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LIFE IN A COLD CLIMATE

What impact could global warming have on the Arctic marine food web?

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CNR'S **PROFESSORS MARIA GIOVANNA TRIVELLA** AND **EZIO-MARIA FERDEGHINI** ON THE DREAM OF THE CLINICAL PHYSIOLOGY INSTITUTE (IFC): A FULL INTEGRATION OF MEDICINE AND TECHNOLOGY

New frontiers in cardiology

From its origin in 1968, IFC has tried to be in the centre of both national and international innovation research, aiming to transfer new scientific knowledge into the clinic. Scientific projects gather experimental data to build up and to validate models of pathophysiology interpretation, supported by appropriate instrumentation. In fact, the core idea was to add the concept of measurement – hitherto confined to physiological research – to the medical practice. Thus, the institute was aimed at the integration of experimental research with clinical, epidemiological and more advanced technology, together with careful attention being paid to patients' expectations.

Evidence-based medicine

The adopted Scandinavian name of 'clinical physiology' was, in fact, anticipating the cultural and ethical conception of what would eventually be called 'evidence-based medicine'. To this end, the IFC activities were, and continue to be, realised by a multidisciplinary team from different fields including medicine, biology, chemistry, bioengineering, physics, mathematics and computer science.

Today, it is not difficult to meet many of the above competences integrated into the same research environment, and yet, up to 20 years ago, IFC, together with a small number of world research centres, had the privilege of employing and managing many facilities and fields, such as positron emission tomography, single-photon emission computed tomography, healthcare information systems, echocardiography, magnetic resonance imaging, catheterisation laboratories and artificial heart research.

For instance, in the 1980s, the IFC was actively involved with the first PET in Europe, supported by an on-location laboratory for the production of suitable radiopharmaceutical drugs; the pioneering use of informatics and the hardware required for digital recording, monitoring, storing and analysing cardiac signals, as well as with as the first experiences of telemedicine and teleconsulting via a broadband digital network.

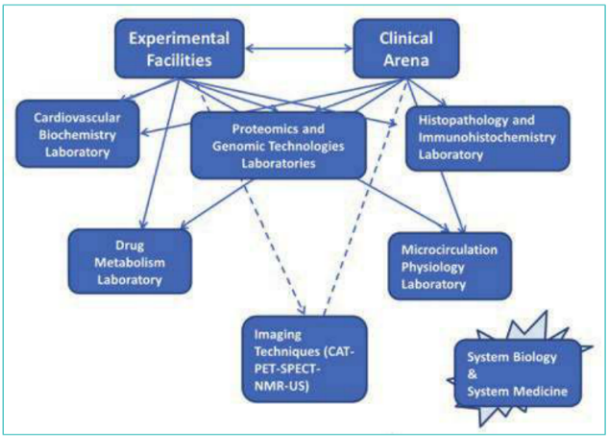

Fig. 1 Translational research from bench to bedside and *vice versa*

The IFC has a staff of over 500, of which 118 are tenured researchers and technologists, mainly in Pisa headquarters but also in Milano, Lecce, Roma, Siena, Massa and Reggio Calabria units, together with the satellite units of Catanzaro and Mezzina. The intense co-operation of the IFC researchers with the most important world institutions has allowed the researchers to reach excellent levels, together with the opportunities of being co-ordinators or partners in many international projects.

From bench to bedside

From the beginning, the IFC mission has been the improvement of patient care through the immediate transfer of scientific and technological advances, once proved successful and after careful testing, to the clinic, thereby making them immediately available to participate in the battle against disease.

This has been achieved through the side-by-side work of researchers within the current healthcare system, which has resulted in the creation of the archetype of what, in the coming years, could prove to be the new clinical approach and the education of a new generation of versatile researchers in Europe.

