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Merck KGaA, Darmstadt, Germany and Inbrain Neuroelectronics Collaborate to Develop the Next Generation of Bioelectronic Therapies

- **Innovation Center project of Merck KGaA, Darmstadt, Germany aims to develop smart neurostimulators for targeted treatment of chronic diseases**
- **Second collaboration within the Bioelectronics innovation field of Merck KGaA, Darmstadt, Germany focuses on increasing the selectivity and power efficiency of the device to enable energy intensive neurostimulation using graphene electrodes**
- **Joint development agreement represents a promising step towards the next generation of highly selective and efficient bioelectronic therapies**

Darmstadt, Germany, July 8, 2021 – Merck KGaA, Darmstadt, Germany, a leading science and technology company, today announced a second collaboration agreement in its Bioelectronics innovation field with Innervia Bioelectronics, a start-up and subsidiary of Inbrain Neuroelectronics S.L., Barcelona, Spain. The aim of the collaboration is to co-develop the next generation of graphene-based bioelectronic vagus nerve therapies targeting severe chronic diseases within the therapeutic areas addressed by Merck KGaA, Darmstadt, Germany.

“We aim to accelerate developments in the emerging field of bioelectronics by boosting the novel modality of selective neurostimulation,” said Laura Matz, Chief Science and Technology Officer of Merck KGaA, Darmstadt, Germany. “Today’s agreement with Innervia Bioelectronics gives our company access to a unique



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technology that increases energy efficiency in neurostimulators and could therefore become a true enabler for digital personalized treatment of patients suffering from severe and chronic diseases such as inflammatory disorders.”

Both partners will closely collaborate over the next few years to actively drive this potential paradigm change in treating diseases with high unmet medical needs. With its bioelectronics research facilities, Merck KGaA, Darmstadt, Germany is well equipped and can build on its data science, clinical, regulatory, and quality expertise to bring novel devices to patients in the near future. Innervia will add its technical expertise in the development of graphene interfaces, device development, and signal processing for clinical applications. Initial work will focus on inflammatory, metabolic, and endocrine disorders, using the promising capabilities of graphene for miniaturization, precision, and high modulation efficiency in the vagus nerve.

“This partnership highlights the importance of key players in their respective domains joining strengths to develop electronic therapies based on minimally invasive technologies and precise signal coding, enabled by graphene, for patients with debilitating, systemic, chronic conditions,” said Jurriaan Baker, CTO of Innervia Bioelectronics. “Our shared mission is to improve outcomes for these patients, who live with scarce information about their conditions and little control over their journey,” added Carolina Aguilar, Co-founder & CEO of Inbrain Neuroelectronics.

“Bioelectronic devices have the capability to directly communicate with the nervous system. Recording nerve signals and combining them with other accessible physiological datasets will lead to a better understanding of disease conditions and enable personalized treatment regimens,” said Robert Spoelgen, Head of Bioelectronics, Innovation Center of Merck KGaA, Darmstadt, Germany. “We are convinced that bioelectronic devices will play a significant role in the future therapeutic landscape.”

Altered and dysregulated nerve signals occur with many severe chronic diseases. Bioelectronic therapies aim to address a wide range of chronic diseases using small, implantable devices to modulate electrical signals passing along nerves in the body. Furthermore, neurostimulation devices are expected to become increasingly smart as a result of additional features such as continuous readouts, data analysis and

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data transmission, which will increase the energy use of the device. Yet at the same time, the devices are expected to miniaturize further. These trends are creating significant challenges for the supply of power to these devices. In addition, certain indications have particularly high and continuous power requirements due to the specific disease characteristics. With current technologies, it is extremely difficult to develop viable neurostimulation therapies for these indications.

