IT IS FOR HEALTH

ADVANCED RESEARCH
FOR PERSONALIZED MEDICINE

INFORMATION TECHNOLOGY FOR YOUR HEALTH

An Interview with Niels Kuster, Founder and Director of the *IT'IS Foundation*

Niels, in choosing the name of the Foundation, you set out a very broad topic. What exactly goes on at IT'IS?

We develop computational methods to simulate the physical, chemical, and biological processes of the human body. Physiology is complex and disease adds even more intricacy. To be sure we have it right, a large part of our work is validation of our computational predictions, which means we also put substantial effort into developing new measurement techniques. In short, we model life processes, we simulate interactions with external stimuli, we develop and combine physical, chemical and biological models, and we check all our work against reality.

How did IT'IS become a center of excellence?

When *IT'IS* was founded in 1999, the mobile communications world was evolving at a dizzying pace. The question on many minds was, "Can we be sure there's no health hazard from exposures to mobile phones?" There wasn't enough in-depth knowledge for an answer, so *IT'IS* stepped in to fill a wide scientific gap. In a relatively short time we were able to make major advances in understanding how radiofrequency energy is absorbed in the body. Our instruments, software, and exposure systems were critical for the many scientists worldwide conducting laboratory experiments and epidemiological studies, and setting standards for the safe use of electromagnetic energy.

Those groundbreaking developments involved a lot of hard work by many brilliant researchers from the physical, biological, medical, computational and engineering sciences. It has been critically important that our researchers are great at teamwork and collaborate closely with many groups at renowned institutions throughout the world. In this way, beginning from a focus on mobile phones, our successes due to our unique mix of disciplines and a large collaborative network created this exceptional center where we can generate concepts and models for simulations of living systems. This also is the key to progress in understanding health and disease.

Title page: Simulation of blood flow in the aortic arch (hemo-magneto-dynamic project).

What is next?

We will continue high quality research in the core areas of electromagnetic exposure measurement and modeling where we are the pacesetters. There's more to do and we plan to stay in the lead.

In a new direction, we are excited by the opportunity to have a central role in the next epoch of medical science, personalized medicine. New biomedical concepts, information, and understanding are coming at a startlingly fast pace. Today, biomedical science is moving so fast that the time has come to harness our abilities as innovators and creators to bring about the first generation of computational tools for personalized medicine. The opportunities are immense and so are the challenges because this new form of therapies will manipulate the very activities of cells, tissues, and organs. Ordinarily they work together harmoniously, but create disease when they don't. *IT'IS* is poised to drive progress in medical technologies by applying its powerful computational methods and exceptional intellectual capacity to bring about therapies tailored for individual patients.

When the era of personalized health treatment arrives, therapies will be highly effective with minimal side effects, particularly for cancer treatments. In the future, oncologists would work to modulate communications within and among cells rather than by poisoning them or switching off responses to the environment.

IT'IS for Health was founded specifically to conduct the research needed in computational methods for personalized medicine. The time is now and we are ready.

Prof. Niels Kuster, Director of the IT'IS Foundation, discussing the new research findings and the next steps with his team.

INVESTING IN SCIENTIFIC DISCOVERY, ADVANCED TECHNOLOGY, AND HUMAN HEALTH

The History and Mission of the *IT'IS Foundation* at the Intersection of Medicine, Biology and Engineering

IT'IS, the Foundation for Research on Information Technologies in Society, was founded as a non-profit research organization in November 1999 with the support of both the executive board of ETH Zurich and the Department of Information Technology and Electrical Engineering. The goals for the Foundation today remain unchanged: conduct independent research that positively impacts human lives and provide the research community with interdisciplinary expertise in engineering technology, biology, and medicine.

