

ITALY

# Bio Minds



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parallel zero



Pontedera (Pisa). Emanuela Del Dottore, researcher at the Italian Institute of Technology, demonstrates the Plantoid created by Barbara Mazzolai and her team. Plantoid recreates the behaviour of plants that move away from negative events and are attracted to positive ones, using roots to dig into the ground in search of nutrients and safety. It is a system that could be used to find resources or survivors in disaster situations, but also on Mars to find water or other forms of life. Today it is used in agriculture: a project of the Tuscany regional administration is trialling it in the cultivation of vines. The robot analyses the soil and the state of the plants and sends signals to drones that are able to see to the irrigation, fertilisation and treatment of sick plants.





Florence, Villa Torrigiani. The Torrigiani garden is one of the most verdant areas within the Florentine walls: a wonderful private park spanning 6 hectares, rich in species of trees and plants from all over the world. This park is a UNESCO Heritage site and a precious legacy from 19th century Florence.



## How models from the natural world can help us solve problems

- ▶ Biology is a precious source of inspiration for developing ingenious solutions and finding sustainable models.
- ▶ Biomimetics is the study and imitation of mechanisms that govern nature in order to create artificial solutions.
- ▶ Intelligent systems and modular architecture are often inspired by the plant world.
- ▶ Biomimicry can be applied to renewable energies, medicine, the textile industry, architecture and robotics.
- ▶ Increasingly robots are imitating nature and resembling living organisms.

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Pontedera, the Institute of BioRobotics at the Sant'Anna School of Advanced Studies, Pisa. Soft robotics applied to medicine, from the larynx to vocal cords have been created by the team of Cecilia Laschi, lecturer in Industrial Bioengineering at the Institute, one of the pioneers of soft robotics, a branch dedicated to the development of machines with soft and malleable surfaces.





Pontedera (Pisa), IIT. Saravana Prashanth Murali Babu studies the behaviour of snails in order to create robots that imitate their movement; he is trying to reproduce the locomotion and adhesion of the snail. The snail is one natural example that is being studied in robotics.





Padua, Botanical Garden. The Biodiversity Garden was designed as a site for conserving biodiversity. Telmo Pievani is a philosopher of evolutionary science and Italy's first professor of Philosophy of Biological Sciences, at the Department of Biology at the University of Padua.



We are mere visitors in the garden that is called Earth. In this garden 97.3% of the biomass is vegetation, the remaining 2.7% is made up of animals: insects (two thirds) and fish, birds and mammals (the remaining third). The human race, with its seven billion individuals, represents just 0.01% of the entire biomass: nevertheless, it has managed to impose its own development model, which is destroying the natural habitat. Frequently, however, the natural world, with its organisation, its development model and its synergies, can show us possibilities for tackling problems.

“Bio-inspiration”, in fact, is the concept of using biology and nature as a source of inspiration for developing human ingenuity, identifying models that are more sustainable and developing green technology, reducing the pollution of air and water, inspiring modular architecture and intelligent systems without a command centre. Trees, fungi and bacteria can help mankind combat the pollution of the soil and the water table.

To an increasing extent robots are being inspired by nature and are designed to be more similar to living organisms, both in terms of sensorial and locomotive capacities, and in the field of materials science. Then there is biomimetics (also known as biomimicry) a field of research that – by studying the main biological principles of organisms with the purpose of transforming them into artificial solutions – can be applied to diverse fields, from the production of renewable energy to medicine, from the textile industry to design, architecture and robotics.





Pisa, Biology Department, bioremediation with fungi and bacteria. Simone Becarelli, a chemist specialized in the purification of waste water, observes a flask containing soil samples that contain potentially volatile hydrocarbons. Bioremediation is an effective and versatile cleaning technology, it can be carried out in situ to remove environmental contaminants. The principle is based on exploiting the action of microorganisms already present in the polluted environment. Thanks to genetic engineering methods it has been possible to extend the scope for its application.



Pontedera (Pisa), Sant'Anna School of Advanced Studies. Robotic arms in soft materials bio-inspired by octopus tentacles. The soft robots are created with soft, flexible materials, inspired by nature, capable of interacting safely with man and the external environment. The school has a multi-disciplinary approach bringing together in a single research institute robotics experts, botanists and mathematicians as well as specialists in material sciences, design and IT.



