MASTER OF SCIENCE IN

# COMPUTATIONAL BIOLOGY AND BIOMEDICINE

Bioinformatics
Biomedical signal and image analysis
Modeling in neuroscience

*A truly inter-disciplinary one-year learning experience*

University of Nice Sophia Antipolis, France

# University of Nice Sophia Antipolis

**University of Nice Sophia Antipolis** (UNS) covers the entire area of Alpes-Maritimes, with 8 colleges, 2 institutes and 2 undergraduate schools (Ecole Polytechnique Universitaire and IUFM – School for Teachers). With a total of more than 26,000 students, UNS brings to the region a great capacity for research and development:
» Ranked second in France as a multi-disciplinary university
» Ranked among the Top Ten French universities focused on research
» 1,000 professor-researchers
» 1,300 PHD students within its 5 PHD programs

**Scientific research** has a predominant place at UNS and its achievements are recognized internationally, **in all major sciences:**
» Maths
» Physics
» Sciences
» Information and communications technologies
» Environment and Astronomy studies
» Human and social sciences

**Research at UNS is focusing its resources in three major directions:**
» Research and Development
» Education/Training (undergraduate and graduate) and ongoing education
» Relationship with the workplace (research projects, placement, etc.)

**www.unice.fr**

for more information

**Research at UNS mobilizes about:**

• **52 research labs accredited by the French Ministry of Education, with among others:**

20 CNRS-UNICE units
7 INSERM-UNICE units
1 INRA – UNICE unit
1CEA-UNICE unit

• **Partnerships with French research institutes like INRIA, OCA, IRD, ENS and several French and foreign universities**

• **Leadership of the PRES Euro-Méditerranée**

Euro-Mediterranean Center for Research and Higher Education

With the following partners:
• in France : Universités Pierre et Marie Curie (Paris VI), Corse, Toulon Var
• in Italy: : Universities of Genoa and Turin

# Meet the new challenges

While biological data exhibits a formidable diversity, the past two decades have seen the advent of massive data produced either by high throughput experiments or by measurement devices of increasing accuracy at very different scales ranging from nano to macro. Handling these massive and complex data within a virtuous cycle linking modeling and measurements is one of the major challenges in Computational Biology and Biomedicine.

To take up this challenge and foster new discoveries in biology and new applications in medicine, the ambition of Master of Science in Computational Biology is to provide a state-of-the-art training geared towards computational biology in computer science, mathematics and statistics to address biological and medical problems. So this new master program from University of Nice Sophia Antipolis is specially tailored for students interested in a truly interdisciplinary learning experience.

The scientific goal of this program is to focus on the human being from different perspectives (understanding and modeling functional aspects or interpreting biomedical signals for various devices) and at different scales (from molecules to organs and the whole organism).

The aim of this program is to provide excellent academic or industrial career opportunities by offering high level coverage of modeling and computing principles that will enable the challenges to be met and make tomorrow's technological choices in biological, medical computing domains. To achieve this, classes will be given by outstanding professors and researchers from the research institutes in the campus: Nice Sophia Antipolis University/CNRS (I3S, IPMC, LJAD, INLN) and INRIA.

Elisabetta De Maria and Théo Papadopoulo
Coordinators of the program

**Program committee:**
G. Bernot (UNS-I3S), F. Cazals (INRIA), B. Cessac (INRIA), E. De Maria (UNS-I3S), F. Diener (UNS), F. Duprat (CNRS-IPMC), P. Kornprobst (INRIA), O. Meste (UNS-I3S), T. Papadopoulo (INRIA), X. Pennec (INRIA), J. Zerubia (INRIA)

**www.computationalbiology.eu**

for complete program details

Jacques Pouysségur

CNRS Research Director

Member of EMBO, the French Academy of Sciences and Academy of Europea

Biologist

*"Biology is experiencing an extraordinary revolution. With the emergence of new technologies, this last decade has seen an acceleration in knowledge in the fields of genomics, proteomics and metabolomics. While the functionality of each gene product remains to be deciphered by biologists they need urgent assistance. This amazing explosion of new data requires new skills into data managing, informatics, imaging, physics, mathematic modelling, to integrate and resolve the multiple layers of the complexity of cellular and organismal networks. Highly qualified Master students capable of speaking with biologists and of creating and implementing strong computational and mathematical tools are needed in academic and developmental research laboratories. This new Master program in Computational Biology is being set up in the High Technology Park of Sophia Antipolis, which is known for its excellence in Mathematics, Informatics and Biology. It is now urgent to accompany the revolution in Medical Biology with a revolution in Training. Now is the time to apply."*

