Modelling neurological disorders using graphene-based neurovascular organoids derived from pluripotent human cells

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ABSTRACT

Neurological Disorders impose a heavy burden on human health. Self-organizing three-dimensional organoids derived from patient pluripotent cells are a promising new model to study neurological disorders and discover meaningful therapeutics. Brain organoids have revolutionized the way we will be studying neurological disorders in the next few years, however along with some important caveats: cell death due to poor oxygenation and nutrient availability and poor representation of the human brain cytoarchitecture and cell-types. To bypass these obstacles in brain organoid technology, vascularization (including endothelial and mural cells essential for vascular integrity) was recently proposed as the ideal addition to brain organoids to increase viability. To increase the validity of brain organoid models by promoting an accurate representation of human brain cytoarchitecture and cell-type representation, nanomaterials such as graphene were proposed as substrates for organoids. Graphene not only is thin yet extremely strong, optically transparent and a good conductor of heat and electricity, but it also acts as an excellent substrate for neuronal and vascular cells promoting neurogenesis and angiogenesis.

Project NEUROPHENE studies and develops models using neuronal and vascular cells and 3D neurovascular organoids cultured on graphene substrates, which are an excellent translational research model for studying the molecular and cellular underpinnings of neurological disorders. First, NEUROPHENE examines the effect of graphene as a substrate on neurovascular health. Second, NEUROPHENE investigates the incorporation of graphene in 3D vascularized brain organoids.

Establishing the graphene neurovascular organoid model within FORTH, via collaboration of BRI and IESL groups initiated a new line of multidisciplinary research. Graphene's versatility allows for the incorporation of further detection/biosensing applications in future versions of the platform (Electrophysiology to record neuronal activity, Optogenetics to control neuronal activity and investigate neural networks in human-derived brain organoids and Biosensing of neurovascular function using metabolic nutrient/oxygen biosensors). This will prompt new collaborations with the broader Neuroscience community within FORTH, with exciting future applications in nervous or vascular system disorders basic and applied research.

REFERENCES

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