Genetic memory (biology)

In biology, memory is present if the state of a biological system depends on its history in addition to present conditions. If this memory is recorded in the genetic material and stably inherited through cell division (mitosis or meiosis), it is genetic memory.

Contents

Somatic memory

Somatic memory is limited to the organism and not passed on to subsequent generations. However, its mechanism may involve mitotically stable genetic memory. The term applies for cellular memory, animals' memory, and plants' memory, as described in the following paragraphs.

Cellular memory

All cells in multicellular organisms are derived from a pluripotent zygote and contain the same genetic material (with a few exceptions). However, they are capable of recording a history of their development within the organism leading to their specialized functions and limitations. Cells often employ epigenetic processes that affect DNA-protein interactions to record this *cellular memory* in the form of mitotically stable changes of the genetic material without a change in the DNA sequence itself. This is typically achieved via changes of the chromatin structure.[1] Examples are methylation patterns of the DNA molecule itself and proteins involved in packaging DNA, such as histones (also referred to as "histone code").[2][3]

In animals

A case of somatic genetic memory is the *immunological memory* of the adaptive immune response in vertebrates. The immune system is capable of learning to recognize pathogens and keeping a memory of this learning process, which is the basis of the success of vaccinations. Antibody genes in B and T lymphocytes are assembled from separate gene segments, giving each lymphocyte a unique antibody coding sequence leading to the vast diversity of antibodies in the immune system. If stimulated by an antigen (e.g. following vaccination or an infection with a pathogen), these antibodies are further fine-tuned via hypermutation. Memory B cells capable of producing these antibodies form the basis for acquired immunological memory.[4] Each individual therefore carries a unique genetic memory of its immune system's close encounters with pathogens. As a somatic memory, this is not passed on to the next generation.

In plants

Plants that undergo vernalization (promotion of flowering by a prolonged exposure to cold temperatures) record a *genetic memory of winter* to gain the competence to flower. The process involves epigenetically recording the length of cold exposure through chromatin remodeling which leads to mitotically stable changes in gene expression (the "winter code").[5] This releases the inhibition of flowering initiation and allows the plants to bloom with the correct timing at the onset of spring. As a somatic memory, this state is not passed on to subsequent generations but has to be acquired by each individual plant. The process of vernalization was falsely assumed to be a stably inherited genetic memory passed on to subsequent generations by the Russian geneticist Trofim Lysenko. Lysenko's claims of genetic memory and efforts to obtain or fabricate results in proof of it had disastrous effects for Russian genetics in the early 20th century (also see: Lysenkoism).[6]

Inherited epigenetic memory

In genetics, genomic imprinting or other patterns of inheritance that are not determined by DNA sequence alone can form an epigenetic memory that is passed on to subsequent generations through meiosis. In contrast, somatic genetic memories are passed on by mitosis and limited to the individual, but are not passed on to the offspring. Both processes include similar epigenetic mechanisms, e.g. involving histones and methylation patterns.[7][8]

Microbial memory

In microbes, genetic memory is present in the form of inversion of specific DNA sequences serving as a switch between alternative patterns of gene expression.[9]

Evolution

In population genetics and evolution, genetic memory represents the recorded history of adaptive changes in a species. Selection of organisms carrying genes coding for the best adapted proteins results in the evolution of species. An example for such a genetic memory is the innate immune response that represents a recording of the history of common microbial and viral pathogens encountered throughout the evolutionary history of the species.[10] In contrast to the somatic memory of the adaptive immune response, the innate immune response is present at birth and does not require the immune system to learn to recognize antigens.

In the history of theories of evolution, the proposed genetic memory of an individual's experiences and environmental influences was a central part of Lamarckism to explain the inheritance of evolutionary changes.

Animal behavior

In ethology, genetic memory refers the inheritance of instinct in animals.

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Further reading

- Alan Bullock; Oliver Stallybrass (1977). "Genetic memory". *The Harper Dictionary of Modern Thought*. Harper & Row. p. 258.