Olivier Faugeras

INRIA Research Director

Member of the French Academy of Sciences

*Computer Scientist and Mathematician*

*"Biology, and neuroscience in particular, has not yet benefited as much as physics from the "unreasonable effectiveness of mathematics", to quote the physicist and Nobel prize winner Eugene Wigner (1960). This is probably because most of the relevant mathematical theories, such as the theory of bifurcations in dynamical systems or stochastic calculus, have only been developed in the second part of the 20th century and are not taught in our engineering schools and departments even at the Masters level. One of the exciting goals of this new Master is to face this challenge and bring our students up to speed so that they are able to apply these modern mathematical tools to real biological problems. "*

# Environment

## Sophia Antipolis

Sophia Antipolis is a wide scientific park of approximately 1300 corporations and 30.000 jobs in R&D, mainly focusing on information technology, multimedia, medicine and bio-technologies.

University of Nice Sophia Antipolis and the CNRS with their multiple laboratories and research and training institutes, the IUT and the IUP, are highly integrated and in harmony with the knowledge and the know-how of the site.

The engineering schools and research organisms (INRIA, CNRS, INRA, EURECOM, CERMICS, CERAM, Ecole National Supérieure des Mines and Polytech'Nice Sophia) consolidate the strategic vision of Sophia Antipolis in the subject matter of training.

## A rich network to start your career

You will have access to a wide network of contacts helping you to find the best opportunities for your internship, PhD or industrial position. Our professional network includes partners from other French or international academic institutions, but also industrial partners such as Galderma, General Electric, Leica, MXM, Philips, Sanofi-Aventis, Siemens, Sobios, Zeiss.

## Polytech'Nice-Sophia

All courses will be given in English in the Polytech'Nice-Sophia French engineering school from the University of Nice Sophia Antipolis. Polytech'Nice-Sophia developed since more than 15 years exceptionally strong partnerships with the industry world, which is achieved through numerous R&D projects in France and Europe.

## On-site equipments and devices

• **IPMC**
- • Around 20 electrophysiological workstations (patch clamp, microelectrodes, ERG), and physiology workstations (arteriography, myography)
- • IPMC imaging and flow cytometry core facility: Confocal microscopy, two-photons microscopy, video-microscopy, standard fluorescence and transmitted light microscopy, flow cytometry
- • DNA sequencing: DNA sequencer Applied ABI3100
- • Proteomic: Maldi-TOF and Maldi-TOF-TOF mass spectrometers, nano HPLC, 2D gelelectrophoresis, peptide sequencer.
- • Genomic platform: Production line of pangenomic DNA microarrays

• **IBDC**
- • Molecular biology, cell biology, biochemistry and animal housing facilities: Quantitative PCR, protein analysis, cell culture, flow cytometry, hypoxic incubators, LPLC, /in vivo/ experimentation, etc.
- • Scientific Imaging: 2 wide-field microscopes, deconvolution microscope, 2 confocal microscopes, 2 multi-photon microscopes (including Second Harmonic Generation and Laser Microsurgery), confocal macroscope.

• **C3M Nice L'Archet, IPMC Valbonne, CCMA Valrose**
- • Correlative microscopy imaging platform: Scanning electron microscopes (SEMs), transmission electron microscopes (TEMs), Confocal microscopes, Two-photons microscope, Standard fluorescence and transmitted light microscopes.

• **INRIA, Athena project team**
- • 64-channel EEG recording device, within a dedicated Faraday room

• **INRA and IBDC**
- • Confocal microscopy

• **Equipe DyVA, INCM (UMR6193 CNRS Université Aix-Marseille**)
- • Optical imaging

# Scientific Program

**M2S1(30 ECTS)**

**A 2 week of intensive course (2ECTS)** will be proposed at the beginning of the program to help students learn the basics and main concepts in the mother disciplines (biology and mathematics).

**A 16 week course of half day lectures** (22 ECTS). *8 required* courses (16 ECTS) will be complemented by *3 elective* courses (6 ECTS) chosen from the MSc panel with the assistance of the coordinator to form a coherent plan of study.

**M2S2 (30 ECTS)**

A **project** to specialize yourself (6 ECTS).

