# Neuroprosthetics: CPG Chip

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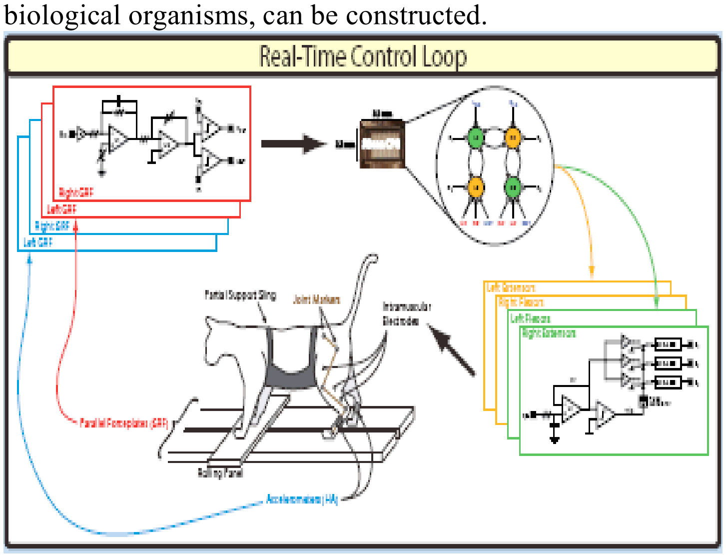
The Central Pattern Generator Chip (CPG) is a new technology currently being researched and developed at John Hopkins University. It is a silicon circuit implanted into the spinal cord of a paralyzed patient (or animal) which sends electrical neuronal impulses to the muscles, therefore stimulating locomotion. Spinal cord injuries are very dangerous because when it's snapped, the brain looses communication with the rest of the body, and paralysis occurs. However, a chicken can run around with its head cut of for a few seconds. This proves that the signals sent from the brain were stored in the spinal cord, so even with out the brain, the spinal cord allows the chicken to 'run around'. To provide locomotion to an animal or human with a spinal cord injury, this memory-like neural process needs to be reproduced.

Researchers at JHU discovered this could be done by implanting a silicon CPG chip into the spinal cord and wiring the muscles wanted for stimulation. A few components were necessary to develop before running the trials on a living animal. An analog signal processor chip was necessary to process signals to feed into CPG, a microprocessor to control output to subject, a constant current stimulator output stages, and of course the analog CPG chip. The chip itself consisted of electronic analogues of biological neurons, synapses and time-constants, dynamic analog memories, and phase modulators. Using these components, non-linear oscillators, based on the central pattern generators of biological organisms, can be constructed.




When ready to test this new CPG chip, a cat was temporarily paralyzed and the chip was implanted into its spinal cord. Four sets of neural circuitry were wired to four different muscle areas of the cat: left and right hind flexor and extensor muscles. Signals from chip were used to these stimulate muscles, and limb movement was detected and fed back into the neural network. The cat was able to 'walk normally' and was fully adaptable to the surface of which it was stepping. This experiment was huge as it showed some success in proving the concept of recording sensory info, processing it, and generating a reasonably successful activation pattern of specific muscles.

The circuit created uses less than 1 microwatt of power and occupies less than 7 mm of chip area. Silicon was chosen because the physics of silicon is in many ways analogous to the biophysics of the nervous system, so is a safer, more dependable material to use (also used for silicon cochleas and retinas).

This CPG chip has many advantages over current commercial products for spinal cord injury patients. Current therapies for spinal cord injury patients are primitive, for example prostheses consist of devices that require the user to press a button on left side if they want to step with left, or on right to step with right. There is no sensory feedback, and this is certainly not a natural process. CPG chip implant would allow for much more natural movements, and much more fluent control of body movements.

There is still a lot of work and research to be done with this method of neuroprostheses. In the future, JHU hopes to Combine CPG chip with microelectronic implants in the spinal cord itself instead of stimulating muscles directly through surface or implanted wires placed throughout legs. These implants would allow the activation of intact neuronal networks within the cord, which are responsible for generation of flexor and extensor alternations in legs. This would eliminate the need to implant wires directly to legs and produce more natural, fatigue-resistant walking.

## References: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