appeared on 23rd Mar 2007

Genes act to make memories

The body is found to consciously switch genes ‘on’ and ‘off’ to control the formation of cells that create the memory, says S.Ananthanrayanan.

Scientists in the University of Alabama at Birmingham have traced the mechanism by which the brain forms and renews it’s memory records. The mechanism is found to be the same as the embryo uses to get its cells to develop into one or another kind of cell, depending on what organ is being developed.

Memory mechanism

Memory and learning is considered to form with the strengthening of channels of nerve cells, or ***neural pathways***, as a result of particular stimuli or behaviour patterns taking place. It is known that the number of neurons, or brain cells that we are born with increase rapidly for a few years. At the same time, nerve cells also throw out branches that can communicate with other neurons, to transmit or receive stimuli, through connections called ***synapses***.

Visual stimuli, for instance, send messages that need to pass to the area of the brain which deals with vision. A newborn’s genes would then guide the creation of pathways to enable vision, hearing, etc. These connections then get strengthened with use, while unused pathways die out or are ***pruned***. With experience with the environment, the infant would learn behaviour by strengthening pathways that connect visual or audio stimuli with specific muscular motion. Experiences that are frequent or appear to be important would lead to strengthening connections to neurons that record past stimuli.

Strengthening of connections would then mean the same thing as learning, or the firming of memory. At the same time, disuse of pathways would lead to atrophy of the pathways and loss of recall or of a skill.

How pathways form

That a neuron ‘throws out a branch’ may make sense if the neuron were a person or a machine programmed to behave in that way. It does not make sense when we talk of a cell. By what mechanism can dendrite or axon cells, of which the pathways are made, actually grow? It could be the preprogrammed schema for the growth of cells of a limb or an organ of definite form. But how can it be for cells that lead to learning or memories? These are not pre-determined! What mechanisms make these cells grow in one place and not in another?

Neurobiologists Courtney Miller and David Sweatt were working with a process called DNA methylation – where groups of atoms called methyl groups attach to genes and

switch them off. When the methyl groups are not there, the genes are active, but when they are there, the genes are blocked!

Cells use this method during embryonic development to switch off selected genes to enable the cells to specialize into different types. This kind of regulation is called "epigenetic," because it is a layer of genetic control beyond the regulation which is part of the gene structure itself.

Methylation leads to a permanent change in the gene activity. Hence, although there was already evidence that DNA methylation occurs in adult brains, it was not taken as the mechanism for establishing memory. But then, it was seen that errors in DNA methylation occurred in some cases of schizophrenia or mental retardation. Sweatt and colleagues hence designed experiments to test whether the process had anything to do with memory formation.

Experimental rats were conditioned by a fearful experience, of electric shock, when placed in a particular chamber. The test was to see if the rats remembered the experience by reacting when placed again in that chamber.

It was found that drugs that inhibit methylation did not allow the rats to form such memories. Methylation was hence necessary for the rats to form memories. Particularly, the level of methylation appeared to directly control the activity of genes known to either suppress or promote memory formation.

"To our knowledge, this study is the first to present evidence that DNA methylation, once thought to be a static process after cellular differentiation, is not only dynamically regulated in the adult nervous system but also plays an integral role in memory formation," concluded Miller and Sweatt.

The researchers also note that abnormal epigenetic regulation has been seen in cancer, some types of autism, and schizophrenia. Their findings could thus help in basic understanding of epigenetic mechanisms that underlie those disorders.