**6-month paid fulltime internship in research lab or industry**
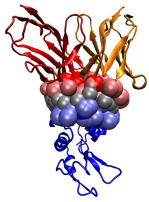
**Basics**

BASICS IN MATHEMATICS:
MULTIVARIATE ANALYSIS AND OPTIMISATION, GEOMETRY, RUDIMENTS OF PROBABILITY AND DATA ANALYSIS, DYNAMICAL SYSTEMS
F. Delarue (UNS)

BASICS IN BIOLOGY AND MEDICINE
FOCUS ON NERVOUS SYSTEM, HEART, CANCER, IMAGING TECHNIQUES
F. Duprat (IPMC)

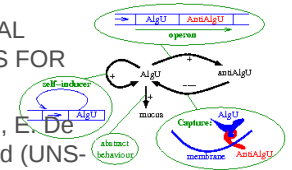BASICS IN COMPUTER SCIENCE

**Required courses**
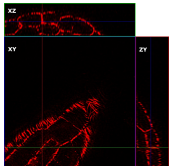
## Bioinformatics

ALGORITHMIC PROBLEMS IN COMPUTATIONAL STRUCTURAL BIOLOGY; UNDERSTANDING PROTEINS AND PROTEIN INTERACTIONS

F. Cazals (INRIA)

DISCRETE AND DIFFERENTIAL MODELS, SOFTWARE TOOLS FOR BIOCHEMICAL NETWORKS

J.L. Gouze, M. Chaves (INRIA), E. De Maria (UNS-I3S) and A. Richard (UNS-I3S)
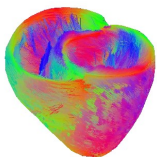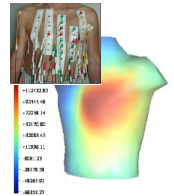


## Biomedical signal and image analysis

DECONVOLUTION AND DENOISING FOR CONFOCAL MICROSCOPY

J. Zerubia (INRIA) and Laure Blanc-Feraud (CNRS)

DIGITAL SIGNAL PROCESSING FOR THE ANALYSIS AND MODELING OF ELECTROPHYSIOLOGICAL RECORDS
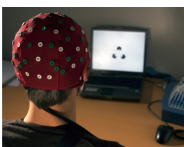
O. Meste, P. Comon and V. Zarzoso (CNRS-I3S)

COMPUTATIONAL ANATOMY AND PHYSIOLOGY OF THE HUMAN BODY

X. Pennec, H. Delingette, G. Malandain and N. Ayache (INRIA)

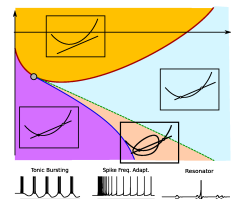VARIATIONAL METHODS AND GEOMETRIC FLOWS FOR BRAIN IMAGING

R. Deriche (INRIA)
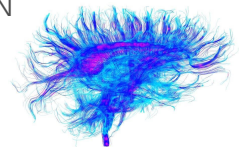
## Modeling in neuroscience

INVERSE PROBLEMS IN FUNCTIONAL BRAIN IMAGING
M. Clerc and T. Papadopoulo (INRIA)

NEURON DYNAMICS
B. Cessac and O. Faugeras
(INRIA)

# Admission information

## Admission Criteria

This international program is is open to french or foreign students.It is designed for those having completed the first-year Master program at their home institution in either computer science, electrical engineering, applied mathematics, mathematical biology, bioinformatics or biophysics. All courses are taught in english.

By Master program, we refer to the basic framework adopted in Europe which is of three cycles of higher education qualification. The cycles are defined in terms of qualifications and European Credit Transfer and Accumulation System (ECTS) credits:
» **1st cycle**: typically 180 - 240 ECTS credits, usually awarding a Bachelor's degree. [3 years]
» **2nd cycle**: typically 90 - 120 ECTS credits (a minimum of 60 on 2nd-cycle level). Usually awarding a Master's degree. [2 years]
» **3rd cycle**: Doctoral degree. No ECTS range given. [3 years]

If the structure of the curriculum in your country is different (e.g., your bachelor lasted four years), we shall check whether your curriculum is equivalent to a Master 1 degree, based upon your transcript of record and the information you will provide in the application form.

## Procedure

Applications must be submitted through the MSc website where application and referee forms are available. There are two selection rounds. It is in the applicant's best interest to submit his/her application at the first round of applications to increase the chances of receiving a scholarship.

## Contact Information

### Coordinators of the program
Elisabetta De Maria and Théo Papadopoulo
Email: cbb@unice.fr

**Head of BIM**
Francine Diener
**Head of Computer Science Department**
Jacques Farré

## Tuition Fees

The French educational system allows all students to follow their studies with a low cost financial commitment. The cost of this program is based on regular French university fees which is approximately 600 euros. Tuition fees cover course expenses.