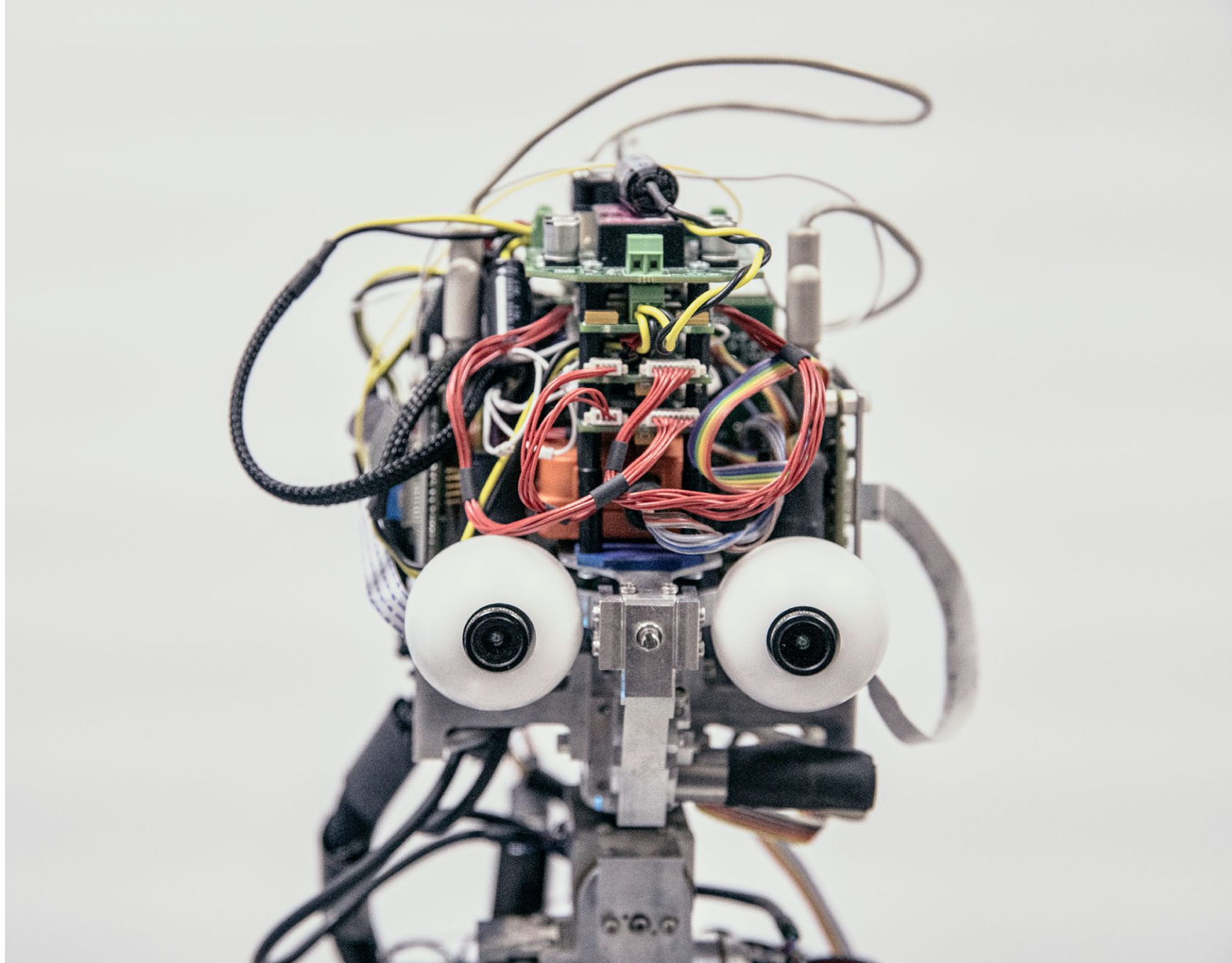


Pontedera (Pisa). Barbara Mazzolai, director of the centre of Micro BioRobotics at the IIT has created the first Plantoid and is coordinating the GrowBot project, the goal of which is the creation of robots capable of climbing and adapting to their surrounding environment, just as plants do. The new climbing robots can potentially be used in architectural or urban planning scenarios or for archaeological exploration.



