Real-time health data with breath analysis
ETH Professor Emma Slack, Zurich Exhalomics
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Passionate about empowering others
Donor Joel Roos
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Funding focus
Medical technology innovation
Effective transfer to clinical practice

ETH Zurich has defined health and medicine as a strategic action area, with over 100 professorships conducting research in this field. Their work involves close collaboration with medical practitioners, an approach that adheres to ETH’s fundamental belief in linking basic research with practical applications: indeed, when it comes to technology transfer, we reach out to partners of all kinds, whether in industry, professional associations or, as here, hospitals.

Besides interdisciplinary teams, this also calls for people operating at the interfaces. In terms of professorships, for example, this requires one person holding two positions simultaneously, one at a hospital and one at ETH. After all, knowledge of both sides leads to shorter transfer paths. In other words, get the structures right and translation will inevitably be faster. An excellent example here is Volkmar Falk, who acts as both Medical Director of the German Heart Center Berlin and Professor of Translational Cardiovascular Technologies at ETH. Read on to learn more about this trailblazer and others making advancements in medicine to enhance patients’ well-being.

Christian Wolfrum, Vice President for Research at ETH Zurich
Enhanced technology for our heart

Renowned cardiac surgeon Volkmar Falk is making strides at the intersection of clinical practice and engineering sciences. ETH is his long-standing partner.

You’re Director of the German Heart Center Berlin and travel to Zurich several times a year. Conversely, ETH researchers travel to Berlin, and our students do internships with you. How did these close connections come about?

VOLKMAR FALK – From 2009 to 2014, I held the position of Director of Cardiovascular Surgery at University Hospital Zurich. Even before that, I was drawn to the field of engineering and was exploring topics like robotics and computer-assisted surgery. When I arrived in Zurich, I presented myself to ETH in the very first week, our talks at that time focussing on a specific project to model catheter-based heart valve procedures. However, in parallel, the idea of developing a novel artificial heart emerged, as the technology still in use from the 1980s continues to exhibit problems. I managed to get an array of ETH researchers excited by the idea and – under the umbrella of Hochschulmedizin Zürich – we formed a consortium of around 10 professorships. We set up multiple fundamental research projects in fields like sensor technology, control engineering and biocompatible artificial surfaces and gained valuable insights into ways of optimising existing cardiac support systems. Since my move to Berlin in 2014, I’ve been working in Europe’s leading heart clinic. However, I still see Zurich as the most fertile ground for technological collaboration.

Your professorship in Translational Cardiovascular Technologies (TCT) was created in 2019 to institutionalise this successful collaboration at ETH. How much has been achieved for patients since then?

With minimal human resources – besides my 10 per cent position, there are two other roles – we and various ETH departments are working under the name “ETHeart” to develop innovative technologies for cardiovascular medicine. Our aim is to see these technologies find their way into clinical practice and save lives. But the hurdles are high: while bright minds can come up with...
Minimally invasive surgery for mitral valve repair.

In just four years, Volkmar Falk’s extremely lean professorship in Translational Cardiovascular Technologies has initiated 16 collaborative projects, contributed to two patents and co-supervised 15 doctoral students and two post-docs. It has participated in six preclinical translational trials and in three clinical studies with over 300 patients.

Continuing the success story

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You’re also involved in teaching – what do you think of the ETH Bachelor of Human Medicine introduced in 2017?

I’m highly impressed by the students I meet on internships here in Berlin. Such people will be ideally equipped for translational research in the future because they’ll have an understanding of engineering and computer science, which is a completely different skillset to that of traditional medical students.
Under the umbrella of Hochschulmedizin Zürich, Renato Zenobi and Emma Slack from Zurich Exhalomics are researching the opportunities that breath analyses offer for future diagnostics.

You run Zurich Exhalomics in partnership with your colleague Renato Zenobi, ETH Professor of Analytical Chemistry. Can you explain the project?

