

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

8th December 2023 – 12th 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 behaviours. 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 and Biophysics**

Egidio D'Angelo

11:00 – **MRI**

Mara Cercignani

12:00 – **Dynamic systems**

Alessio Marta

13:00-15:00 *Lunch*

15:00 – **Overview of neuron and microcircuit modeling platforms: Neuron, Arbor, NEST, BSB**

Danilo Benozzo

15:30 – **BSB and atlasing**

Dimitri Rodarie

16:00 – **NEST and cosimulations**

Marialaura De Grazia

16:30 – **TVB**

Spase Petkoski & Anita Monteverdi

Day 2 – 9th December 2023

CONSTRUCTION OF BRAIN DIGITAL TWINS

08:30 – **Welcome**

09:00 – **Multiscale brain modelling & digital twins**

Egidio D'Angelo

09:45 – **What is a digital twin & what it should be**

Viktor Jirsa

10:30-11:00 Coffee Break

11:00 – **Molecular models**

Janette Hellgren Kotaleski

11:45 – **Cellular models**

Michele Migliore

12:30 – **Multiarea and multiscale 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 – 10th December 2023

SOCIAL OUTING

Networking & team building day out – Christmas markets!! Or visiting something nice, e.g. Selinunte temples or Mozia salt island 😊

Day 4 – 11th December 2023

DATA AND STRATEGIES FOR PERSONALISED DIGITAL TWINS

08:30 – Strategies for personalisation of digital twins

Claudia Gandini Wheeler-Kingshott

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 – Lightning talks from poster presenters (*Chair: Marisa Saggio*)

16:00-16:30 Coffee break

16:30 - Decision making using virtual brain models

Petra Ritter

17:15 - Twins beyond the brain

Marc Tittgemeyer

Day 5 – 12th December 2023

CLINICAL PERSPECTIVES OF DIGITAL TWINS

09:00 – From synchrony to asynchrony: data and modelling of consciousness levels

Mavi Sanchez-Vives

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 – Group photo and Poster award

15:00 – Digital Twin for aging

Viktor Jirsa

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

17:00 – Conclusions & farewell