Improving the energy efficiency of these devices will play an important role in overcoming this power supply dilemma, since alternatives such as energy harvesting are still in their infancy and are far from practical clinical applications. Reduced Graphene Oxide (rGO) offers ideal material characteristics for significantly decreasing power consumption while maintaining stimulation efficacy. This is achieved through a high charge injection limit combined with very low impedance compared with all other available electrode materials. Graphene, a two-dimensional material first isolated in 2004, is made of a lattice of carbon atoms only one atom thick and is the strongest material ever tested at roughly 100 times the strength of an equivalent thickness of steel. Innervia's technology harnesses the power of graphene, which has unique electrical and thermal conduction properties that are still being explored.¹

The Bioelectronics innovation field of Merck KGaA, Darmstadt, Germany builds on the company's experience and expertise in its Healthcare and Electronics business sectors. This collaboration agreement complements a [recently announced](#) partnership between Merck KGaA, Darmstadt, Germany, B. Braun and its start-up neuroloop GmbH to evaluate the feasibility of neurostimulators for targeted treatment of indications with high unmet medical needs.

About INNERVIA Bioelectronics

INNERVIA Bioelectronics, a subsidiary of INBRAIN Neuroelectronics, is dedicated to the development and commercialization of intelligent graphene interfaces designed to modulate vagus nerve signals, decoding them into medical solutions. For more information, please visit www.innervia-bioelectronics.com.

¹ Cao, K. (2020). "Elastic straining of free-standing monolayer graphene". Nature Communications. 11 (284): 284.

Novoselov, K. S.; Geim, A. K.; Morozov, S. V.; Jiang, D.; Zhang, Y.; Dubonos, S. V.; Grigorieva, I. V.; Firsov, A. A. (22 October 2004). "Electric Field Effect in Atomically Thin Carbon Films". Science. 306 (5696): 666–669.

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About INBRAIN Neuroelectronics

INBRAIN Neuroelectronics S.L., founded in 2019, is a medical device company dedicated to developing the world's first intelligent graphene-brain interface to treat a variety of conditions. INBRAIN's first product is designed to read and modulate brain activity, using artificial intelligence to trigger adaptive responses for personalized neurological therapy for epilepsy and Parkinson's disease. For more information, please visit www.inbrain-neuroelectronics.com.

Innovation Center of Merck KGaA, Darmstadt, Germany

To complement existing research and development in the three business sectors of Merck KGaA, Darmstadt, Germany, the company's Innovation Center team aims to create new businesses outside of the current R&D scope. It strives to unlock the untapped potential of Merck KGaA, Darmstadt, Germany by leveraging assets and competencies across sectors, generating projects around these assets, and ultimately incubating these ideas into viable new businesses. With [Bioelectronics](#) as the latest addition, the Innovation Center of Merck KGaA, Darmstadt, Germany now pursues projects in two innovation fields. In the [Cultured Meat](#) innovation field – also referred to as cultivated meat – the company focuses on the biotechnology required to produce genuine meat and seafood grown in vitro and aims to become the technology enabler for this emerging industry. Other projects in the Innovation Center include [OneZeroMed](#) a 3D printing (laser sintering) solution that will simplify tablet production tremendously, leading to significant cost and time savings during clinical development.

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About Merck KGaA, Darmstadt, Germany

Merck KGaA, Darmstadt, Germany, a leading science and technology company, operates across healthcare, life science and electronics. Around 58,000 employees work to make a positive difference to millions of people's lives every day by creating more joyful and sustainable ways to live. From advancing gene editing technologies and discovering unique ways to treat the most challenging diseases to enabling the intelligence of devices – the company is everywhere. In 2020, Merck KGaA, Darmstadt, Germany, generated sales of € 17.5 billion in 66 countries.

The company holds the global rights to the name and trademark "Merck" internationally. The only exceptions are the United States and Canada, where the business sectors of Merck KGaA, Darmstadt, Germany operate as EMD Serono in healthcare, MilliporeSigma in life science, and EMD Electronics. Since its founding in 1668, scientific exploration and responsible entrepreneurship have been key to the company's technological and scientific advances. To this day, the founding family remains the majority owner of the publicly listed company.