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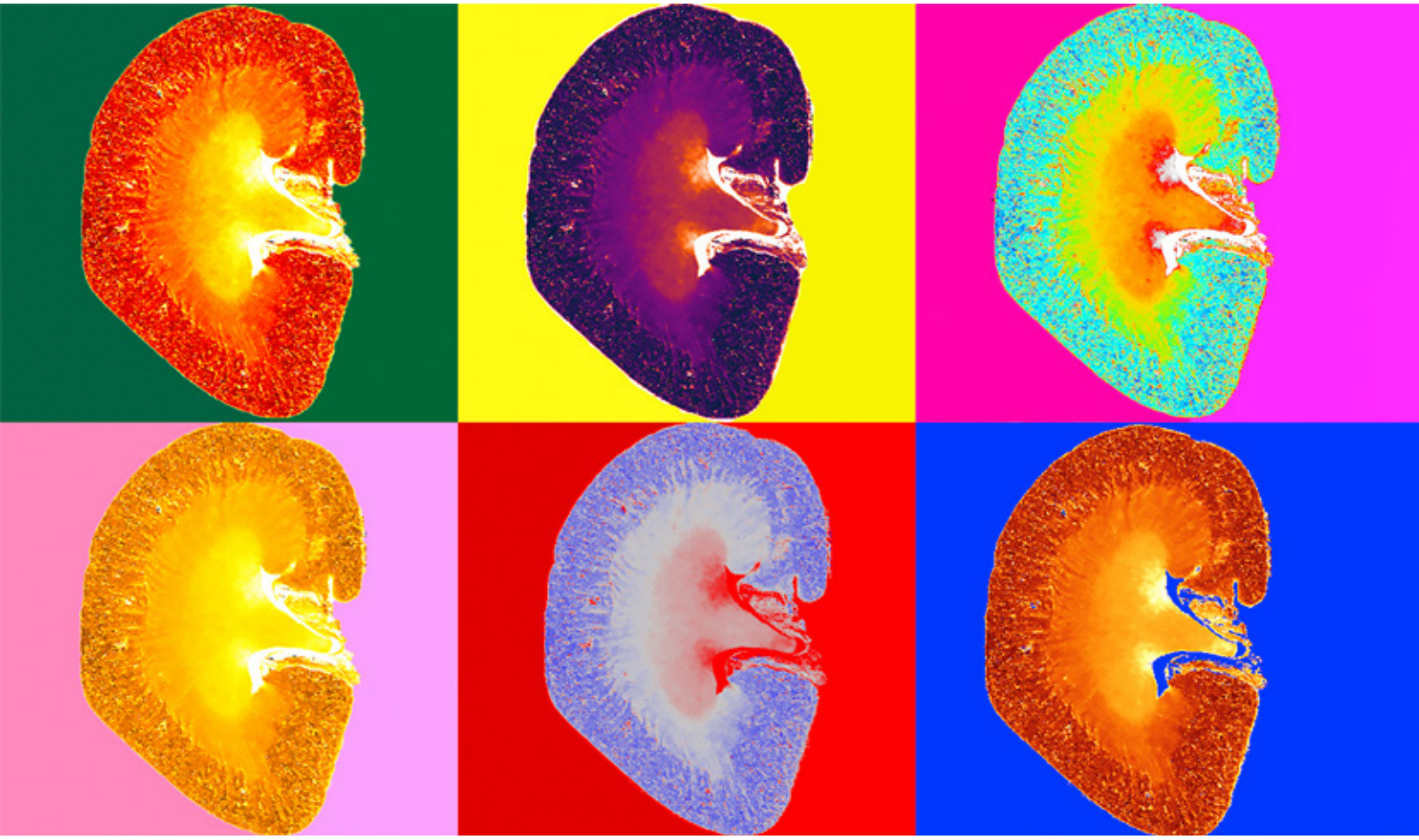

Life Sciences Report 2022 | 2023

Biotech | Pharma | Medtech | Digital Health in Berlin-Brandenburg

THE GERMAN CAPITAL REGION

excellence in life sciences & healthcare

HealthCapital
BERLIN BRANDENBURG

Joint cluster management for a strong healthcare region

The management team for the HealthCapital Berlin-Brandenburg Cluster at Berlin Partner for Business and Technology and Economic Development Agency Brandenburg (WFBB) is driving networking, technology transfer and supporting regional companies and international corporations interested in relocating their business, research, or development to the German capital region.

For more information about the cluster HealthCapital Berlin-Brandenburg: healthcapital.de or send an email to info@healthcapital.de.

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Cover Photo
Winner of the Best Scientific Image Contest 2022: Andy Warhol Kidney.
It shows structures of a rat kidney obtained with magnetic resonance imaging MRI.

The German capital region: Top life sciences location with high impact on global health

Innovators and companies from the German capital region have made major contributions in the global fight against the pandemic. Being in the COVID-19 recovery phase, there is unfortunately no time for a breather. Against the backdrop of the climate change, new challenges to economy and society are added such as increasing inflation and the current energy crisis. The vibrant life sciences ecosystem in Berlin-Brandenburg is in the middle of a transformation process. This Life Sciences Report gives an impressive snapshot of how the region has transformed into a world-leading life sciences hub. Find out how regional players are responding to new trends and market opportunities to sustainably strengthen their impact on biomedical research and global health.

When the last Life Sciences Report was published in 2020, the COVID-19 pandemic had just started to take the world in its grip. Innovative and smart life sciences approaches have played a central role in the global fight against the pandemic and innovators and companies from the Cluster HealthCapital Berlin-Brandenburg have made major contributions here.

The team of Professor Christian Drosten at Charité's Institute of Virology developed the world's first RT-PCR test to detect SARS-CoV-2. Diagnostics companies based in the German capital region have since then manufactured and shipped millions of test kits or provided key instrumentation to diagnostics and leading vaccine manufacturers. Berlin also emerged as a hub for collecting, analyzing, and sharing health data and has started strong research activities into long COVID. Consequently, the WHO opened the new center for epidemic and pandemic preparedness in Berlin.

