The evolution of largely intact sex chromosomes in ostriches

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DNA is the genetic material which contains all the information necessary to make an organism. It is a very long molecule which should fit in very small cells. To make this possible, DNA is folded several times and has been packed in bodies called chromosomes.

In many organisms, sex is determined using sex chromosomes. In mammals (such as humans), females have two copies of the same sex chromosome (XX), and males have one X and one Y, where genes on the Y chromosome generate the male features. In birds, it is the males who have two copies of the same sex chromosome (to distinguish it from XY system, we call them ZZ), and females have one Z and one W chromosome.

In most organisms, the W and Y chromosomes are usually much smaller than the Z and X. As one of the sex chromosomes becomes specific to one sex, it starts to accumulate changes that are beneficial to one sex and neutral or even harmful to the other sex. Usually all chromosomes can exchange part of their DNA with each other. This swap of DNA is stopped to prevent the transfer of sex-specific genes to the other sex. This exchange of DNA between chromosomes also acts as a mechanism to correct the harmful errors without which errors can be accumulated. As a result, the W and Y chromosomes start to accumulate harmful changes, lose their genes and shrink to a much smaller size than their partners.

The interesting exception to this degradation trend of sex chromosomes is found in a group of largely flight-less birds including ostriches. The two sex chromosomes are of almost the same length in these birds. We wanted to see when in the bird lineage, the exchange of DNA between the sex chromosomes ceased and why the sex chromosomes have not degraded in these birds. Using the DNA from male and female ostriches, we could estimate that the two sex chromosomes stopped swapping their DNA before the split of modern birds about 150 million years ago. This is an interesting result because these old chromosomes show us that the degradation of sex chromosomes is not an inevitable process. But why this is so? We made several speculations regarding the reason of this non-degraded pattern of sex chromosomes in ostriches. One reason could simply be a longer generation time of ostriches which lead to the lower rate of change in the DNA; as a result, it takes more time that the changes accumulate in these birds. The second reason could be due to the fact that many genes in ostriches are used at much higher level in males than in females and there seems to be no mechanism to keep the products of these genes at the same amount, therefore, the W chromosome has retained its original gene content to a large degree and has not fallen in the vicious cycle of degradation.

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