

## International School of Brain Cells & circuits “Camillo Golgi”

The Ettore Majorana Foundation and Centre for Scientific Culture opened, in 2015, the International school of brain cells & circuits dedicated to the Italian Nobel laureate “Camillo Golgi”.

The brain, with  $10^{12}$  neurons interacting through  $10^{15}$  synapses, is quite surely the most complex structure of the whole Universe. Neurosciences are systematically tackling brain functions at multiple complexity levels, from cells to microcircuits to the whole brain. Understanding the brain is a Grand Challenge for the Humankind with social implications in the biomedical and technological fields. Multiscale computational modelling is a new powerful approach for understanding the brain that has recently been supported by international initiatives like the *Human Brain Project* and EBRAINS.

The school of Brain Cells & Circuits will face hot topics in modern Neuroscience, providing the basics of understanding, fuelling discussion, and helping to form a critical perspective in the new generation of Neuroscientists. Our vision is that, to explain brain functions, it is fundamental to integrate molecular and cellular knowledge into microcircuits and large-scale networks through the use of multiscale computational models.

Further reading can be found in the review articles:

Modelling the brain: Elementary components to explain ensemble functions

Authors: *Egidio D’Angelo and Claudia Gandini Wheeler-Kingshott* (2017)

*Il Nuovo Cimento*. DOI: 10.1393/ncr/i2017-10137-5 pp. 297-333

The coming decade of digital brain research - A vision for neuroscience at the intersection of technology and computing.

Authors: *Amunts, et al.* (2022).

*Zenodo*. DOI: 10.5281/zenodo.6345821

The quest for multiscale brain modelling

Authors: *Egidio D’Angelo and Viktor Jirsa* (2022)

*Trends Neurosci.* 2022 Jul 26; S0166-2236(22)00125-4.

doi: 10.1016/j.tins.2022.06.007.

2023 course

## Modeling the brain in health and disease: towards digital twins

8<sup>th</sup> December 2023 – 12<sup>th</sup> December 2023

Ettore Majorana Foundation and Centre for Scientific Culture  
Erice (Italy)



**Course Directors:** *Egidio D’Angelo, Claudia Gandini Wheeler-Kingshott and Viktor Jirsa*

*The 2023 Course of the school of brain cells and circuits will be dedicated to the hot topic of brain digital twins: what is a digital twin and how can we construct it? What are the clinical fallouts of such emerging technology? What should we concentrate on as a multi-disciplinary community to achieve the highest impact? Modelling of molecular, cellular, microcircuits and large scale properties of the brain is fundamental for developing the building blocks of a brain digital twin. Once we have the scaffold, though, how can we personalize the brain digital twin in a way to maximise benefit for the single patients? The complexity of the brain requires all different modeling strategies to deal with both the complexity of its physiology and biology as well as with the data generated by current imaging (primarily MRI) and neurophysiological techniques. The problem therefore requires understanding of single neurons and local microcircuits as well as of global network behaviors. The course will include discussion on fundamental definitions, on data collection and on validation. From the discussion sections and networking events of the course we will forge new collaborations and foster the development of ideas on what to concentrate on in years to come, inspiring young and established scientists, promoting inter-disciplinary integration.*

## Preliminary Programme

### Arrival day – 7th December 2023

**9pm : Evening gathering in the Marsala Cellar St. Rocco Monastery, main cloister**

Marsala wine and marzipan pastries typical of Erice.

Music and chats as people join in.

### Day 1 – 8th December 2023

#### FOUNDATION LECTURES, SIMULATION ENVIRONMENTS & NEUROINFORMATIC INFRASTRUCTURES

10:00 – **Physiology**  
*Egidio D'Angelo*

11:00 – **MRI**  
*Mara Cercignani*

12:00 – **Dynamic systems**  
*Alessio Marta*

13:00-15:00 *Lunch*

15:00 – **Neuron and microcircuit modeling platforms: Neuron, Arbor, Nest, BSB**  
*Alessio Marta*

15:30 – **NEST**  
*Alice Geminiani*

16:00 – **BSB**  
*Alberto Antonietti*

16:30 – **TVB**  
*Spase Petkoski & Fulvia Palesi*

### Day 2 – 9th December 2023

#### CONSTRUCTION OF BRAIN DIGITAL TWINS

08:30 – **Welcome**

09:30 – **Multiscale brain modelling & digital twins**  
*Egidio D'Angelo*

10:30 – **What is a digital twin & what it should be**  
*Huifang Wang*

11:00-11:30 *Coffee Break*

11:30 – **Cellular models**  
*Michele Migliore*

12:15 – **Multi-area and multi-scale circuits with spiking neural networks**  
*Alberto Antonietti*

13:00-15:00 *Lunch*

15:00 – **Applications of spiking neural networks to simulations of neuropathologies**  
*Alessandra Pedrocchi*

15:45-16:15 *Coffee break*

16:15 – **Mean field models**  
*Alain Destexhe*

17:00 – **Questions and general discussion on what a digital twin is**

## Day 3 – 10<sup>th</sup> December 2023

### SOCIAL OUTING

Networking & team building day out – visiting something nice, e.g. Selinunte temples or Mozia salt Island.

## Day 4 – 11<sup>th</sup> December 2023

### DATA AND STRATEGIES FOR PERSONALISED DIGITAL TWINS

09:00 – **Microstructure modelling from large scale signals**  
*Marco Palombo*

09:30 – **Measuring functional and structural brain connectivity**  
*Mara Cercignani*

10:00 – **The importance of conduction delays**  
*Matteo Mancini*

*10:30-11:00 Coffee break*

11:00 – **Cellular biology data from patients iPSC**  
*Jenny Pocock*

11:30 – **Questions and general discussion - data integration & validation**

*12:30-14:30 Lunch*

14:30 – **From synchrony to asynchrony: data and modelling of consciousness levels**  
*Mavi Sanchez Vives*

15:15 – **Lightening talks from poster presenters (Moderator: Marisa Saggio)**

*16:30 Coffee break and poster presentations in San Rocco*

## Day 5 – 12<sup>th</sup> December 2023

### CLINICAL PERSPECTIVES OF DIGITAL TWINS

09:00 – **Strategies for personalisation of digital twins**  
*Claudia Gandini Wheeler-Kingshott*

09:45 – **Towards digital twins for understanding dementia and cerebellar ataxia**  
*Fulvia Palesi*

*10:30-11:00 Coffee break*

11:00 – **Digital twins for epilepsy**  
*Huifang Wang*

11:45 – **Is there a role for brain digital twins in predicting therapy outcomes?**  
*Neil Harrison*

*12:30-14:30 Lunch break*

14:30: 15:00 – Group photo and Poster award

15:00 – **Digital Twin for ageing**  
*Viktor Jirsa*

16:00 – **Questions and general discussion: what's next for digital twins in physiology and pathology**

17:00 – **Conclusions & farewell**