In 2022, numerous other crises have added to the list of global challenges that strongly affect economic, social and environmental aspects of the healthcare industry. Along with the digital transformation comes the sustainability transformation – affecting the life sciences and healthcare system as well as all other sectors.

Our healthcare system has a major climate impact, contributing to an estimated 5 % of greenhouse gas emissions. Sustainable healthcare matters: the field must improve its environmental performance and reduce its climate impact throughout the value chain. Smart innovations and enabling technologies will be key in reaching the European Green Deal targets.

Our new Life Sciences Report Berlin-Brandenburg gives an impressive overview of the vibrancy and innovativeness of the German capital region ecoystem. This report spotlights six areas with exceptionally strong research and translational activities: Cell and gene therapies, computational biology and medical informatics, precision diagnostics, artificial intelligence applications in imaging and beyond, additive manufacturing and sensorics.

The unique concentration and networking opportunities of science, clinics and business have long been recognized as one of the region's biggest strengths. It comes with no surprise that this vibrant and highly innovative ecosystem was placed third in a recent benchmarking study among the leading healthcare industry centers globally. We are committed to supporting our partners and further expanding the region internationally – to sustainably strengthen the healthcare industries and life sciences impact on global health.

Dr. Kai Bindseil
Cluster Manager HealthCapital
Berlin-Brandenburg
Berlin Partner for Business and Technology

Content

By scanning the QR Code you will find an overview of more than 670 player of industries, startups and research institutions in the HealthCapital region Berlin-Brandenburg.

Healthcare Industries Cluster Berlin-Brandenburg – HealthCapital

Companies[1]	~22,500
Employees[2]	~395,500
Euros in revenue[1]	~32 billion

Largest university hospital in Europe

Charité – Universitätsmedizin Berlin

Sectors[3]

Pharmaceutical	35	12,340
Biotech	281	7,183
Medtech & Digital Health	356	14,706
	672 Companies	34,229 Employees
Hospitals	145	35,800

Technology parks focusing on life sciences	Large research facilities and institutions of higher learning focusing on life science	Health-related programs of study
8	40	150

Sources: [1] Amt für Statistik Berlin-Brandenburg, [2] Federal Employment Agency, [3] Own survey

BerlinBioCube incubator center for start-ups on the Berlin-Buch campus

Key factors for dynamic and sustainable development

The Berlin-Brandenburg capital region is one of the leading life science regions in Europe. With its unique number of scientific institutions, clinics, its broad range of infrastructure and the growing number of companies and start-ups, the region offers excellent conditions for innovation, growth and employment. A central factor for successful development is the close cooperation of all stakeholders and especially the close networking between science and business. Together with the international and cosmopolitan community, a unique and vibrant scene for innovation and successful business exists here.

Translation is key for innovation

Berlin-Brandenburg is one of the largest and most diverse science regions in Europe. More than 40 life sciencerelated scientific institutions are represented in the region, including the ***Charité University Hospital, the Brandenburg Theodor Fontane Medical School, the Berlin Institute for Health Research (BIH), the Max Delbrück Center for Molecular Medicine in the Helmholtz Association (MDC), the Robert Koch Institute, the German Heart Institute Berlin and other renowned Fraunhofer, Helmholtz, Leibniz and Max Planck Institutes in Berlin and Brandenburg***.

One flagship is the ***Berlin Institute of Health @Charité (BIH)***. The BIH is not a typical research institute. Its innovative approach is to utilize a novel concept of clinically anchored cross-organ systems medicine in a comprehensive translational ecosystem to significantly increase the speed and effectiveness of medical translation. Here digitization is playing an increasingly important role. To foster this development the BIH's Translation ***Hub Digital Medicine*** was established as a scientific hub, focused on key areas such as health informatics, artificial intelligence and big data. Its activities include, for example, developing IT infrastructures, big data analytical tools and mobile healthcare apps.

Research at the ***Max Delbrück Center for Molecular Medicine (MDC)*** aims to elucidate the molecular mechanisms of health and disease and translate those findings into medical practice. These core activities are pursued in 88 independent research groups and are complemented by twelve clinical research groups in the ***ECRC (Experimental and Clinical Research Center)*** of the MDC and Charité Berlin. The mission of the ECRC is to expand and strengthen interdisciplinary activities between basic and clinician scientists as well as to shorten the pathway from discovery to clinical applications.

The network of cooperation between the three major Berlin universities, including Charité - Universitätsmedizin Berlin, the ***Berlin University Alliance***, is becoming even more tightly knit. The goal is to combine strengths in order to open up opportunities for new innovative research projects and to shape the future together. It is an alliance that benefits everyone: science and teaching, Berlin and its economy, society and the people. One of the goals is to establish a lively and sustainable start-up culture.

With the ***"Modellregion Gesundheit Lausitz"***, a state university hospital will be established in Cottbus in the coming years and the ***Carl-Thiem-Klinikum*** in Cottbus will be turned into a university hospital and digital leading hospital. An important building block for this is the ***Brandenburg Health Campus***, which has already been targeted for development for several years. The networking of universities, non-university research institutions and clinics in the Health Campus, which is unique in Germany, opens up new opportunities for securing skilled workers and medical and nursing care in the Brandenburg region and strengthens the science and research landscape in the health sector.

In addition to these representative institutions, the scientific institutions and clinics offer a variety of excellent cooperation opportunities for regional companies to further develop their products and technologies with academic expertise or to launch completely new products on the market. This is demonstrated by a large number of joint projects between science and industry.

The place to be for start-ups and investors

The science institutions also focus in particular on the exploitation of research results by founding innovative start-ups. For example, the Berlin University Alliance has bundled its start-up activities in the "***Science & Startups***" initia-

Potsdam Science Park © Standortmanagement Golm GmbH/sevens+maltry

tive. “Science & Startups” provides a gateway and access to the joint programs and resources of Berlin’s universities to successfully start and develop a company. This includes innovative research, infrastructure, incubator space, scientific mentors, access to co-founders, grants or coaching.