Our first task was to lay the scientific foundation for the quantification of potential wireless-related health effects, which required us to design and assemble a suite of novel devices and measurement technologies in addition to simulation models. Today, the methods developed at *IT'IS* to assess human exposure to electromagnetic fields (EMFs) from mobile handsets, base stations, and WLAN hotspots have been widely adopted by governments, universities, and industry across the globe. Our exposure systems have become the gold standard for high-quality biological research and our simulation tools have found countless applications, including the functional optimization of mobile phones, body-worn sensors, and health maintenance devices. *IT'IS* is also a source of critical information for health risk assessment, and the Foundation is among the most cited institutions in publications by international safety standards committees and in scientific reports by the International Agency for Research

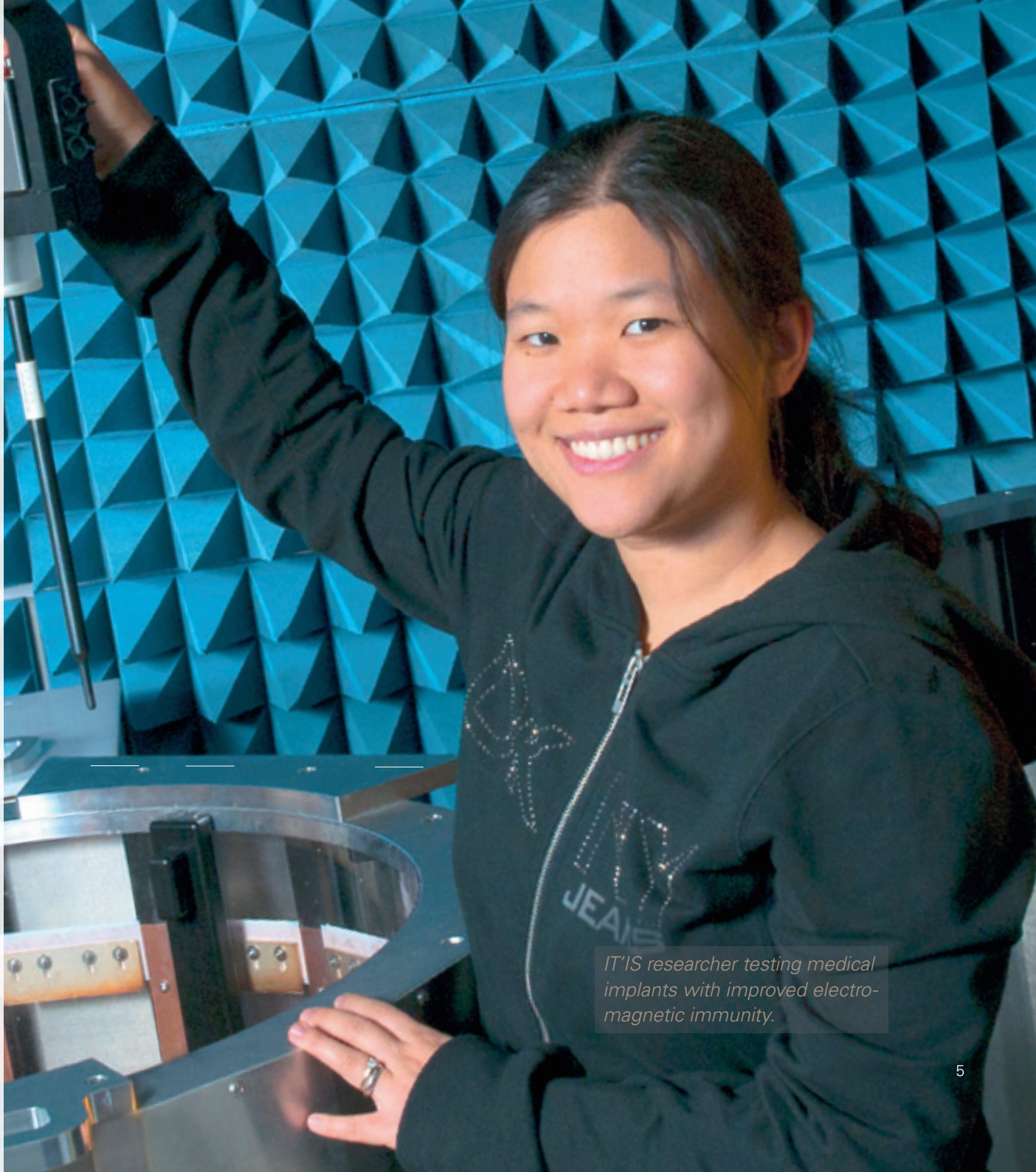
Fundamentally new knowledge requires that we join deterministic linear thinking with the realm of interactive systems.

