Polio Biology IX
Peering at Post-Polio Syndrome under the Microscope

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A Lincolnshire Post-Polio Library Publication
25th January 2000

The Microscope is an instrument that revolutionized the study of biology. Before it existed everyone believed the human body was only composed of amorphous flesh. After Galileo and Janssen, the simultaneous inventors of the earliest microscopes at the beginning of the 17th Century, we knew that we were composed of tiny structures called cells. The human body contains about 10 trillion cells, small circumscribed entities with an organized internal anatomy and a complicated biochemistry. These parts together are the essence of life.

In human beings there are cells of many different types. For our purposes we will concern ourselves with just two of the types of cells that are affected, both acutely and persistently by polio: motor nerve cells and, secondarily, striated muscle cells.

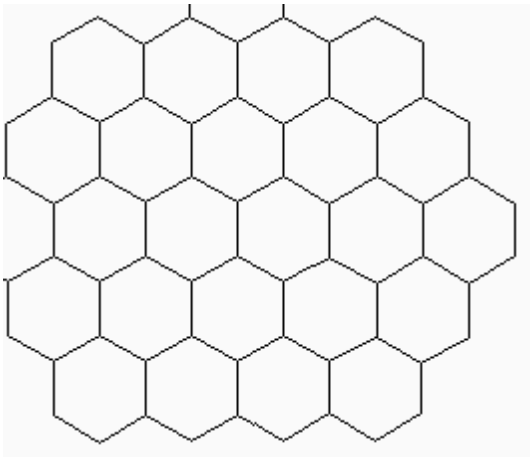
A fairly accurate mental picture of a motor nerve cell can be conjured up by imagining a tree uprooted and cleaned of soil from its roots. The roots of our cell are called dendrites and they would be located inside the spinal cord. Each rootlet would be connected to the branches of another nerve cell above it. Our motor neuron has a branch coming extremely close to a muscle fiber (a long thin cell that can contract (shorten) and elongate).

Picture one nerve cell with 1000 branches, each branch of the cell innervates a single striated muscle fiber. If you can do this you are imagining a "giant motor unit" which is often alluded to in the polio literature. Giant motor units result after acute polio when muscle fibers lose their connection to a branch because the whole tree (nerve cell) dies. Surviving neurons grow extra branches and connect in the process of recovery from polio damage. This giant motor unit consists of a motor nerve connected by end fibers (branches) to 1000 muscle fibers.

When an EMG is performed the technician can tell if muscle fibers are all part of the same motor unit (if there are giant motor units). When the nerve fires, all the muscle fibers connected to it by its end fibers (branches) also fire synchronously. This will show a characteristic pattern recognizable in the EMG.

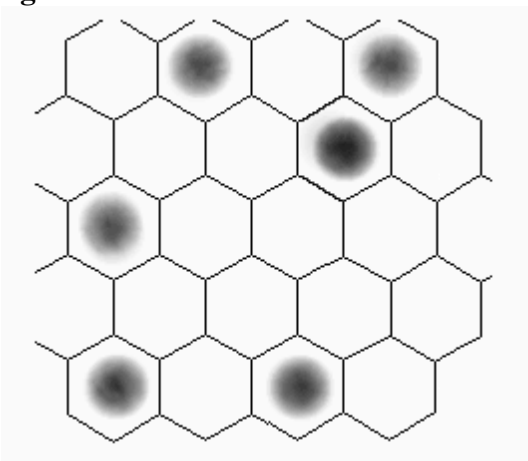
Striated muscle fibers are encased in bundles. I've tried to draw a representation of a group of striated muscle fibers below, although they are not as uniform in shape as my diagram implies. Some are round, some oval, some angular and so on. Anyway, I thought I could make a couple of interesting points about how polio, and post polio syndrome, affect the muscle fibers using these diagrams.

Figure 1.



On the left we have a cross section of a bundle of normal muscle fibers. For the sake of understanding polio we'll suppose that all of them are innervated by healthy nerve cells and are part of the same motor unit. In an individual with Amyotrophic Lateral Sclerosis the entire bundle dies sparing no fibers because the entire nerve cell dies with all of its branches (the entire motor unit.)

Figure 2.



To the left we have a diagram of a muscle bundle but notice that individual fibers (dark centers) are dropping out. It is significant that the entire bundle, with all fibers, is not dying but only a few scattered fibers. This is characteristic of post-polio syndrome under the microscope. It suggests the nerve cell is not dying but rather end fibers are degenerating. It is possible that the fibers dying here could be picked up and reinnervated by another nerve, creating an even bigger giant motor unit. This process is ongoing in patients who have had polio with giant motor units getting bigger and bigger. When a real big one reaches the threshold of cellular exhaustion an entire muscle bundle may die.

At times, under the microscope, muscle biopsies of PPS patients show the loss of entire groups of fibers as happens in ALS. However, in ALS this is the rule while in PPS it is rare. I should add here that the warning against overuse is to spare the muscles and not the neurons. In polio biopsies muscle fibers sometimes appear abnormal with internal nuclei and a ragged shape. These microscopic muscle fiber features are probably due to fewer fibers, because of loss of nerve branches, working harder to maintain function.

Obviously the loss of muscle fibers is the result of stress on the motor nerve (our tree mentioned by analogy earlier). There is the obvious stress of age changes limiting new sprouting and shifting the dynamic compensation mechanism where denervation and reinnervation continue with the advantage tipping toward loss of nerve branches. And we now know that there is a lot of inflammation in the spinal cords of people who had polio. There are infiltrates of lymphocytes (white blood cells which mediate cellular immunity) and also anti-polio antibodies. Poliovirus RNA has even been found in PPS spinal cords. Obviously all of this is stressing the giant motor units we were left with after recovery from polio. These recent microscopic and ultra-microscopically derived facts still leave us with a mystery: is it one cause or many causes which result in our plight. I believe many.

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Document preparation: Chris Salter, Original Think-tank, Cornwall, United Kingdom.
Created: 25th January 2000
Last modification: 21st January 2010.