The ***SPARK program*** at BIH deserves special mention. SPARK is a mentoring program from BIH that supports early-stage academic inventions with education, mentorship and funding. The program is designed to de-risk projects with high potential impact, addressing critical unmet medical needs for any medical indication. The aim is to

Dr. Thorsten Lambertus,
Director DEEP & CDL Site Lead,
ESMT Berlin

"ESMT Berlin brings the Creative Destruction Lab (CDL) to Germany's most dynamic start-up ecosystem. It is the first location of the CDL in Germany and will start with a Health Stream. CDL is a globally recognized accelerator program for massively scalable, early-stage science and technology-based companies. With its strong innovation ecosystem, Berlin is the perfect location for us."

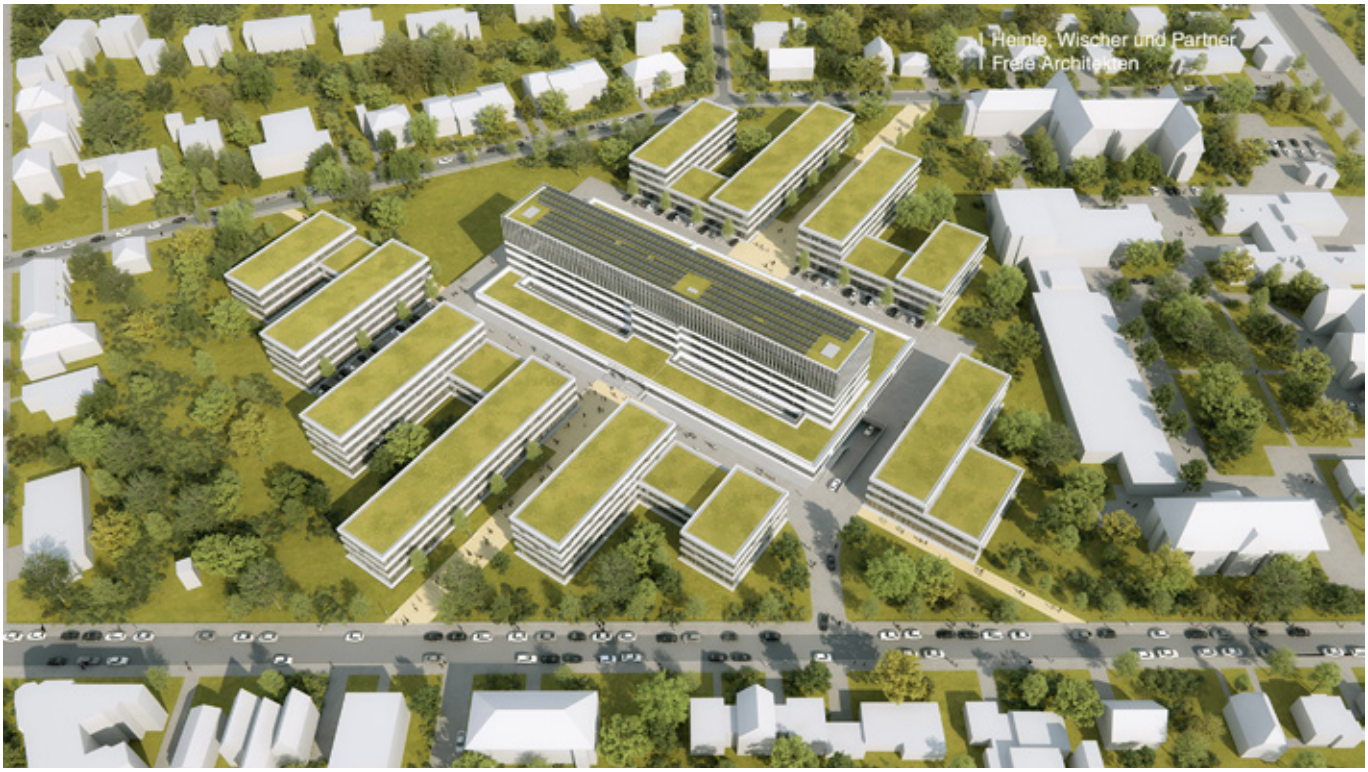
accelerate the translation of academic inventions into outstanding medical products including novel drugs, repurposing drugs, advanced therapy medicinal products, such as cell and gene therapies, diagnostics and medical devices.

In addition to the numerous academic offerings that primarily target their own spin-offs, the region offers a wide range of different support services. In total, there are over 80 accelerators and incubators that provide start-ups with assistance in their early stages. Of these, some have focused on health. For example, ***Vision Health Pioneers Incubator***, a Berlin based early-stage start-up program that supports first-time founders in healthcare. In their 10-month program, they support entrepreneurs with training, free co-working space, business opportunities and equity-free scholarship funding of up to 80,000 Euro per team.

These diverse offerings were recently complemented by the launch of the "***Creative Destruction Lab***" ***(CDL)*** in Berlin. CDL is a global non-profit organization that delivers an objectives-based program for massively scalable, seed-stage, science- and technology-based companies. CDL has designed a new approach to enterprising research and innovation, nurturing an entrepreneurial mindset through expert opinion, funding opportunities, research analysis and business development support.

The recent "***Startup Barometer E&Y***" from Ernst&Young shows the large number of support offerings for start-ups. In 2021, the largest amount of investment capital flowed to start-ups in the health sector. In 59 financing rounds, they received a total of 588 million Euro. Once more Berlin is it the frontrunner in Germany and among the Top 3 in Europe.

Two public financing programs have made an important contribution to this. The two regional banks of Berlin (IBB) and Brandenburg (ILB), with their funding programs and their holding companies ***IBB Ventures*** and ***ILB Beteiligungsgesellschaft*** play an important role in financing. They provide start-ups with the grant money or share capital they need and supplement these funds with commit-



FUBIC (Business and Innovation Center next to Freie Universität Berlin Campus)

ments from private investors or even provide initial access to such investors.