EMMA SLACK - We want analyses of exhaled air to become a valuable tool for medical practice. For our work, we use a mass spectrometer to determine a large variety of exhaled molecules – the exhalome. To put it simply, our aim is for a person to blow into a pipe and we immediately have key data about their state of health. Compared to diagnoses from blood analyses, this method is non-invasive and we have the results in almost real time.

What can breath analyses be used for? Eleven interdisciplinary teams of biologists, clinicians and engineers are currently researching all kinds of possible applications, ranging from disease diagnosis to medication intake monitoring to dietary recommendations. One area of focus is the diagnosis of lung diseases such as asthma and infections in cystic fibrosis. Three hospitals are currently collecting data to create respiratory profiles for these diseases. This offers particular hope for paediatric medicine, as it’s difficult or even impossible for children to describe their symptoms. The method could also be used to monitor rare genetic diseases – such as urea cycle disorder, a metabolic condition that, if left untreated, can lead to severe brain damage – in real time. This would be particularly valuable in the early stages of newborn babies, as their exhaled air can be measured in the incubator, avoiding the need for invasive blood sampling. Another project that’s already at an advanced stage focuses on monitoring obesity therapy.

How does measuring breath help with obesity? When treating obesity, one of the critical success factors is the optimal timing of food intake. For patients to monitor and tweak their diet efficiently, they need information on their fat metabolism. In cooperation with University Hospital Zurich (USZ), Professor Andreas Günther has developed a breath sensor and an easy-to-handle measuring device that patients can use to measure the acetone content of their breath and obtain indications on their nutritional status. Since obesity is one of the main causes of diseases like type 2 diabetes and heart disease, combating the condition would reduce the burden on the healthcare system.

Where do you see the greatest opportunities for development with Zurich Exhalomics? Hand-held analysers are certainly a great opportunity to make breath analysis widely accessible. We can then use mass spectrometry to determine other relevant breath markers. We want to develop measuring devices that, combined with the right sensors, can be produced cost-effectively and used at home, in clinics and in medical practices. The next step would be a plug-in installed on the device, which would save the data directly to an app on the patient’s mobile phone. In my view, Zurich Exhalomics has the potential to not only simplify the diagnosis and monitoring of diseases, but to also improve our understanding of them.

The project is financed by donors. Where can further funding make a difference? The funding to date has enabled us to make major progress, for example in our ability to identify relevant disease markers. An important but costly and time-consuming next step involves validating these markers. Further funding would speed up further developments in the hand-held measuring device and enable the method to be tested for other diseases, such as metabolic disorders or infectious diseases.

The large-scale project was initiated by Malcolm Kohler, then Director of UZH’s Clinic for Pneumology, and ETH’s Renato Zenobi, a leading figure in mass spectrometry research. The strengths that ETH brings to the table lie in technology development (not only in mass spectrometry, but also in optical spectroscopy and sensor technology), in reference data management, and, of course, in data science and artificial intelligence. Alivion is an ETH spin-off that has succeeded in commercialising this outstanding expertise to create applications for medicine, the environment and food safety.

Besides your role as co-head of Zurich Exhalomics, you also lead the Laboratory for Mucosal Immunology at ETH and the University of Oxford. What is this lab researching?

We’re examining the connections between the microbiome and diet, the immune system and metabolism. The composition of our microbiome – the microorganisms that colonise us – has a stark influence on our health and, by improving our understanding of this connection, we want to prevent and treat diseases. Since our breath even contains clues to our microbiome, for example in our gut, Zurich Exhalomics offers exciting opportunities for our research.

Find out more: exhalomics.ch, ethz-foundation.ch/en/zurich-exhalomics

“With Zurich Exhalomics, we’re maximising the impact of our funding for the benefit of future patients.”

Martin Burkhardt, Chairman of the Evi Diethelm-Winteler Stiftung Board of Trustees
For the benefit of our health

Getting a medtech start-up off the ground is no mean feat, particularly as the industry is subject to strict regulatory guidelines. Nevertheless, this doesn’t deter ambitious researchers at ETH Zurich. From the several promising start-ups backed by donors of the Pioneer Fellowship programme, we present a selection:

**ENTREPRENEURSHIP**

**For the benefit of our health**

**IMAI**

New approach in cancer diagnostics: IMAI presents a rapid and automated method to detect diseased tissue with greater reliability using a 3D image.