## Scholarship

The scholarship program offers outstanding foreign students the chance to receive a grant for the first half of the program (M2S1) covering life expenses.The second half (M2S2) will be funded by the employer (research lab or industry) for every student who is admitted to
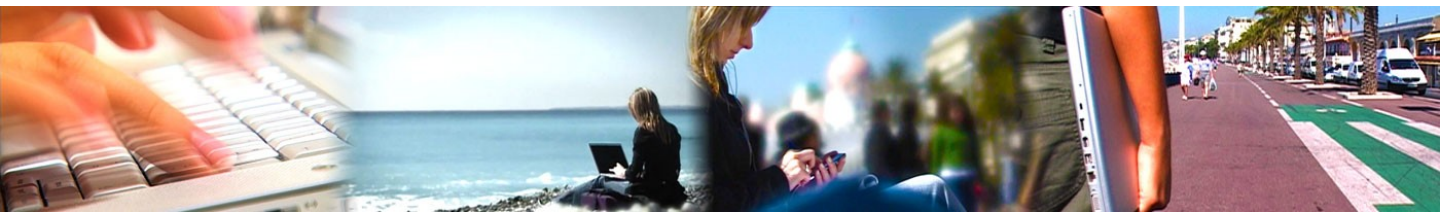the program.

## Housing

Several low cost University residences in Sophia Antipolis welcome students during the academic year. Antibes and Nice which are nearby cities also have
accommodation possibilities.

## French lessons

French lessons will be proposed to foreign students to teach them the basics

November:
First round of applications

Beginning of May
Notification of acceptance for the first round

May – June
Second round of applications

End of June
Notification of acceptance for the second round
Most recent information available at:
http://cbb.unice.fr

# Faculty

**Nicholas Ayache**, Research Director, INRIA project team leader. *2008 Microsoft Prize for Research in Europe and 2006 Grand Prize EADS*
PhD, Université Paris XI, France
Research interest: biomedical image analysis and simulation.

**Guillaume Baudin**, Senior Resident, University Hospital of Nice, France.
MD, Medical and Interventional Imaging Unit, Archet 2 Hospital, Nice, France.
Research interest: imaging, interventional, oncology, CT-scan, MRI, X-rays, ultrasound, MRI.

**Laure Blanc-Fér**aud, Research Director, CNRS-I3S
PhD, Université de Nice-Sophia Antipolis, France
Research interest: inverse problems in image processing, variational approach, PDEs, optimization algorithms, parameter estimation, satellite images, biological images.

**Frédéric Brau**, Research Engineer, CNRS-IPMC.
PhD in Life sciences, Université Claude Bernard, Lyon, France
Research interest: standard fluorescence and transmitted light microscopy, flow cytometry

**Frederic Cazals**, Research Director, INRIA. Project team leader
PhD, Université de Paris VII, France
Research interest: Protein complexes, macro-molecular flexibility, geometric modeling, computational geometry, applied differential geometry, data structures.

**Bruno Cessac**, Research Director, INRIA.
PhD, Université de Toulouse, France
Research interest: Dynamical systems, statistical physics, neural dynamics, complex systems.

Madalena Chaves, Research scientist, INRIA.
PhD, Rutgers University, New Jersey, USA
Research interest: Dynamical systems, control theory, applications to biological networks.

**Maureen Clerc**, Research scientist, INRIA.
PhD, Ecole Polytechnique, France
Research interest: inverse problems, signal processing, numerical approximation, bioelectromagnetism, electroencephalography, functional neuroimaging.

**Pierre Comon**, Research Director, CNRS-I3S, *IEEE distinguished lecturer in 2002-2003, Monpetit price from the French Academy of Sciences in 2005, Individual Technical Achievement Award TAA from Eurasip in 2006, Fellow Member of the IEEE, Emeritus member of the SEE*
PhD, Université de Grenoble
Research interest: Signal processing, high-order statistics, tensors, blind techniques, inverse problems, statistical sensor array processing, data analysis, biomedical, environment.

**Frédéric Dayan**, Sobios
PhD in Life Sciences Universite de Nice-Sophia Antipolis, France
Engineer in Physics & Chemistry (ESPCI Paris), PharmD in University Rene Descartes, Paris.
Research interest: Analysis and modelling of biological dynamics.