Infrastructure as an essential success factor

A key success factor is the infrastructure that makes effective and efficient collaboration possible. Fast routes, high R&D density, close networking: This is the short formula for successful clusters such as that of the Berlin-Brandenburg healthcare industry. And what applies to the entire region also applies to the numerous technology parks in Berlin and Brandenburg. The parks provide companies with optimal space, modern laboratories and space depending on their specific needs, thus contributing to the success and growth of the region. The direct proximity of science and business make the parks a melting pot for interdisciplinary technology development. With a total of eight technology parks in the life sciences, this infrastructure is unique in Germany in terms of size and diversity. These include ***berlinbiotechpark Charlottenburg***, ***Biopark Luckenwalde***, ***Campus Buch***, ***Campus Dahlem FUBIC***, ***Innovationspark Wuhlheide***, ***Potsdam Golm Go-In***, ***TZ Hennigsdorf*** and ***WISTA***. These parks provide a total of about 250,000 square meters. And the development continues at a rapid growth. In 2023, for example, the ***BerlinBioCube*** will open in the Berlin-Buch Campus, creating space for 400 new jobs. With the ***FUBIC***, a new site is being developed in close proximity to the Freie Universität Berlin, which will create an additional 40,000 square meters of new space for life science companies over the next few years. At the Potsdam-Golm site, the ***Potsdam Science Park*** is also being significantly expanded with around 60,000 square meters of new space. Complementing these expansions, new, highly specialized sites are being developed, such as the "***Competence Center for Biomaterials Teltow-Seehof***" with over 2,000 square meters and the "***Chemical Invention Factory***" at the ***Technische Universität Berlin*** with a similar size. These areas are planning for spin-offs from their respective faculty members.

SEE:LAB is opened. Laboratories for young companies on the research campus Teltow-Seehof. www.tgz.pm © TGZ PM GmbH

"With the BerlinBioCube start-up center, we are creating 8,000 square meters of laboratory and office space for young innovative biotech companies in the life sciences with up to 400 new jobs. The opening of the BerlinBioCube in late summer 2023 represents another milestone for the Berlin-Buch Campus. Demand already exceeds supply. This is a clear indication that the biotech industry is booming in the capital region. With the new space, we are responding to the encouraging development and will continue to expand in the future."

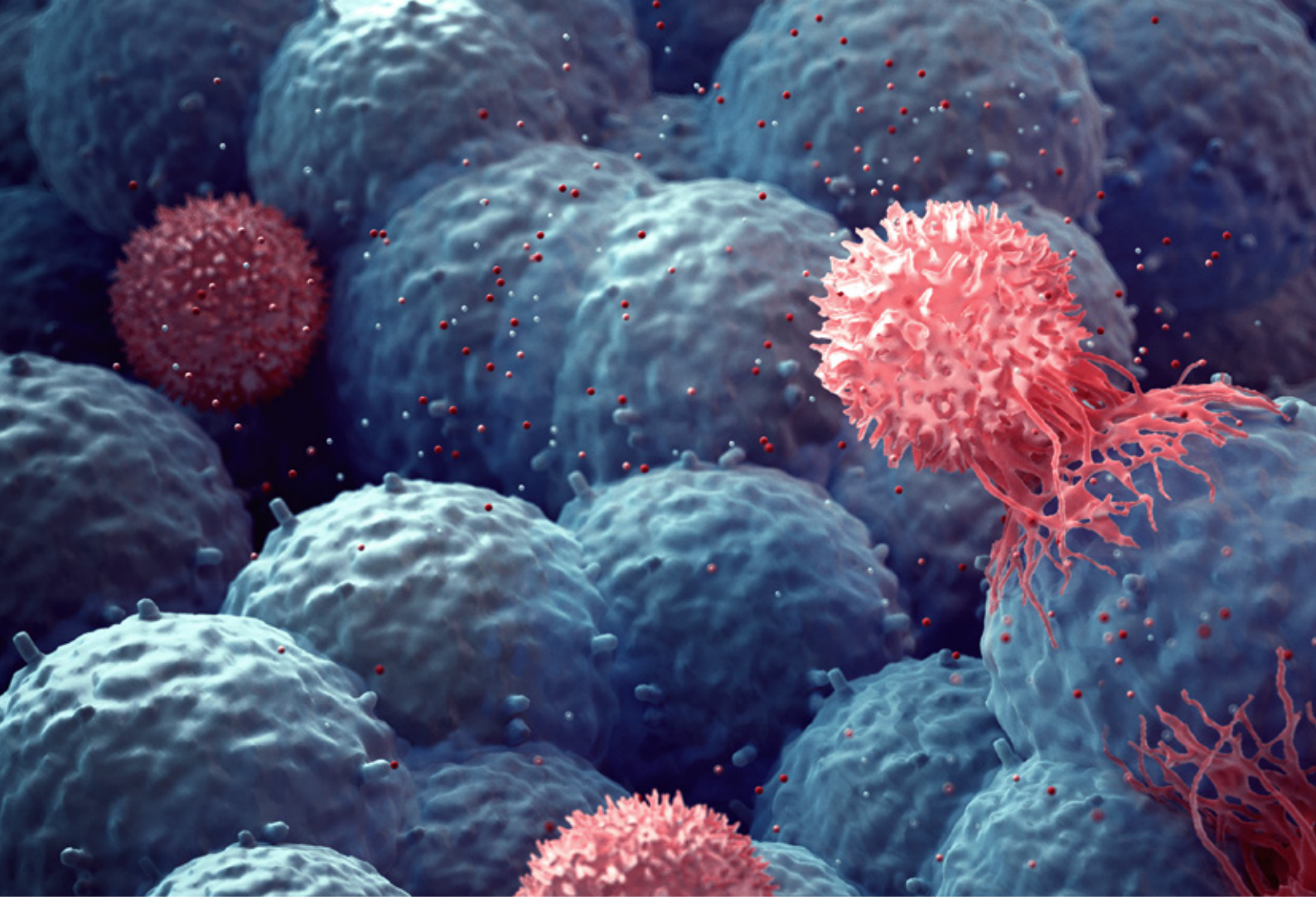
Dr. Christina Quensel,
Managing Director of Campus Berlin-Buch GmbH

Photo © David Ausserhofer Campus Berlin-Buch GmbH

Networks for new technologies and services

The concentration of players from many institutions and companies is the ideal breeding ground for close and interdisciplinary cooperation. Many have joined forces in joint networks to benefit from each other and to develop new technical solutions. The German capital region features a number of networks working on specific topics that allow stakeholders along the entire value chain to collaborate. These includes Network ***Bio-PAT***, ***DiagnostikNet Berlin-Brandenburg***, ***glyconet Berlin-Brandenburg*** and ***NetPhaSol***.