Prof. Jakob Nüesch
President of the ETH Zurich, 1990-1997

on Cancer, an arm of the World Health Organization. Within the last five years, we have added the application of low frequency EMFs to our expertise and simultanously developed methods and techniques for the analysis and improvement of Magnetic Resonance Imaging (MRI) safety and compatibility with medical implants. Our work also resulted in new systems for planning hyperthermia therapy using EMFs.

We have attracted worldwide interest in our research, including the detailed anatomical models we developed and our computer-based analyses of physical processes. This widespread interest in our research programs has created strong momentum for our future growth. More information about the success story of *IT'IS* and about each of our projects is available at:

WWW.ITIS.ETHZ.CH



IT'IS researcher testing medical implants with improved electro-magnetic immunity.

ANATOMICAL MODELS FOR RESEARCH AND CLINICAL APPLICATIONS

The Virtual Population

Understanding the complexity of the human body requires more than just a textbook; it requires various approaches, including computer-based simulations to explore biological mechanisms and functional processes in their multi-faceted complexity. Simulations inspire novel hypotheses, minimize the experimental burden on animals and humans, provide detailed information and precise control, and ultimately contribute to the design of new therapies featuring efficient patient-specific treatment. The raw material for such simulations is a precise computer-based representation of human anatomy overlaid with its physiological information.

IT'IS already provides the scientific community with the most detailed anatomical models ranging from infants and children to pregnant women and adults of different ages and sexes. These models are widely used to determine variation in physiological responses to internal and external stimuli across anatomies and ages. We also conduct relevant projects to collect and assess various tissue parameters as a function of age, sex and health status, and to continuously expand and refine our publicly available databases. This is only our starting point. Further innovations such as anatomical models with pathological modifications or models for the simulation

The Virtual Physiological Patient will revolutionize medical device development and treatment optimization as the wheel did for human mobility.

Dr. Wolfgang Kainz
Food and Drug Administration, USA

of nerve activity, tumor growth, respiration, blood circulation, and liver function are within our reach.

The Virtual Population already serves as a standard of reference in anatomical modeling. With additional efforts, we can accelerate the development of new and improved models and provide the scientific community with free tools that are expected to result in major breakthroughs in various areas of life sciences.

WWW.ITIS.ETHZ.CH/VIP
WWW.ITIS.ETHZ.CH/DATABASE

Segmentation of medical images of the whole body for the development of functional anatomical models.

CONVERSING WITH CELLS

Basic Research for New Ways to Treat Cancer

In recent years, the *IT'IS Foundation* has participated in numerous successful research projects aimed at improving established modalities and exploring new avenues for tumor treatment. Promising results were achieved in collaboration with researchers from the Comprehensive Cancer Center of the University of Alabama at Birmingham, USA. Together, we gained a better understanding of how modulated electromagnetic fields affect cell proliferation and tumor growth, which in turn spawned novel hypotheses and new treatment ideas. We are particularly excited by the prospect of exploring the possibilities of artificially modulating cell communication and proliferation, leading to the possibility of radically new and highly efficient therapies. To do so, we will develop new physicochemical models, models of tumor tissues, and specific experimental systems for studying therapeutic EMF effects. We strongly believe that this research will generate useful basic knowledge and, in the event of a major discovery, pave the way for new therapies against cancer and other diseases.

Our know-how can be put to use for other important applications: our tools can be used to optimize the delivery of internally- and externally-applied ultrasound and/or electromagnetic fields for electroporation (creating transient permeability of cell membranes to specific

This line of research provides a unique opportunity to develop new and safe targeted therapies that kill cancer cells without collateral damage.