San Miniato (Pisa). LIFE ZEOWINE is a demonstration project financed by the European Community that aims to improve the protection and management of the soil, the health of vines and the quality of grapes and wine, through the application to the soil of the innovative product ZEOWINE derived from composted waste matter from the wine production cycle plus zeolites.





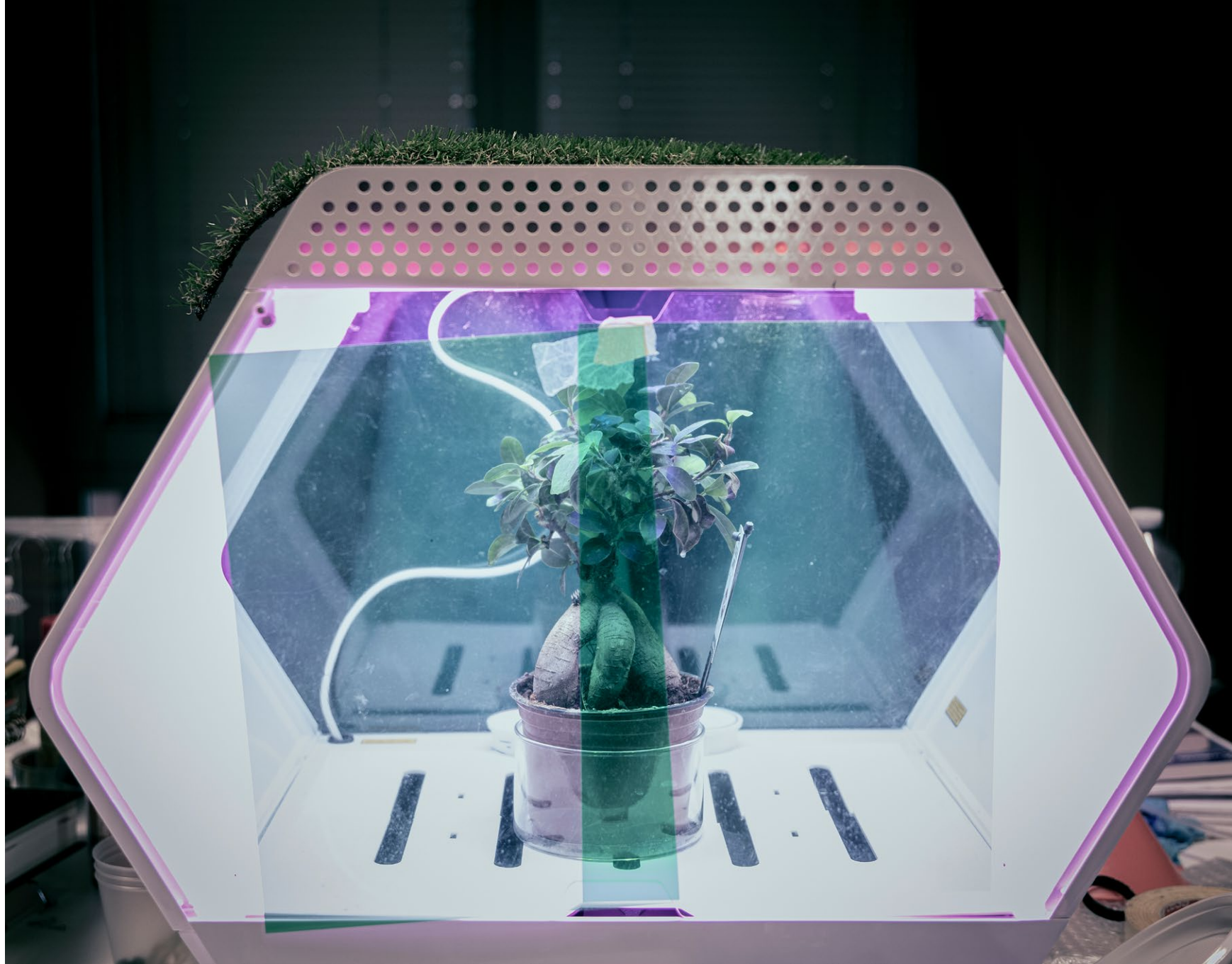
Pontedera (Pisa), the Institute of BioRobotics - Sant'Anna Valdera. A humanoid robot platform on which Artificial Intelligence algorithms are tested. AI is being used increasingly often in robotics to optimize robots' capacity for autonomy and learning, or to enable them to anticipate future situations through acquiring knowledge in a perceptive or imitative way.