The combination of entrepreneurial spirit and established industry as well as the extensive networking between science and industry provide an extraordinary infrastructure for innovation and company growth in Berlin and Brandenburg.



T cell killing a tumor cell © T-knife Therapeutics, Illustration: SCI-ILLUSTRATE

Boosting a cell-based medicine ecosystem

The core concept in regenerative medicine is the use of living cells to heal disease. With the advent of powerful cell technologies and genome editing tools, a growing number of cell-based therapies have entered the clinic. As a powerful new treatment option, they have raised the interest of investors and the biopharma industry. Berlin builds on its tradition and excellent biomedical infrastructure to become a hot spot of cell-based medicine approaches of the next generation.

When describing the future of medicine, Professor Heyo Kroemer, the Chief Executive Officer of Charité – Universitätsmedizin Berlin, is pretty clear: “Alongside mRNA-based methods, cell and gene therapies have the biggest global growth potential when it comes to developing new approaches to the treatment and prevention of severe illnesses.”

Using cells as living agents to heal disease or to restore impaired organ function – the idea of regenerative medicine – has been around for decades. But it is only in recent years that cell-based therapeutics have experienced explosive growth in both clinical deployment and expansion within the pharmaceutical marketplace. Their remarkable efficacy in diseases with great medical need has spurred the interest of the pharmaceutical industry and has also attracted the attention of the capital market.

There is a growing number of commercially approved immunotherapies in oncology using genetically reprogrammed T cells. And breakthrough developments in stem cell-based approaches deliver the material for cell replacement therapies. In addition, powerful genome editing tools have enabled tremendous progress in advancing gene therapeutic approaches.

Because each therapy is a complex procedure tailored specifically to a patient, cell therapy developers still face numerous challenges. As a location that is home to nationally and internationally esteemed institutions for biomedical

research and the health industry, the Berlin-Brandenburg region offers an excellent environment for an emerging ecosystem paving the way for the next generation of cell-based therapeutics.

Excellent infrastructure in healthcare and biomedical research

The only cell therapy that has been in clinical routine use for decades is blood stem cell transplantation. Blood stem cell transplants are used in the treatment of blood cancers such as leukemia. There are three big hospitals in Berlin and three in the Federal State of Brandenburg that have specialized in this procedure. The ***Charité Stem Cell Facility*** is one of biggest of its kind in Europe. Per year, the facility manufactures more than 800 transplants for internal and external use.

The mission of the ***Berlin Institute of Health (BIH)*** as the translational research unit at Charité is to translate findings from biomedical research into novel approaches to personalized prediction, prevention, diagnostics and therapy. The Max Delbrück Center for Molecular Medicine in the Helmholtz Association (MDC) is the privileged partner of the BIH. Among other activities, the BIH has established a Translation Hub on Organoids and Cell Engineering, part of which are two stem cell facilities developing new human models for preclinical research and focusing on the methodical development of cell-based therapies.

Regenerative therapies seek to use cells transplanted into a patient to restore the impaired functions of living tissues and organs. The ***BIH Center for Regenerative Therapies (BCRT)*** is an interdisciplinary translational center. Here, several teams are conducting research on the body's own healing processes and developing new therapies and diagnostics.

Prof. Dr. med Petra Reinke
Founding Director of BeCAT

"Among the frontrunner projects in the pipeline of the Berlin Center for Advanced Therapies (BeCAT) are various T cell and innate immune cell therapy approaches to treat viral infections, autoimmune diseases, cancer or transplantation-linked disorders. The new BeCAT building will mainly house a state-of-the-art GMP production facility."

Photo © BIH Charité

Cell-based medicinal products containing living cells which are expanded in the lab and/or genetically modified during manufacturing are legally classified as Advanced Therapy Medicinal Products (ATMPs) in the European Union. Bringing this kind of cell-based therapeutics into the clinical practice is the central aim of the ***Berlin Center for Advanced Therapies (BeCAT)***. The research and development center involves a growing number of interdisciplinary research teams. The BeCAT is also strongly connected to the BIH and can rely on the internationally highly recognized infrastructure for early clinical studies at the Charité.

"The BeCAT pipeline is already huge," says nephrologist and transplant physician Professor Petra Reinke, the founding director of BeCAT. Among the frontrunner projects are

Berlin Center for Advanced Therapies (BeCAT) at the Charité © Architect DGI Bauwerk

various T cell and innate immune cell therapy approaches to treat viral infections, autoimmune diseases, cancer or transplantation-linked disorders. “We also considering approaches based on induced pluripotent stem cells or tissue engineering as well as bioprinting.”

At the heart of the BeCAT is the new building funded with 29.5 million Euro both from federal and state money resources at the Charité Campus Virchow. In May 2022, it celebrated its topping-out ceremony. “The new building will mainly house a state-of-the-art production facility for ATMPs with a modular laboratory unit according to Good Manufacturing Practice (GMP)”, Reinke says. She estimates it will take another year or two until the first BeCAT teams can fully start to work on projects there. Until then, the BeCAT researchers can also rely on an already existing GMP facility at the BCRT that Reinke’s team has established at the Charité Campus Virchow.

