

### 1.1 Advanced nano-sensors for Environment and Health

Recent progress and advancements in the synthesis of nano-scale materials and coatings have paved the way for the development of innovative and high-performance sensor architectures. The desired properties of such nano-sensor devices include ease of fabrication and integration, compactness, high sensitivity, short response time, reliability and re-usability. In order to achieve the maximum sensor performance, sensing mechanisms (optical, chemical, electrical, mechanical, magnetic, etc.) should be understood clearly. Besides nano-scale materials synthesis, sensor design, sensor fabrication process and recipe development, sensor performance testing is as critical as well for optimum device performance. Environment and health are two major fields in which sensor technologies are heavily used.

The aim of this topic is to pursue research and development (R&D) activities between European and Russian research institutions to promote a strong cooperative interaction, based on KET - Key enabling technologies (nanotechnologies, ICT, advanced materials, etc.) and on the use of top-down and/or bottom-up micro/nano-fabrication processes for advanced and innovative nano-scale sensor structures primarily for environmental and health applications. Sensing mechanisms to be explored might include but are not limited to optical, electrical, chemical, mechanical, and magnetic detection.

### 1.2 Novel functional nanomaterials based on design and modelling

Functional nanomaterials play a key role in modern technologies improving their cost effectiveness and efficiency as well as expanding industrial applicability. However, the development of novel functional nanomaterials must progress from a laboratory-driven ad hoc discovery process to a more systematic engineering approach based on the use of advanced fabrication and characterization tools along with modelling and simulation. The aim of this topic is to pursue research and development (R&D) activities between European and Russian research institutions to promote a strong operative interaction, based on KET - Key enabling technologies (incl., nanotechnologies, ICT, advanced materials, biotechnology, advanced manufacturing and processing) and on the use of micro- and nanofabrication infrastructures, large-scale research facilities (e.g., synchrotrons, nuclear reactors, neutron sources, free electron lasers) and high performance computing.

Simulation and modelling became an efficient tool for designing robust and high-performance functionalized nanomaterials. Diverse methods, including quantum-chemical calculations, QSAR/QSPR (Quantitative-Structure-Activity/Property-Relationships) or QNAR as a QSAR option for nanomaterials, data mining, the use of artificial neural networks and genetic approaches, accompanied by high-throughput experimental library tests should be used for elaboration of predictive algorithms aimed at development of the new generations of functionalized nanomaterials. The development of nanomaterials by design should be also complemented by rigid nanotoxicity and nanoecotoxicity metrology tests aimed at directing the progress in production of nanomaterials toward human-friendly and environment-friendly products.

### **2.1 Regenerative Medicine, Biomaterials and Organ-on-a-chip-systems**

Regenerative medicine remains one of the great challenges of clinical practice. Many of the world's leading pathological processes, including cardiovascular diseases, cancer, diabetes, and traumatic injuries, could be alleviated by regenerative medicine. For example, new methods for pancreatic endocrine cells regeneration can be used to treat diabetes, tissue engineering therapy can help in coronary artery disease, and novel nervous tissue regeneration technologies can be utilized in stroke treatment. Effective biomaterials for tissue regeneration will, therefore, find applications in practically every clinical discipline. Regenerative medicine has the potential to improve patient outcomes, lower the incidence of complications, reduce hospital stays, enable cost-effective treatments, and lessen morbidity and mortality.

Organ-on-a-chip-systems provide a promising model to predict pharmacokinetic response *in vitro*. Thus, they may offer an alternative to animal experiments for testing the toxicity and efficacy of pharmaceuticals in the future. An organ-on-a-chip is in particular a microfluidic cell culture device that simulates the physiological response of organs to drugs and metabolites *in vitro*. It contains continuously perfused compartments with living cells that enable the analysis of biochemical, mechanical and metabolic processes. Research should focus on the development, validation and optimization of such systems. Extensions to multi-compartment devices simulating multiple organs that allow predicting the systemic effect of drugs on the human body ("human-on-a-chip") will be encouraged.

### **2.2 Drug Discovery for Cancer, Cardiovascular and Infectious Diseases**

The need for principally novel drugs for treatment of cardiovascular diseases, cancer and infectious diseases is evident since these diseases represent the top causes of mortality world-wide (excluding incidents). The investigation of rational design and high-throughput screening of potential drug candidates (leads) offers many possibilities for a successful EU-Russia scientific cooperation.

The understanding of specific molecular mechanisms/pathways which underlie the particular disease initiation and progression, treatment resistance, etc. allows for an identification of relevant biomarkers and promising targets for drug development.

Research projects should focus on the validation of known biomarkers using state-of-the-art technologies, the development of relevant pre-clinical models, and biomarkers for patient stratification to improve the response to therapies.

The investigation of potential disease-specific target biomolecules in order to characterize new molecular diagnostic tools for early stage drug discovery will be encouraged.

### 3.1 Demography, Migration, Conflicts and Security Issues

The main goal of this research theme is to develop a common framework for research of conflicts and security issues, leading to the accomplishment of the Horizon 2020 strategic goals in tackling global societal challenges together with international partners of the EU. Topics such as multi-paradigmatic understanding of war and peace, violence, ethnic conflicts, globalization, regionalization, integration, national and international security will be the key areas of research and innovation.

The EU countries, several countries associated to the EU's Horizon2020 (e.g. Turkey, Moldova) and Russia share a long history of war and peace. The geographic proximity, geopolitics, competition and cooperation for the global markets are issues that need to be addressed with priority. However, the whole plethora of initiatives and partnerships or generous strategic goals cannot be completed without a common understanding of the roots of cultural, historical, ethnic or ideological conflicts, and a construction of a common vision, based on research and innovation.

Three issues deserve thorough study in this context: demographic challenges, migration and ethnic conflicts in the EU and in Russia, which arise as a consequence of many factors. Demographic challenges, migration, the nature of conflict in general and of ethnic conflicts in particular must become an object of multidisciplinary investigation. This research involves historical, psychological, sociological, philological, economic, political and other aspects. The result of this will be an unprejudiced general picture of the contemporary demographic developments as well as migration issues in the EU and in Russia. On the basis of this empirical research, a conceptual framework will emerge permitting to show ways for solving practical problems.

### 3.2 Opportunities for and Challenges to Regional Development and Social Cohesion

Research proposals under this theme will include comparative, multiple-methodology-using, boundary spanning (academia-policy-practice) studies on the nature and impacts of economic, political, social and/or environmental developments on sub-national level. Research may look at urban and rural issues, as well as make use of the notions of city-region and other hybrid spaces. Key topics where joint research may be of particular benefit would include the development challenges and solutions in sparsely populated areas (e.g. strategies against poverty and for sustainable local development, including social services, networks of enterprises, social innovation); the changing patterns of land use and their impact on sustainability and local production systems (e.g. the presence of industrial companies in agricultural and primary production, impact on market chains and local food systems); agency, community initiatives, and associations for local development; different forms of civil society and governance systems and their interrelation on local level; research and business links for regional development, avenues for multi-stakeholder collaboration, new economic forms, and organisational innovation. Social cohesion is inherent and linked to any of the above mentioned themes and it concerns exploring the sharing of values, sense of belonging, civic participation, trust, justice, equality and others.