Parma, Botanical Garden. Renato Bruni, works at the Department of Food Science and Pharmacy at the University of Parma, where he studies medicinal plants, dietary supplements and various chemical substances produced by plants. He is the co-founder of the research group LS9-Bioactives & Health dedicated to studying the links between applied botany, natural substances, food, health and nutrition.





Pontedera (Pisa), IIT, the Italian Institute of Technology. A small greenhouse containing bonsai trees. At IIT plant behaviour is studied in order to create bio-inspired robots.





Padua, Botanical Garden. Aquatic lettuce (*Pistia Stratiotes L.*) is a perennial, tropical, aquatic and invasive plant from the arum family, araceae, frequently used as ornamental plants in aquaria and ponds. This species is called Pistia. It has hydro-repellent properties that are inspiring researchers who are trying to create impermeable fabrics.





Pisa, Department of Biology, bioremediation with fungi and bacteria. Simona di Gregorio is about to enter the room where the contaminated soil is kept. She is wearing a gas mask in order to protect against dangerous aerosols. Bioremediation is an effective cleaning technology. The principle exploits the action of microorganisms already present in the polluted environment.



Pontedera (Pisa), IIT, the Italian Institute of Technology. A robotic tentacle to retrieve objects from inaccessible places such as oil wells. The bio-inspired arm of the octopus can grasp shapes that are not easy to pick up, such as a spanner.





Florence, Manifattura Tabacchi. La Fabbrica dell'Aria (The Air Factory) is the first prototype of an innovative solution to reduce indoor pollution, designed by neurobiologist Stefano Mancuso and PNAT, a collective of designers, architects and biologists. This device uses and improves plants' capacity to absorb and degrade atmospheric pollutants. It is a fully-fledged botanical filtration system, with its own peculiarities that differ from traditional filtration systems: pollutants are separated by biological activities and are incorporated into the plants' biomass. Using a mass spectrometer, the data collected concerning the air quality has demonstrated a 98% reduction in the atmospheric pollutants.





Baratti (Livorno), the interior of Casa Esagono, the holiday home of architect Vittorio Giorgini, inspired by a beehive. On the wall is an architectural design of the Casa Balena (the Whale House), Vittorio Giorgini's most famous work. Bio-inspired because the idea started with the observation of nature. The house now belongs to the Piombino municipal council.





Pisa, Department of Biology, bioremediation with fungi and bacteria. A researcher observes a fungus colony of isolated fungi. Bioremediation is an effective and versatile cleaning technology, applicable in situ without the need for removing the contaminated environmental matrix. The principle exploits the action of microorganisms already present in the polluted environment. Thanks to genetic engineering methods, it has been possible to extend the scope of its application.



Padua, Botanical Gardens. *Arabica Coffee plant L.* Used as a stimulant due to the presence of caffeine, an alkaloid.