Prof. Boris Pasche
Director, Division of Hematology/Oncology
University of Alabama at Birmingham, USA

medicines), hyperthermia (selective heating to induce tumor cell death), and tumor ablation (focused energy to destroy tumor tissue). In addition to tumor treatments, minimally invasive applicators for ablation enable very effective therapies, e.g., for atrial fibrillation. By merging these various tools with effective means to extract accurate biophysical models from raw medical imaging data, quasi-real-time simulations of patient-specific treatments can become reality. *IT'IS* serves as a catalyst for this highly interdisciplinary research.

PhD Student preparing the next cell experiment in the live-imaging RF exposure system developed by IT'IS (Department of Biomedicine, University of Basel, Switzerland).

FROM MOLECULAR- TO MICRO- TO MACRO-BIOLOGY

Biology in Multi-Scale Simulations

Biological processes occur on a variety of temporal and spatial scales. To gain a comprehensive understanding of the human body, its anatomy, physiology and pathology need to be studied simultaneously at the molecular, cellular, tissue, and organism levels. Computational modeling makes it possible to investigate the mechanisms of such complex multi-scale systems in a controlled and isolated manner, and to analyze the importance of specific parameters. The simulation approaches that we are developing bring a new dimension to basic research and open the door to the individualized optimization of diagnosis, medication, treatment planning, and therapy.

The *IT'IS Foundation* conducts basic research on simulation methods that are optimally suited for the study of complex multi-scale, multi-physics systems. We continually develop novel functional tissue and organ models that incorporate detailed physiological mechanisms and coupled chemical and physical interactions.

Our multi-physics tools are already successfully applied in the development of faster and improved MR imaging approaches, electromagnetic-compatible implants, and novel diagnostic procedures for vascular diseases. Further applications include the study of vessel formation,

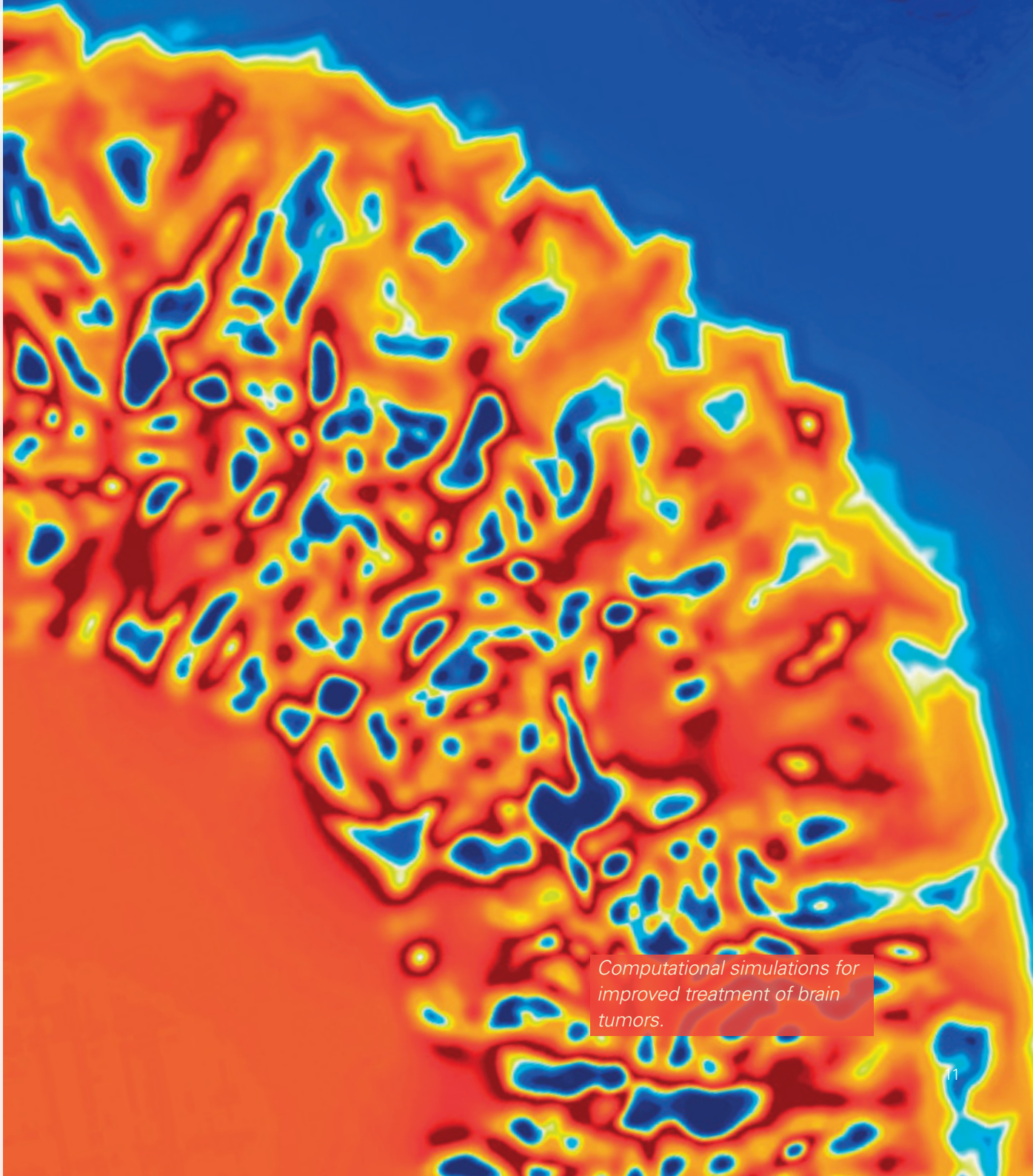
In silico medicine will be key for breakthroughs in specific treatment of individual problems.

