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Electrodes and Chronic Optic Nerve Stimulation

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Visual pathways are often schematized as a parallel afferent transmission of pixel image matrices. Suggested interfaces would thus have numerous contacts in close proximity to the target elements. However, well organised tissue reactions would actively keep electrodes away from the neural units.
Alternatively, self sizing spiral cuffs were wrapped around the optic nerve of two blind volunteers in an attempt to develop a visual prosthesis. Unexpected features of the optic nerve code have emerged. This interface remained well tolerated for more than ten years. However, there is still a long way to go before to reach the useful vision rehabilitation.

K e y w o r d s: implantable electrodes, foreign body reaction, visual prosthesis, optic nerve code, neural interface

1. Introduction

The visual pathways are very much seen as a parallel structure with some degree of retinotopy, that is a point-to-point topological correspondence between the retina (or the visual field) and more central structures. This fundamental organisation has suggested that an artificial visual prosthesis should interface with the neural tissue through some grid of contacts, each transmitting a point or 'pixel' of an image captured by a camera [1]. This basic model supports the pioneering work of Brindley who implanted an 80 contact electrode array over the cortex of two human volunteers [2]. This massive parallel approach is also the main encoding scheme used in more recent retinal approaches [3], including the sub-retinal replacement of cones and rods by artificial photo-sensors, in an attempt to restore the natural eye camera [4]. At that level, the images of the outside world indeed take the shape of a straightforward array

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of pixels. However, further in the retina and down the visual pathways, a complex and largely unknown spatio-temporal encoding takes place. The visual areas of the brain are nothing like an internal projection screen upon which image pixels could be transferred in parallel.

Much work has been devoted to the development of miniature electrodes carrying an array of numerous contacts [5]. For an efficient stimulation, that is a selective activation with minimal currents, the electrode must be placed in close proximity to its target. However, any foreign material, even clean and sterile, devoid of toxicity or allergens will trigger protein adhesion and a well organised [6, 7] physiologic inflammatory reaction with fibrosis and neovascularisation (Fig. 1).

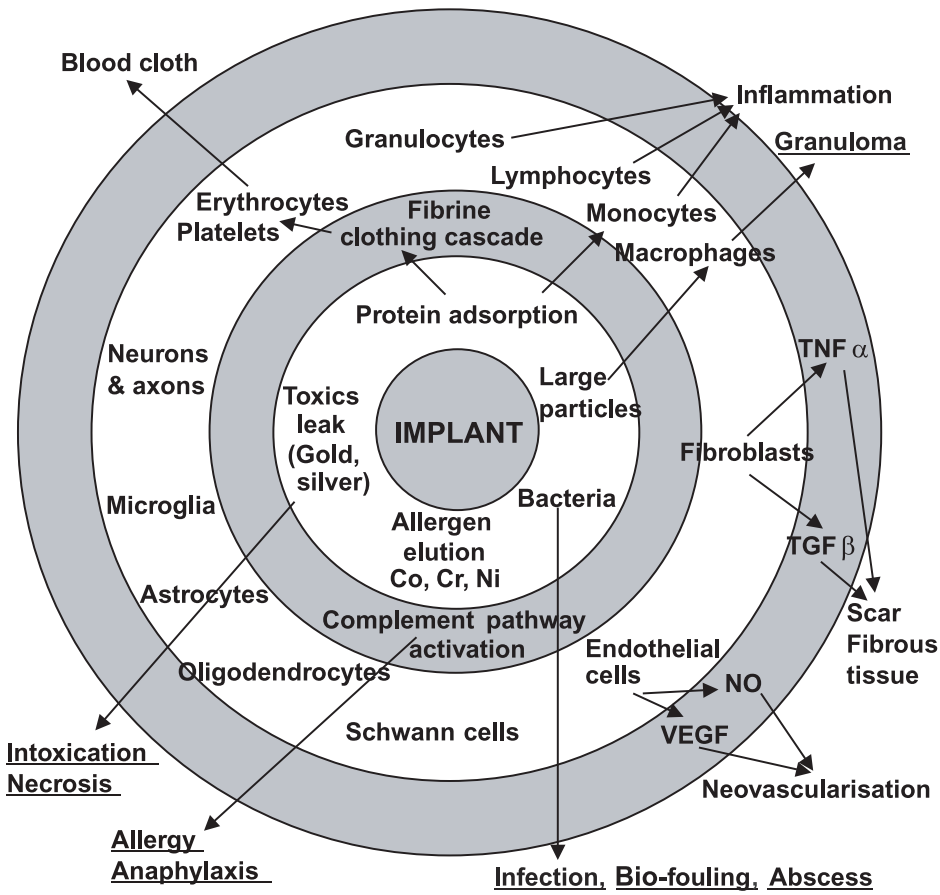

Fig. 1. Schematic view of events and actors activated by a neural implant. From the central circle (implantation) to the periphery: surface interactions (seconds), cell migrations (minutes), cell multiplication / differentiation (hours), paracrine cascades (days), matrix formation (weeks). The arrows underscore some major links. Underlined font is used for the adverse events