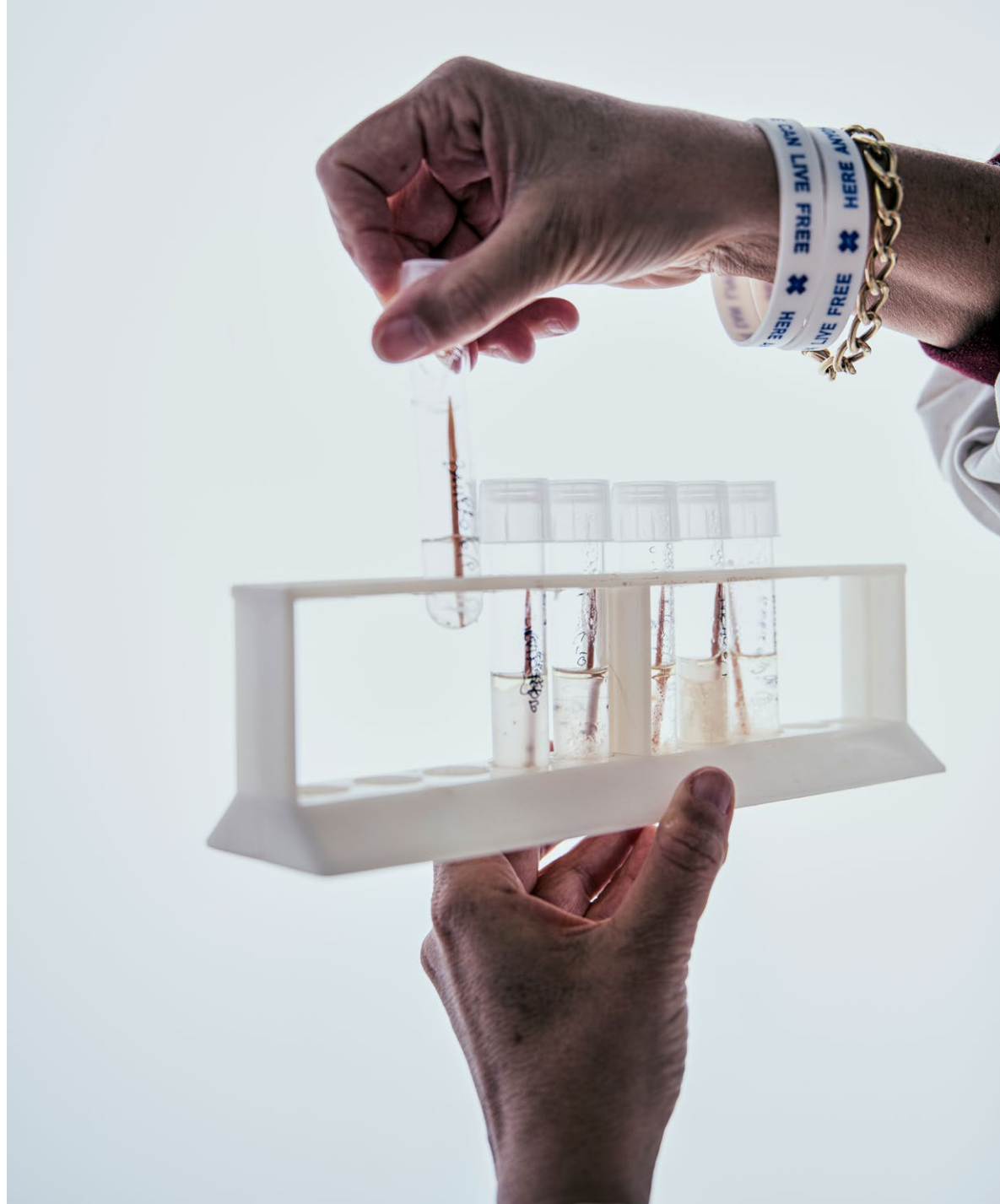
Pontedera (Pisa), IIT, the Italian Institute of Technology. The nanotechnology laboratory: here elements from the natural world are studied in order to create bio-inspired materials. The IIT has a multi-disciplinary approach and combines in a single research institute experts, botanists and mathematicians as well as specialists in materials science and IT.





Parma, Botanical Garden. The original garden, known as the "Giardino dei Semplici", was created in 1630 by Enrico Velario of Brabantia, at the behest of Duke Ranuccio I Farnese; directly connected with the Faculty of Medicine at the University of Parma, it was a space dedicated to the cultivation of medicinal plants.





Pisa, Department of Biology, bioremediation with fungi and bacteria. Bacteria cultures in bacteriological tubes from contaminated soil. Bioremediation is an effective cleaning technology. The principle exploits the action of microorganisms already present in the polluted environment.



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