specialisation." uu.diva-portal.org/smash/get/d … 85090/FULLTEXT01.pdf

Provided by Uppsala University