A start-up at the forefront of companies developing novel T cell therapies

Engineering the next generation of cell-based therapeutics has catapulted Berlin-based biotech start-up ***T-knife Therapeutics*** to the forefront of companies worldwide developing novel T cell immunotherapies to treat cancer. Based on a technology developed over decades of research by co-founder Professor Thomas Blankenstein/MDC, the T-knife team is teaching a patient’s T cells to identify cancer cells as invaders by equipping them with new T-cell receptors (TCR). As a powerful alternative to CAR-T cell therapy, TCR-T cell therapy could open up new treatment options for cancer patients – as even solid tumors can be targeted.

This also has raised the interest of international investors: Breaking news came in August 2021 when T-knife was able to raise US$ 110 million in a series B financing round, making the MDC-spin-off founded in 2018 one of the best-funded start-ups in the German biotech sector. In previous financing rounds, T-knife had already collected more than US$ 90 million. “We will use the proceeds from this financing to expand our scientific team, increase production capacity, and add additional innovative and differentiated T-cell receptor therapies to our pipeline,” says Elisa Kieback, the founding CEO and now Chief Technology Officer of T-knife (see interview).

Advancing a gene therapy to treat rare muscle diseases

Using tissue stem cells for regenerative therapies to restore impaired functions of patients’ muscles is the aim of the ***MyoPax*** team. The muscle research team lead by Professor Simone Spuler at the Charité and MDC has developed a technology to produce highly regenerative muscle stem cells. This innovation is now being developed for muscle stem cell therapies for the treatment of different muscle wasting conditions. In patients with genetically caused muscular dystrophies, cells are extracted and modified using CRISPR-based gene editing to repair the underlying gene defect. The engineered cells are then transplanted into the muscle of the patient.

“Funding initiatives such as the SPARK-BIH program and the excellent clinical research infrastructure have built an ecosystem that strengthens entrepreneurship and leverages the development and the validation of novel cell and gene therapies.”

Dr. Verena Schöwel-Wolf, CEO at MyoPax GmbH

Photo © MyoPax GmbH

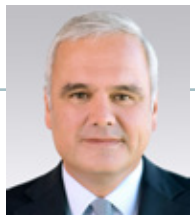
A first-in-human trial for this gene and cell therapy is in advanced preparation. “With the new spin-off MyoPax, we will accelerate the clinical developments of these advanced and clinically pivotal muscle stem cell therapies,” says Verena Schöwel-Wolf, who together with Simone Spuler founded the company and is the CEO of the start-up.

“Without funding by the SPARK – BIH program, the Federal Ministry of Education and Research and the Helmholtz association, we would never have been in the position to go into clinical developments,” Schöwel noted. MyoPax recently received a 1.3 million Euro loan from the BioInnovation Institute Foundation (BII) as seed capital.

Bayer AG’s BlueRock establishes European site in Berlin

Big Pharma has also identified the area of novel gene and cell therapies as a major driver for innovation. Life science company ***Bayer AG*** with the headquarters of its pharmaceutical division based in Berlin has put the field at the center of its focused growth strategy.

In June 2022 Bayer announced that its wholly owned subsidiary ***BlueRock Therapeutics*** had established a new site for cell therapy innovation on Bayer’s campus in Berlin, representing the first European site of the company headquartered in Cambridge, Massachusetts in the United States.



Stefan Oelrich, Member of the Board of Management and President of Pharmaceuticals Division of Bayer AG

"Establishing a presence for BlueRock Therapeutics in Berlin as its first site in Europe offers the opportunity to strengthen our collaboration, with the ultimate goal to deliver cell therapies with transformational potential."

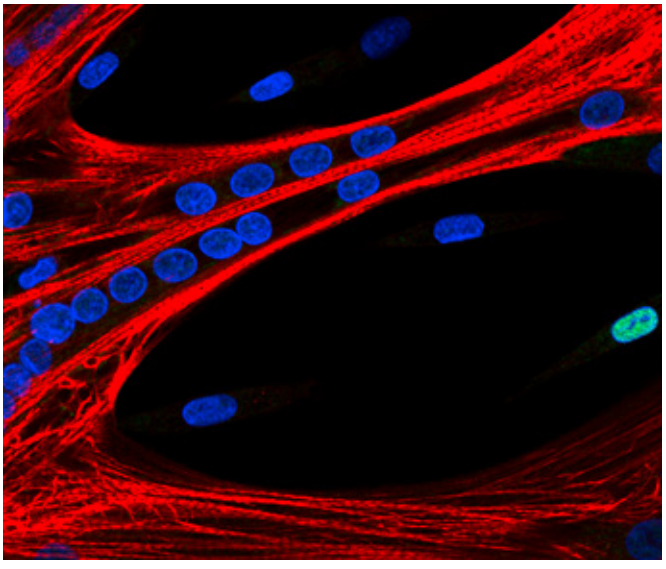
Photo © Bayer AG

A multidisciplinary BlueRock team will be set up to provide clinical development and operational support for Europe. The team will expand as the company's growing pipeline of innovative cell therapies for treating patients with neurological, immunological, cardiovascular and ophthalmic diseases progresses.

"This is a significant step forward in advancing our company's leadership in cell therapies globally. Establishing a presence for BlueRock in Europe offers the opportunity to strengthen our collaboration, with the ultimate goal to deliver cell therapies with transformational potential," says Stefan Oelrich, Member of the Board of Management, Bayer AG and President of Bayer's Pharmaceuticals Division.

Center for translational research in the area of gene and cell therapy

A further push for the cell-based medicine ecosystem came in April 2022 when Governing Mayor of Berlin Franziska Giffey together with other Senate members, Bayer's Stefan Oelrich and Charité CEO Heyo Kroemer signed a joint Memorandum of Understanding on founding a ***center for translational research in the area of gene and cell therapy*** in Berlin.



