

Understanding Motor Activity

Here is an excerpt from George C. William's book *The Pony Fish's Glow and Other Clues to Plan and Purpose in Nature* (1992. New York: Basic Books. p. 66-68.). I thought you might find this part helpful in thinking about the bones, muscles, and nerves acting together. I have added some questions in parentheses and italics which you should be able to answer. Answers are given at the end.

“Manipulation, like any other motor activity, requires muscle contraction. The manipulation muscles are mostly in the forearm (*1. which muscles would these be?*). As you alternately squeeze and release the remaining pages of this book with your right hand, you can use your left to feel the muscle contractions and relaxations (*2. which cause what kinds of motion?*). You can also feel the tensing and slackening of tendons in your wrist and palm. These tendons (*3. which are made of what?*) are the cables that convey force from the forearm muscles to the bones of the fingers. They pass through precisely aligned systems of tubes and grooves (*4. which are called?*) to accomplish this, and each tendon ends with an attachment at exactly the right spot (*5. called muscle what?*) on the right bone to produce the needed squeeze or straightening of the finger. There are many such tendons, from many separable bundles of muscle (*6. what are these bundles called?*), so that the fingers can perform many kinds of motion, such as curling up and straightening out and waving from side to side. There is some sharing of muscle groups between fingers, so that we are limited in our ability to move the fifth digit without moving the fourth.

All this manipulative ability is understandable in detail as a purely mechanical consequence, via tendons and their attachments, of the contraction of muscles in the forearm (and at the base of the thumb). A finger does not curl up or straighten out because it wants to, but because it is forced to by the pulling of the tendons. These tendons pull only because they are pulled by muscles. Why do the muscles pull? Their pulling is an active shortening of the muscle as a whole, and this shortening in the realm of the readily visible reflects a shortening process in the realm of the ultramicroscopic (*7. which looks like?*). Muscles are densely loaded with parallel protein fibers running from one end to the other. These fibers actively shorten, and provide the muscle with its forcefully fold, somewhat like the bellows of a camera. Their normal relaxed state is stretched out. Their contraction requires a supply of energy from a substance called adenosine triphosphate (ATP). The energy taken in from the metabolism of this substance comes ultimately from the food we eat and the oxygen we breathe. Understanding all this requires an impressive array of technical knowledge of the molecular machinery of the cell, but this knowledge is entirely of physics and chemistry. No subtle immaterial processes are employed.

A muscle's protein fibers (*8. made of what?*) fold and make the muscle contract and pull on the tendon because they are stimulated to do so by a nerve impulse (*9. how?*). People may think they understand the conduction of electrical impulses by nerves because they

think they understand the conduction of messages by telephone wires. What goes on in a telephone wire is more complicated than most people realize. What goes on in a nerve fiber is incomparably more so. There is a rough analogy because both processes seem extremely rapid, both sorts of impulses travel through a long, thin conductor, and both involve electrical charges. They have very little else in common, and calling the nerve impulse electrical can be misleading. There is no electric current moving along a nerve. A nerve impulse is a wave of exchanges of electric charges between atoms (*10. which atoms or ions?*) of the outer and inner surfaces of the membrane that bounds the nerve fiber (*11. what is the result of this "exchange?"*). The wave typically travels many meters per second, but this speed is a minute fraction of that of an electrical impulse in a wire."