Activity areas

The institute's activities have been broadly defined as fitting into four main areas: clinical cardiology, experimental medicine, bioengineering and epidemiology. The research working hypotheses are confirmed by a multidisciplinary, rigid methodology, and this has provided IFC researchers with the knowledge and tools required to participate in the designing of standard protocols and procedures, and to understand the

complexity of physiology in health conditions as well as in different pathological processes.

The availability of imaging facilities, which are continuously upgraded on the basis of the synergy with industry, has allowed IFC to not only provide the clinic with better tools but also to participate in drafting the guidelines for a safer, more appropriate, less invasive diagnostic and therapeutic plan.

For the last 46 years, each scientific area has had the constant aim of boosting knowledge and innovation and has contributed to the spread of physiological perspectives through a whole body approach, from the heart to all the other organs.

The achievements made through the experience that has been gained in this first long chapter of the IFC story are encapsulated in the SPERIGEST project, which was assigned to the IFC by the Italian Health Ministry for the realisation of the first computerised cardiology department.

By splitting clinical research and patient care into different institutions, in 2007 the institute delegated the healthcare activities for adult and paediatric cardiology and cardiosurgery to the Fondazione CNR/Regione Toscana 'Gabriele Monasterio' (located in the same building at the CNR research campus in Pisa and at the 'G. Pasquinucci' hospital of Massa). Through this, the IFC investigators addressed their efforts in translational research.

Thus, the IFC expanded its interests to clinical pathophysiology, deepening the study of atherosclerosis, heart failure, cardiopulmonary diseases and neuroendocrine correlates, as well as introducing new techniques in chest ultrasound for early diagnosis of pulmonary oedema and stress echo for innovative applications beyond coronary artery disease (including aged donor heart recruitment).

The IFC's expanded interests are also applied to experimental medicine, by supporting new imaging facilities, such as micro-PET, micro-CT and micro -ultrasound, and expanding its view to the molecular and cellular dimensions, genetic regulation and the 'omics' environment towards the multiple data interpretation by system biology and medicine (see Fig. 1).

Technosciences, devoted to applications for e-health, have also become a further focus for the IFC by expanding its interests to miniaturisation and nanomaterials, as well as clinical, social, environmental and molecular epidemiology by looking at health-environment relations.

Relevant attention has also been paid to the impact of diagnostic activities on clinical practice, as well as to their appropriateness and to their risk/benefit for both patients and staff.

Bioengineering and medical informatics

As previously underlined, the role of bioengineering has always been central to the IFC, and the institute's technoscience group has been involved in different fields, including clinical data management (data acquisition, archiving, processing and distribution, patient medical records, personal devices for ubiquitous monitoring and computing, data fusion and knowledge extraction, and medical decision support); bio-signal analysis with multimodal and multivariate approach (mathematical modelling, pattern recognition, nonlinear dynamics, time-frequency analysis, and blind source separation); computers, and computing in cardiology and pneumology; biocompatible tissue engineering. This has achieved a strong involvement in national and international industries, not only in research fields, but also in the development of projects and standards relative to biomedical instrumentation.

The bioengineering scenario also spreads to new research in the field of extreme condition physiology in underwater activities, at high altitude, and in space, as well as in extreme sport.

As an example of the joint synergy of medicine and bioengineering in IFC, the project SensorArt has recently opened new paths toward the therapeutic frontiers of the development of an artificial heart. The European project has been successful in developing sensorised ventricular assist devices without cables as part of a telemedicine and telecontrol platform.

Personalised patient care

The new generation of IFC researchers is directing their efforts towards achieving the goal of personalised care. The main aspects of this new research trend are strictly related to the promotion of health and quality of life; monitoring and control of patients and fragile citizens; therapeutic intervention optimisation; reduction of hospitalisation time; multi-level patient-specific modelling, simulation and decision support system; specific attention to stakeholders, from patients to healthcare providers; opening new frontiers in multimodal imaging to improve appropriateness; better healthcare risk/benefit ratios; and better diagnostic and therapeutic procedures.

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