Myotubes – Immunofluorescence © Eric Metzler, MyoPax GmbH

Referred to as a healthcare lighthouse project unique in Germany, the center is supposed to have an international impact on business and science and create highly qualified jobs along with new potential for cooperation with partners from all over the world. It seeks to strengthen Berlin as a research hub and healthcare capital. The center could be located on the premises of Bayer AG's pharmaceutical headquarters in Berlin and would be a stellar example of cooperation between science and business.

Realizing the concept of cell-based medicine

Realizing the next generation of cell-based therapies requires the use of cutting-edge technologies and new models of collaboration in basic research and the health industry. Understanding and targeting diseases by analyzing the molecular information by sophisticated single-cell technologies and powerful informatics is at the heart of the ***Berlin Cell Hospital***. The project was announced on the occasion of celebrating the 200th birthday of pioneering Berlin pathologist, Rudolf Virchow, in 2021. Professor Nikolaus Rajewsky from the Berlin Institute for Medical Systems Biology of MDC and Charité-Professor Angelika Eggert have spearheaded the project. "The Berlin Cell Hospital aims at building an AI-driven ecosystem to advance and realize the concept of cell-based interceptive medicine," explains Rajewsky. The idea behind it is targeting disease-causing cells to prevent diseases before irreparable damage occurs. The Berlin Cell Hospital's key participants are the MDC, the Helmholtz Association, Charité, the BIH and the Berlin Institute for the Foundations of Learning and Data (BIFOLD).

The core pillars of the Berlin Cell Hospital (BCH) are single-cell technologies, patient-specific model systems such as organoids, and new AI solutions. These will mainly be applied to the major chronic diseases such as cancer, cardiovascular diseases, infectious diseases and neurological diseases. "The Cell Hospital aims to develop molecular prevention strategies and new precision diagnostics, as well as to reliably identify new drug targets for molecular and cellular therapies," Rajewsky says. "So far there is nothing comparable to the BCH for cell-based medicine anywhere in the world."

The systems biologist was also the driving force behind the innovation cluster concept Virchow 2.0, an ambitious Berlin-Brandenburg initiative that was among the 15 finalists in the second round of the Clusters4Future competition of the

Three questions to...

Dr. Elisa Kieback

CTO and co-founder of
T-knife Therapeutics

With US$ 110 million raised in a series B financing round, you were among the best financed German biotech companies in 2021. How will you invest the money to bring your T cell immunotherapy pipeline forward?

We are currently focused on treating the initial patients in a Phase 1/2 clinical study. The IMAG1NE study has been designed to evaluate the safety and initial efficacy of our lead product candidate TK-8001, which is a T-cell receptor (TCR) -based T-cell therapy targeting the tumor antigen MAGE-A1. A large part of the investment will be used to manufacture products and treat patients to generate clinical proof-of-concept data for TK-8001.

What are the primary points of differentiation that allowed you to attract your investors?

T-knife has a very unique technology based on decades of biomedical research that allows for the discovery of novel tumor targets and their receptors. Our MyT platform can deliver receptors of optimized affinity and high specificity. Furthermore, the potential to scale TCR discovery to select from hundreds of specific binders is unprecedented. And equally important, we have built a strong team with presence on both sides of the Atlantic, both in Berlin, Germany and San Francisco, US.

Can you name some of the important aspects of why Berlin-Brandenburg is an excellent ecosystem for a biotech-company in the booming field of cell and gene therapies?

Berlin-Brandenburg has an outstanding research landscape with leading STEM-focused universities, hospitals and renowned research institutions, including the Humboldt University, Charité, the Max Delbrück Center and the Max Planck institutes. This means we have excellent academic talent that is important for a science-driven biotech company. At the same time, Berlin has a growing biopharma landscape, and cell therapy has become a focus for several of these players. Others already have an established footprint in the region for many years.

Federal Ministry of Education and Research (BMBF). The concept aimed at building up an innovation ecosystem for cell-based medicine in the Berlin-Brandenburg area. Although Virchow 2.0 did not make it amongst the seven winning clusters, it has strengthened the emerging Berlin-Brandenburg ecosystem for cell-based medicine.

Other relevant players from Berlin-Brandenburg:

BTU Cottbus-Senftenberg's Institute of Biotechnology has specialized on tissue engineering with a focus on bone and cartilage applications in diagnostics and therapy.

Captain T-Cell is an MDC-based start-up that has developed a toolbox for next generation TCR-T cell therapies to treat solid tumor patients.

CellDot GmbH is a provider of biotechnologies needed to obtain individualized pluripotent stem cells suitable for cell therapy.

CheckImmune GmbH offers consultancy and laboratory services to support clinical development of immunotherapeutics via biomarker studies.

EpiBlok Therapeutics GmbH is a start-up that develops a gene therapy to treat epilepsy.

German Stem Cell Network (GSCN) pools national expertise in stem cell research and translation and cooperates closely with the Berlin Institute of Health (BIH).

GrOwnValve GmbH is a pre-clinical stage medical device company, developing a unique heart valve prosthesis system using patient-donated tissue.

TissUse GmbH is a Berlin-based biotechnology company which has developed a unique "Multi-Organ-Chip" platform for pre-clinical research and toxicity testing.

TheryCell GmbH develops and manufactures dedicated, tumor specific T-cells for future individual tumor therapies.

Photo © SCIENION GmbH

Next-generation precision diagnostics

Laboratory-based diagnostics is the backbone of modern medicine. The pandemic has made infection diagnostics a part of our everyday life. Processes in laboratories are becoming increasingly digitalized. Miniaturization and automation are other drivers of innovation. Combined with other powerful technologies such as single cell analysis, organoid technology and artificial intelligence, they pave the way for precision medicine.

In vitro diagnostics are a crucial part of modern evidence-based medicine: Laboratory-based tests performed on biological samples provide information that is key for the prevention, treatment and management of disease. This is particularly true for the concept of precision medicine, which aims at treating patients according to their individual molecular make-up.