Hervé Delingette, Research Director, INRIA
PhD, Ecole Centrale Paris
Research interest: Simplex meshes. Surface regularization, surgery simulation, cardiac modelling, computational physiology, image segmentation.

**Elisabetta De Maria**, Maitre de Conference, UNS-I3S. Research interests : coupling biological models, protein structure prediction problem, biological sequence comparison, model-checking, games-theory.

**Sophie Demolombe**, Principal Investigator, CNRS
PhD in Biochemistry, Orsay (Paris XI), France Winner of the Edouard Coraboeuf Prize for Research 2008
Research interest : Ion channels, heart, arrhythmias, stretch

**Olivier Deschaux**, Lecturer, UNS
PhD in Neuroscience, University of Pierre and Marie Curie (Paris)
Research interest : Learning, Memory, Post traumatic stress disorder

Rachid Deriche, Research Director, INRIA. Project team leader.
PhD, Université de Paris-Dauphine, France
Resarch interest: Computational brain imaging, mathematical image processing, variational methods, geometric flows for curves and surfaces, inverse problems.

Fabrice Duprat, Researcher, INSERM-IPMC. *"Chair of excellence" (Interface contract) in Université de Nice-Sophia Antipolis*
PhD in Life sciences, IPMC, CNRS, Valbonne, France
Research interest: Ion channels, mechanoperception, central and peripheric nervous systems, neurons, vascular system, arteries, aneurysms, fluorescence imaging, in-vivo imaging, electrophysiology

**Olivier** Faugeras, Research Director, INRIA. Project team leader. *Member of the French Academy of Sciences, Academy of Technologies*
PhD in Computer Science, University of Utah, Doctorat ès Sciences Mathématiques, Université Paris VI (1979)
Research interest: Mathematics, bifurcation theory, stochastic calculus, neuroscience, visual perception, computational neuroscience, neural fields.

**Jean-Luc** Gouzé, Research Director, INRIA. Project team leader
PhD, Université de Paris-Dauphine, France
Research interests: Dynamical systems and control theory applied to biology.

**Gregoire** Malandain, Research Director, INRIA.
PhD, Ecole Centrale de Paris, France
Research interest: Medical image processing, 3D registration, 3D segmentation, digital topology.

**Olivier** Meste, Professor, UNS-I3S
PhD, Université de Nice-Sophia Antipolis
Research interest: Signal processing, data analysis, biomedical

Jean-Marc Mienville, Professor, UNS University of Nice Sophia-Antipolis PhD in Pharmacology, Georgetown University, Washington, DC, USA Research interest: Ion channels

**Theo** Papadopoulo, Researcher, INRIA.
PhD, Université Orsay Paris XI
Research interest: MEG, EEG, BCI, image processing, computer vision.

**Xavier** Pennec, Research Director, INRIA.
PhD, Ecole Polytechnique, France
Research interest: Medical image processing, image registration, atlases, computational anatomy, statistical computing on Riemannian manifolds, geometric structures, Lie groups, information geometry.

**Adrien Richard**, Researcher, CNRS
PhD, Université d'Evry Val d'Essonne
Research interest: Gene network, Boolean network, Feedback circuit, Fixed point.

**Vicente** Zarzoso, Assistant professor, UNS-I3S, *Research Fellow of the Royal Academy of Engineering, UK (2000-2005), Robert Legget Prize for best thesis submitted to Faculty of Engineering, Univ of Liverpool (2000)*
PhD, University of Liverpool, UK
Research interest: signal processing, higher-order statistics, blind and semi-blind techniques, source separation, channel identification and equalization, biomedical signal processing, atrial fibrillation analysis.

Josiane Zerubia, Research Director, INRIA. Project team leader. *IEEE Fellow, Chevalier de l'Ordre National du Merite*
PhD in Speech Enhancement, PhD in Image Processing, both from Université de Nice-Sophia Antipolis, France
Research interest: inverse problems in image processing, stochastic approaches, optimization, parameter estimation, satellite images, biological images.

**Didier Zugaj**, Scientific Imaging Manager, in Galderma Research and Development, Biot, France
PhD in Computer Sciences, CNAM/ENSAM, Paris
Research interest: image processing & segmentation, management of images & metadata, hyperspectral, standardized photography with cross polarized, parallel polarized, red fluorescence, microscopy & IHC staining, digital slides.

# La Fondation Universitaire UNICE

**Fondation Universitaire UNICE supports UNS in its missions to develop closer links with its community on a regional, national, and international scale, raising funds for new projects and creating new economic opportunities.**

As a not for profit organization, it can receive donation and legacy under a very favorable tax treatment in France.

