

Role of epigenetic as a force in evolution



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Introduction

Epigenetics can be defined as the study of heritable changes in gene function that do not cause a change in the DNA sequence (Dupont et al. 2009), with DNA methylation and histone modifications being two of the epigenetic mechanisms that can lead to these specific changes (Osborne 2017). Epigenetics and its role in evolution has become a focus in evolutionary biology research, particularly DNA methylation (Schrey et al. 2012). With living organisms always being exposed to environmental cues, they need to be able to respond to them (Norouzitallab et al. 2019). This will ensure their survival and ability to evolve in an ever-changing environment (Burggren et al. 2014) and can be achieved through epigenetics. It can be altered by the environment and this will affect the phenotypic plasticity of an individual that can lead to its evolution (Smith & Ritchie 2013).

In this essay, the role of epigenetics as a force in evolution will be discussed. It will start with the interaction between environmental stressors and how individuals react to these through epigenetics, followed by comparing it to natural selection and genetic variation. There will be a focus on the epigenetic mechanism of DNA methylation in evolution, providing examples to support this. The essay will finish with a conclusion that aims to connect all the information and state the role of epigenetics in evolution.

Epigenetics and Natural Selection

Epigenetics can influence many individuals in a population due to the markers arising in response to the environment (Burggren 2016). It allows for individuals to respond to specific information related to the environment

that will let them and their offspring be successful in the heterogeneous conditions (Duncan et al. 2014). An example is seen in water fleas (*Daphnia*) as they can form a structure that looks like a helmet as well as spines on their tails in response to signals released from predators (Harris et al. 2011). It has been seen that when a pregnant female is exposed to high levels of these signals, then her offspring will have these large helmets compared to females that are in water without these signals (Fish et al. 2004). Just exposing the mother to the signals allows for her offspring's phenotype to be adapted to the environment, even without the offspring experiencing the threat.

Even though epigenetic effects can be inherited, epigenetic marks can be removed by process involving enzymes (Moore et al. 2012) and through epimutations where the losses are spontaneous (Mendizabal et al. 2014). This can lead to the individuals reverting to the original phenotype (Burggren 2016) that can lead to the individuals having a reduced fitness in the new environmental conditions.

Natural selection is known to act on random mutations in a single individual that is advantageous for the population so it can evolve (Elena et al 1996). With epigenetics, the variation can arise in several individuals simultaneously when they are exposed to the same change in environment (Jablonka 2017), compared to a single mutation in one individual (Burggren 2016). The modifications to the phenotype that were caused by the mutation alone can take between hundreds and thousands of generations to be present beyond the original population (Burggren 2016).

In terms of evolution, studies are starting to convey a link between genetic

and epigenetic variation across short- and long-term evolution (Mendizabal et al. 2014). If natural selection acts on the variation created by epigenetics in addition to the genetic variation, then populations and individuals can adapt quickly to environmental changes without needing a genetic mutation (Klironomos et al. 2013) but can still have those random mutation causing more variation.

The role of epigenetics as a force in evolution is its ability for individuals to evolve to rapid changes in their environment, aided by the interaction between epigenetic mechanisms and the environment.

DNA methylation

DNA methylation is the epigenetic mechanism that is the most studied as it provides variation in the phenotype between individuals for evolution (Schrey et al. 2012). It modifies a DNA base by adding a methyl group that causes the interaction between DNA and histone proteins to change so it is in a restrictive state (Duncan et al. 2014). There are several studies that have shown how DNA methylation has allowed organisms to adapt and evolve to a new environment. Richards et al. 2008 studied Japanese knotweed along the coasts in North America and found that there was a high frequency of variation in the DNA methylation. They linked this to the varying salt levels along the coastlines and the plants ability to tolerate these levels. Another study conducted on house sparrow subspecies by Riyahi et al. 2017 found that introduced individuals into new habitats had changes in the amount of DNA methylation compared to the native birds.

These epigenetic changes aided the sparrows in adapting to their new environment and expanded their population.

In terms of its role in evolution, DNA methylation has allowed individuals of the same species to evolve to different environmental conditions, even leading to them successful living in various habitats. Researchers are also investigating other epigenetic mechanisms, especially histone modifications in relation to evolution (Schrey et al. 2012) to see if it supports DNA methylation and the role of epigenetic in evolution.

Conclusion

The role of epigenetics as a force in evolution is that it enables an organism to adapt and evolve quickly to rapidly changing environments. This is in comparison to natural selection that requires a beneficial mutation in an individual that could take a long period of time. Even though some epigenetic changes can be heritable, this does not mean that they will be permanent in a population, as the marks can be removed from the DNA. To sum up, evolution could not occur with just epigenetics; it also requires natural selection acting on genetic variation, and potentially epigenetic variation.

References:

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