

Problems and approaches in computational chemistry

Teacher: Giuseppina Gini

Course outline:

Computational chemistry is a well developed intersection of chemistry and computer science that employs the results of theoretical chemistry to compute the structures and properties of molecules. Present computational chemistry can accurately calculate the properties of molecules that contain no more than 10-40 electrons. Approximate methods are available for larger molecules.

The course will introduce the methods used in the basic areas of computational chemistry:

1. The prediction of the molecular structure of molecules
2. Storing and searching for data on chemical entities
3. Identifying correlation between chemical structures and properties
4. Computational approaches to design molecules that interact in specific ways with other molecules (as in drug design). After a review of the area we will present the open challenges. Challenges in size: work with big molecules (proteins, etc), work on large data sets, etc. Challenges in the meaning: classification of the chemical space, classification of the mechanisms space, etc. Challenges in the perspectives: from "in vivo" testing to "in silico" testing. Challenges in the hybridization with new areas: how proteomics, genetics, neurosciences can build over computational chemistry. The course will be organized with the cooperation of external experts and problem holders.

PROGRAM

April 21, DEI, Sala Seminari

h 9:30: Introduction: problems and objectives

Organization

Distribution of papers for final discussion

h 12:15 – 14:00 lunch time

h. 14:00 Chemical notation: Smiles and InChI –A. Chana

After a short review about important characteristics of organic chemistry, we will focus on the problem of chemical notation. We will introduce text notations, in particular Smiles and InChI codes and discuss about their uniqueness and standardisation. We will address specifically their application and use into the modern in silico approach.

h 15:15 Quantum chemical simulation and descriptors - A. Chana

After a short introduction about quantum chemistry, we will introduce the computational methods available for molecular simulation. We will focus on the more accurate simulation approaches, those where the electronic structure is properly depicted. We will depict a basic introduction about methodologies and their applications, with a special emphasis on how these methodologies can produce molecular descriptors.

h 16:30 Chemical descriptors– A. Roncaglioni

Chemical descriptors represent the way to encode the chemical structure in mathematical way. This lecture will introduce the theme of molecular descriptors and their classification. After we will present some categories of molecular descriptors calculated on the basis of the bi-dimensional structures and their applications.

h 17:15: 18:00 discussion

April 22, DEI Sala Seminari

h..9:30 Introduction on QSAR and modelling of physical properties – A. Roncaglioni.

The basic ingredients and steps of a QSAR analysis will be explained. A particular focus will be provided on the application of QSAR towards the modelling of physico-chemical properties.

h10:15 Modelling biological properties – A. Roncaglioni

The most challenging application of QSAR is devoted to the study of biological properties of chemical compounds. Examples of those properties are in the domains of drug discovery, labelling of substances, toxicity prediction. This peculiar field of application will be presented along with the biological hypotheses and the key issues for promoting models acceptance.

h 11:30 New methods and new applications – a survey – G. Gini

h 12:30 – 14 lunch time

h.14:00 From small molecules to biological molecules: modelling interactions - A. Chana

In this lecture we will address the inter phase between chemistry and biology and how mathematical models can be of use to cope, with some degree of accuracy, with massive molecular systems, through their application to Computer Assisted Drug Design and Computational Toxicology. The examples will be taken from docking and metabolic pathways.

h 15:15 From computational chemistry to computational biology – E. Benfenati

In this lecture we will address the applications, perspectives and future possibilities open to the in silico methodologies in a broad meaning. Initiatives which are on going in USA and Europe will be described, together with the open challenges.

h 16:30 – break

h 17:00 – 18:00 discussion

April 28, DEI Sala Seminari

h 14:30 – 18:00

Presentations by

Cagli, Dubois, Mazza, Naccari, Orsi, Poli, Prandi, Tamburrelli, Valenzise

Discussants: all the attendees

May 05, DEI,

h 14:30 – 18:00

Presentations by:

Barengi, Basilico, Di Biagio, Ghozia, Laniado, Malaga, Merlo, Miele, Pasquale, Redaelli

Discussants: all the attendees

Speakers:

Antonio Chana, Researcher in the Laboratory of Environmental Chemistry and Toxicology, at the "Mario Negri" Institute, Milan, is working in molecular descriptors, Docking and QSAR. He obtained his Ph. D. in Computational Chemistry in Complutense University of Madrid, Spain. He has worked in the Spanish Research High Council (CSIC) and Agronomical Research Institute (INRA), France, focused on Computer Assisted Drug Design and Computational Toxicology fields.

Alessandra Roncaglioni graduated in environmental sciences in Milan University in 2001. After three years of specialization course in pharmacological research (2001-2004) she recently obtained a PhD. Since 2001 she has been a researcher in the Laboratory of Environmental Chemistry and Toxicology, focusing her research interests on computational chemistry methods applied to environmental and health issues, in particular in silico approaches (QSAR) and their use in the regulatory framework.

Emilio Benfenati, head of the Laboratory of Environmental Chemistry and Toxicology, at the "Mario Negri" Institute, Milan, is working in predictive toxicology, environmental toxicology and environmental analysis. He received his diploma in Chemistry at the University of Milan. He obtained a post-doc diploma at "Mario Negri" Institute. He worked in Stanford and Berkeley, California, on biochemical research. He has direct experience as coordinator or participant in more than 25 EC funded projects, many of them in computational chemistry.