Founding members and major donors of the Foundation (individuals, corporations, municipal and regional entities) participate together with the University in the management of the Foundation and particularly in the choice of projects to be financed.

The Foundation UNICE is uniquely placed to support and promote the economic development of the region by mobilizing the energies and competences of all its actors.

It presents an extraordinary opportunity for students of UNS, alumni, professor-researchers, staff, and the community at large to directly impact both the future of UNS and its presence in the region.

**Fondation UNICE organizes its strategy around 4 main objectives:**

• Promotion of academic excellence in initial and continuing Education
• Financial and organizational support for start-up companies focused on scientific innovation
• Development of fundamental and applied research by financing new ambitious projects
• Respect of UNS social commitment to diversity with grants and financial support for students in need, foreign students, new graduates, with support to students with a handicap, and to facilitate access to a job,… etc.

**Fondation UNICE offers a new tool for all to:**

• Give UNS additional means to develop its primary educational missions
• Reinforce the relationship between UNS and its economic partners
• Establish new international partnerships with a vision for the future
• Provide UNS with new tools to compete in the 21st century
• Preserve and develop UNS' social commitment

**We need sponsorship**

In order to attract a large number of high quality students, we are seeking sponsors. Your sponsorship will be used to allocate scholarships supporting the student's life expenses which is one of the main objectives of the Fondation Universitaire UNICE. This support, which is mandatory for most students to continue their studies, will be attributed on excellence criteria.

**Why become a sponsor?**

**Visibility**. Our master program will offer your organization extensive visibility through our corporate sponsorships and the communication campaign we do worldwide to find the best students. Sponsors' logo will be displayed on the Master's web site, as well as on the communication supports. Being a sponsor of this program will also demonstrate your organization's commitment to education and computational biology in a fast growing community of researchers from different disciplines.

**Cutting edge expertise**. The relationships formed through this Master program will provide you with new partners for collaborations and a pool of highly qualified people to recruit your future employees. Sponsors will have access to a forum to post job opportunities, be they for master students who just completed the curriculum, or for PhD students who defended and wish to pursue a carrier in industry, thanks to an active network of alumni. Your participation is also a unique opportunity to shape the curriculum so that it best fits your needs.

**www.fondation.unice.fr**

for more information
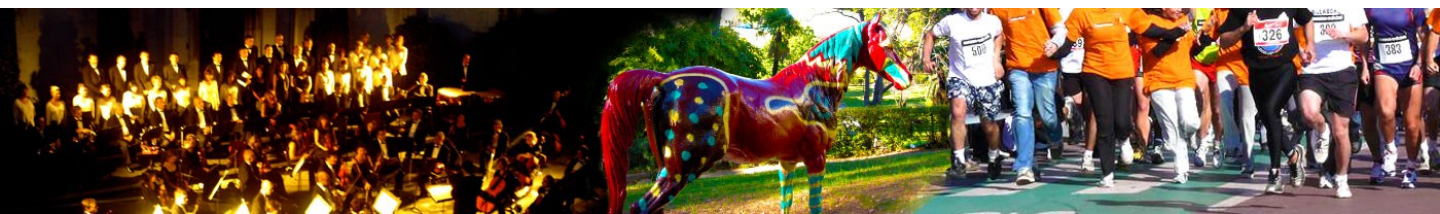
# Academic and research partners involved in this program

**Université Nice Sophia Antipolis (UNS)**
http://portail.unice.fr

**Centre National de la Recherche Scientifique**
http://www.cnrs.fr/

**Institut National de Recherche en Informatique et en Automatique**
http://www.inria.fr

**Institut de Pharmacologie Moléculaire et Cellulaire**
http://www.ipmc.cnrs.fr

**Laboratoire d'Informatique, Signaux et Systèmes de Sophia Antipolis**
http://www.i3s.unice.fr/

**Laboratoire J.A. Dieudonné**
http://math1.unice.fr

**Ecole polytechnique Universitaire**
http://www.polytechnice.fr

**Fondation Universitaire Unice**
http://www.fondation.unice.fr

Master of Science in Computational Biology
Master 2 Informatique: Fondements et Ingénierie
Parcours de Biologie Computationnelle

cbb.unice.fr

Université Nice Sophia Antipolis
Campus-STIC
930 Route des Colles - BP 145
F-06903 Sophia Antipolis Cedex
France

www.unice.fr

Université Nice Sophia Antipolis