Modeling the electrical properties of olfactory receptors

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Sensing proteins (receptors) are nano-structures of about 5 nm diameter that exhibit very complex behaviors (they can pump ions, use energy from the environment, change their conformation, catalyze some reactions, etc). They are constituted by a specific sequence of amino acids (primary structure) and in this sequence the space organization (tertiary structure) is codified. The functioning of these macromolecules is intrinsically connected with their tertiary structure, which modifications are normally associated with their biological function. With the advance of nanotechnology, the investigation of the electrical properties of receptors has emerged as a demanding issue. Beside the fundamental interest, the possibility to exploit the electrical properties for the development of bio-electronic devices of new generations has attracted major interest of many researchers. From the experimental side we cite three complemetary kinds of measurements: (i) current voltage (I-V) measurements in nanometric layers of a given protein sandwiched between macroscopic contacts, (ii) I-V measurements within an AFM environment in nanometric monolayers of a given protein deposited on a conducting substrate, (iii) electrochemical impedance spectroscopy (EIS) meqasurements on appropriate monolayers of self-assembled samples of a given protein. From a theoretical side, a microscopic interpretation of these experiments is still a challenging issue. This paper reviews recent theoretical results carried out within the European project BOND (Bioelectronic Olfactory Neuron Device), which provides a first quantitative interpretation of charge transport experiments exploiting static and dynamic electrical properties of several sensing proteins. To this purpose we have developed an impedance network protein analogue (INPA), which considers the interaction between neighboring amino acids within a distance controlled by a given radius that is chosen appropriately as responsible of charge transfer throughout the protein. The conformational change of the protein structure, due to the sensing action produced by the capture of the ligand (photon, odour), induces a modification of the tertiary structure and thus of the electrical properties of the single protein. By a scaling procedure, the electrical change of the single protein when passing from the natural to the active state is used to interpret the macroscopic measurement obtained within different methods. The developed INPA model is found to be very promising for a better understanding of the role of receptor topology in the mechanism responsible of charge transfer. Furthermore, present results point favorably to the development of a new generation of nano-biosensors within the lab-on-chip strategy.

REFERENCES

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