**Citus**

Instrument for better skin assessment: to optimise the early detection of skin diseases, Bettina Thumm has developed an ultra-lightweight device.

**Skaaltec**

Personalised rehab: SmartVNS is a portable, non-invasive brain stimulation system to help rehabilitate patients after a stroke. It speeds up recovery and reduces costs by minimising hospital visits.

**OBaris**

Painless medication delivery: many diseases today can only be treated by injection. OctoPatch can be applied by the patient to the inside of the cheek, where it releases the medication into the body.

**Veltist**

Smart patch for surgical leaks: in around ten per cent of cases, stitching after abdominal surgery breaks open. AnastoSEAL is a suture and staple sealant patch that remains adhered under the toughest conditions.

**Anavo**

Nanotechnology for wound healing and skin grafts: thanks to a radically new approach, the prototypes not only adhere strongly to tissue and stop bleeding, but they also have antimicrobial, anti-inflammatory and tissue regenerative properties.

**Checktor Biosciences**

Combating antibiotic resistance: to limit the misuse of antibiotics, rapid and reliable diagnostic technologies are key. The test developed by the team can detect infections within 10 minutes.

**COSKIN**

Energy transfer implants against infection: people with heart implants suffer from the risk of infections caused by the device’s cables. Pioneer Fellow Andreas Kourouklis wants to solve this problem.

Find out more: ethz-foundation.ch/en/pioneer-fellowship
Writing his Matura paper was a pivotal moment, Joel Roos recalls. As a volleyball player at national junior level, he developed a machine that players could use to train their ball-receiving skills. Was it a success? His team rose to the next league, at least. After graduating in robotics from ETH Zurich, he spent another year as a professional player. Besides training four hours a day, he followed up on an idea: why not use the technology he’d learnt about at ETH – like camera-based motion analysis – to help athletes? His first prototypes using this technology were created for fitness coaching apps. These were designed to give athletes feedback on how to optimise their movement patterns.

After a few months, Joel Roos convinced a former school friend, who was studying computer science at ETH, of his vision. Later, a graduate of University of St.Gallen was to join the founding team. Despite its successful start, the ETH spin-off VAY found itself in 2020 on the brink of collapse. At this point, Joel Roos had been working for two years without a salary, having ended his volleyball career for his start-up. “Our pilot projects were not going as well as we’d hoped, and we could barely pay our staff’s very low salaries. When at the last moment our seed financing suddenly collapsed because a lead investor pulled out, November saw us in a highly critical situation.”

Deal or no deal?
But shortly afterwards, the pivot – a start-up term for a fundamental strategic shift – that had been introduced a few months earlier finally began to bear fruit: VAY no longer had its own fitness app, but instead licensed the technology to manufacturers of digital fitness and physiotherapy solutions. And suddenly everything took off. “These manufacturers had been looking for a technology like ours. Our product was ready, and way ahead of the competition. We were pushing at an open door.” As if out of nowhere, an initial purchase offer came in March 2021, heralding the start to six months of “surreal negotiations”. In the end, the founding team was to clinch the deal with American company Nautilus. Looking back on this time, Joel Roos says: “As we’d already been working with Nautilus, we knew that we’d feel comfortable with the company. They painted a very clear picture for us of what our future together would look like.” Nevertheless, the negotiations with the purchaser were “scary times” and made up a full-time job: there was no time to acquire new business, and the start-up even had to cancel partnerships with certain customers during this period. “If the deal hadn’t come off, it would’ve been not only a failure, but an extreme setback for us.” In September, the moment finally arrived and the 80-page document, which had been sent back and forth countless times, was signed – and, in one fell swoop, the young

Switching sides
A former professional athlete and founder, he was once on the brink of failure. Today, ETH alumnus Joel Roos champions others in his work as investor and philanthropist.
founders were set for life. And Joel Roos now? He has thrown himself back into work. He doesn’t attribute too much to his success: “We were also lucky – Nautilus had this purchasing power because the home fitness market was doing extremely well during Corona.” But he credits himself and his team for their resilience, as this meant VAY was still around when the offer arrived. “When faced with a choice, I’ll always go for the challenge. Giving up is never an option.” His current challenge is to make headway in digitalising all the products in Nautilus’s range – a hardware company with over 40 years of history.