Prof. James C. Weaver
Massachusetts Institute of Technology, USA

blood clotting, and the treatment of aneurysm progression. We are currently exploring the possibility of using focused ultrasound to locally and reversibly open the blood brain barrier to drugs for the treatment of brain tumors.

Our theoretical and experimental methods for cancer research allow us to study the interplay between cell proliferation and apoptosis (programmed cell death), the mechanisms and dynamics of provisioning cells with oxygen and nutrients, chemical signaling at the cellular level, mechanical forces, and vasculature.

As an interdisciplinary team, we have the skills and knowledge to close the gap between the micro- and macro-world and to build bridges to the molecular world.



Computational simulations for improved treatment of brain tumors.

FUNDING IT'IS AND IT'IS FOR HEALTH

The investments will be deeply satisfying because the rewards are likely to exceed hopes.

Prof. Niels Kuster
Director of the IT'IS Foundation

IT'IS receives funding from public sources such as the Swiss National Science Foundation and the European Commission to support ongoing research on health implications of human exposure to electromagnetic energy from a variety of devices. These funds are for specific projects and for a limited time.

In contrast, *IT'IS for Health* is a long-term undertaking for which we need sponsors willing to make long-term financial commitments. These far-sighted sponsors understand the value of donating not only to scientific research projects but to the realization of a scientific vision.

How does financial sponsorship work?

IT'IS was built on trust and collaboration. Scientists, engineers and sponsors work together to identify problems and build solutions on a sound financial foundation.

IT'IS for Health will work the same way. Sponsors can choose to support a particular PhD student or postdoc, an existing or a new project, or contribute to core financing. Sponsors are encouraged to attend project meetings. In this way, individual sponsors can take part in the excitement of scientific discovery – which is true in many fields – but is especially satisfying when it leads to better treatments and cures for disabling and life-threatening diseases.

We recognize that our sponsors have led lives of great achievement. We hope to benefit from their expertise, business acumen, and personal skills.

How can I find out more about IT'IS for Health?

Let's talk! Contact Prof. Niels Kuster, director of *IT'IS,* directly. Niels will be pleased to discuss the ideas that will lead to practical treatments in personalized medicine.

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