The joy of giving back
Today, ETH and its young entrepreneurs are a matter close to Joel Roos’s heart: “Not long ago, I was on the other side. For a long time, my co-founders and I were unable to find funding which is why, at the time of our exit, we promised to support future entrepreneurs. Looking to the long-term, we want to reinvest up to 50 per cent in the ecosystem.” As a top-tier university with affordable tuition fees, ETH is unique by international standards, but when it comes to promoting start-ups, Joel Roos sees room for improvement. This is why he’s actively involved as an early-stage investor, including in S2S Ventures, a student-led venture capital company. With Nautilus, he’s also an industrial partner to the ETH AI Centre, and he’s a private donor to the ETH Foundation. Commenting on his philanthropic efforts for the planned Centre for Students and Entrepreneurs, he says: “ETH has given me so much, for me it’s a no-brainer to give something back. I expect the Centre to transform countless more ETH graduates into successful young entrepreneurs.”
As an ETH alumna, I’m convinced that ETH will continue to produce innovations that are true gamechangers.

Daniela Bosshardt
Member of the ETH Foundation Board of Trustees

Innovative technology
After ten years of intensive research, the Neurotechnology Group led by Professor M. Fatih Yanik at the Institute of Neuroinformatics at ETH Zurich has now developed a technology that allows drugs to be delivered to specific areas of the brain with millimetre precision and in very high concentrations. With this technology, 1300 times higher drug concentrations can be achieved in a given brain area compared to current drug treatments. Initial studies on small animals have shown that, using this technology, chronic anxiety can be alleviated without side effects. For the delivery process, the group developed special ultrasound-controllable drug carriers. After injecting these carriers into the blood, a two-stage sequence of focused ultrasound – also newly developed – is directed at the desired areas in the brain. The first sequence of ultrasound waves aggregates the drug carriers in the targeted brain region with millimetre precision, thereby achieving a high local concentration of the medication. In the second sequence, the active ingredient is released from the carrier, which then crosses the intact blood-brain barrier locally.

From feasibility study to first patient
To advance this promising technology, preclinical studies on sheep are currently under preparation. In addition to Fatih Yanik and his team, the other contributors to the study are the digital Trial Intervention Platform (dTIP) at ETH, Good Manufacturing Practice Facility at ETH, University of Basel and University Hospital Basel, Vetsuisse Faculty at University of Zurich and the Department of Neurosurgery at University Hospital Zurich. After the preclinical study, the goal is to start clinical trials on patients. A partnership with the Swiss Epilepsy Clinic in Zurich has been planned for this purpose.

Potentially revolutionary effect
The technology described has the potential to revolutionise the treatment of neurological and neuropsychiatric disorders. It will be possible to deliver drugs to specific brain areas in the future and, thanks to high local concentration, to achieve much greater efficacy with minimal side effects. Innosuisse and the Swiss National Science Foundation honoured the project with a Bridge Discovery Award in 2022. To fast-track clinical applications of the technology, further funding is urgently needed. We look forward to engaging in dialogue with partners who wish to help achieve a breakthrough in a technology that holds immense promise for our health.

Find out more: ethz-foundation.ch/en/braindisorders
Your support

Whether it’s in healthcare, cyber security, energy supply or climate protection: scientific and technological innovations create tremendous opportunities for today’s society to live healthier, more resilient and more sustainable lives. The key to success lies in excellent research and teaching, strong partners – and you. By making an unrestricted donation to the Polyfonds, you can help visionary ideas achieve their breakthrough!

The AnastoSEAL suture and staple sealing patch from Pioneer Fellow Alexandre Anthis remains adhered under the toughest conditions, preventing life-threatening leaks after abdominal surgery (see page 11).

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