Berlin-Brandenburg is home to proven innovators in developing molecular tests as well as high-tech instruments and consumables. This is nicely mirrored by the high impact the contributions of infection diagnostic specialists had in combating the Corona pandemic: The team of Professor Christian Drosten at ***Charité's Institute of Virology*** developed the world's first RT-PCR test to detect SARS-CoV-2. Another early mover was Berlin-based ***TIB Molbiol GmbH***, now owned by Roche, which had a commercial PCR test kit available up and running in no time and has by now delivered more than 60 million tests worldwide.

Innovative developments in the in vitro diagnostic field are currently driven by several major trends. One of them is point-of-care testing – tests that are performed on-site or near the bedside or as a self-test rather than in a centralized laboratory. Miniaturization is another megatrend: Applying a set of top-notch bioanalytical techniques to single cells and integrating this data in a multi-omics approach has opened up new avenues to biomedical research and translation. All these are embedded into the ongoing digitalization and automation of diagnostic laboratories. Players in Berlin-Brandenburg are at the forefront of these developments.

Mass spectrometry as key to precision diagnostics

In hardly any other field has the concept of personalized medicine become a clinical reality as in the battle against cancer. Treatment concepts focus on the molecular profile of cancer cells in the body. However, current precision oncology relies mostly on genomics data to infer treatment options.

Mass spectrometry has emerged as another key bioanalytical technology of precision medicine. The technique allows the detection and quantification of disease-relevant biomolecules such as proteins, lipids and metabolites quickly and comprehensively. However, mass spectrometric methods are still strongly underrepresented in medical diagnostics, partly due to the lack of standardized procedures and previous technical limitations of mass spectrometers.

To give mass spectrometry in systems medicine a boost, the Federal Ministry of Education and Research (BMBF) provides funding to four research cores in Berlin, Heidelberg, Mainz and Munich. The Berlin research core ***MSTARS***, which received 5.7 million euros in federal funding, is pooling the regional expertise in mass spectrometry for precision medicine and aims to implement these in clinical routines. A number of research teams from the Charité and the Max Delbrück Center for Molecular Medicine (MDC) are part of MSTARS.

Photo © ASC Oncology

Photo © Wiebke Peitz Charité

"High-throughput approaches in mass spectrometry will have a major impact on precision medicine of the future. In MSTARS, we are building capacity and developing standardized procedures for all processes, from sampling through to data management."

Prof. Markus Ralser,
Director Institute of Biochemistry at Charité – Universitätsmedizin Berlin

The acquired data are integrated to identify biomarkers or signatures that predict the treatment response at the level of the individual patient, with therapy resistance being the focus for cancer and inflammatory diseases. "A major aim in this regard is to make mass spectrometry-based methods even more robust and reproducible," says Professor Markus Ralser, Director of ***Charité's Institute of Biochemistry*** and one of the four coordinators of the alliance. "In order for this technology to improve patient care, we need to be able to analyze large numbers of samples within a short time. To achieve this, we are building capacity and developing standardized procedures for all processes, from sampling through to data management." Ralser's team for example has developed mass spectrometry and AI-powered methods such as Scanning SWATH that quantify thousands of proteins in mere minutes. "This paves the way for high-throughput proteomics approaches and will have a major impact on precision medicine of the future," Ralser says.

Rise of the organoids

Organoids – tiny stem cell-derived 3D cell culture systems – have advanced to stardom status in the health research field. As the living "mini organs" are formidable models of human development and disease processes, organoids have become extremely popular tools for translational medicine. Organ-on-a-chip systems, which involve culturing the organoids on microfluidic biochips, have emerged as excellent drug testing systems that can help reduce the number of animal experiments. A combination of such organ chips and 3D cell cultures is the focus for "***Si-M Der Simulierte Mensch***" (the simulated human), a research center currently under construction in Berlin's Wedding district. The new 34 million euros research building with its spectacular open design is due for completion in 2023.

It will be the centerpiece of a new joint Charité and TU Berlin biotechnology and medical technology campus. "In this house, scientists and engineers from TU Berlin and Charité will work side by side to develop new models in order to better understand the human body and its diseases. This is important to replace animal models, to understand human-specific pathologies and develop better personalized therapies," says Sina Bartfeld, Professor and Head of the Department of Medical Biotechnology at TU Berlin. The organoid specialist will play a leading role at Si-M alongside the initiators, TU Professor Roland Lauster and BIH Professor Andreas Thiel.

Enablers of precision oncology

Organoids can also be produced from tumor tissue from patients – offering high diagnostic and therapeutic potential in personalized cancer medicine. Berlin-Buch based ***ASC Oncology GmbH*** is employing solid tumor organoids from cancer patients to test the effects of cancer drugs prior to use. Dubbed "Reverse Clinical Engineering", the technology enables them to determine which drug or combination of drugs is most effective against the specific tumor. Biotech company ***CELLphenomics GmbH***, right next door at Campus Berlin-Buch, is combining tumor organoid technology with a multi-omics approach and automation to boost drug discovery research regarding almost any solid tumor type, including rare cancers such as sarcomas. Both organoid companies were founded by molecular biologist Dr. Christian Regenbrecht.

Another advanced diagnostics approach shaping precision oncology is liquid biopsy. This minimal invasive technique is used to detect cancer biomarkers via analyzing circulating tumor DNA or cells from bodily fluids. Combined with improvements in omics technologies and artificial intelligence-enhanced analytics, liquid biopsy opens up a lens for greater insights into directing an individual's cancer treatment. A number of players in Berlin-Brandenburg have specialized in liquid biopsy technologies and equipment: Potsdam-based ***GILUPI GmbH*** has developed a system to collect and isolate the rare tumor cells from the blood stream. Also active in this field is ***Invicol GmbH***.

Enabling technologies for precision diagnostics made in Berlin

Multiplexing, miniaturization and automation are key drivers of innovation in the diagnostics world, and this trend has certainly got another boost in recent years. "The Corona pandemic has alarmed us in a way to the importance of quickly providing enabling technologies for mass production of reliable tests," says Frauke Hein, CEO of ***SCIENION GmbH***. The Berlin-Adlershof based company is the market leader for precision dispensing of ultra-low volumes.

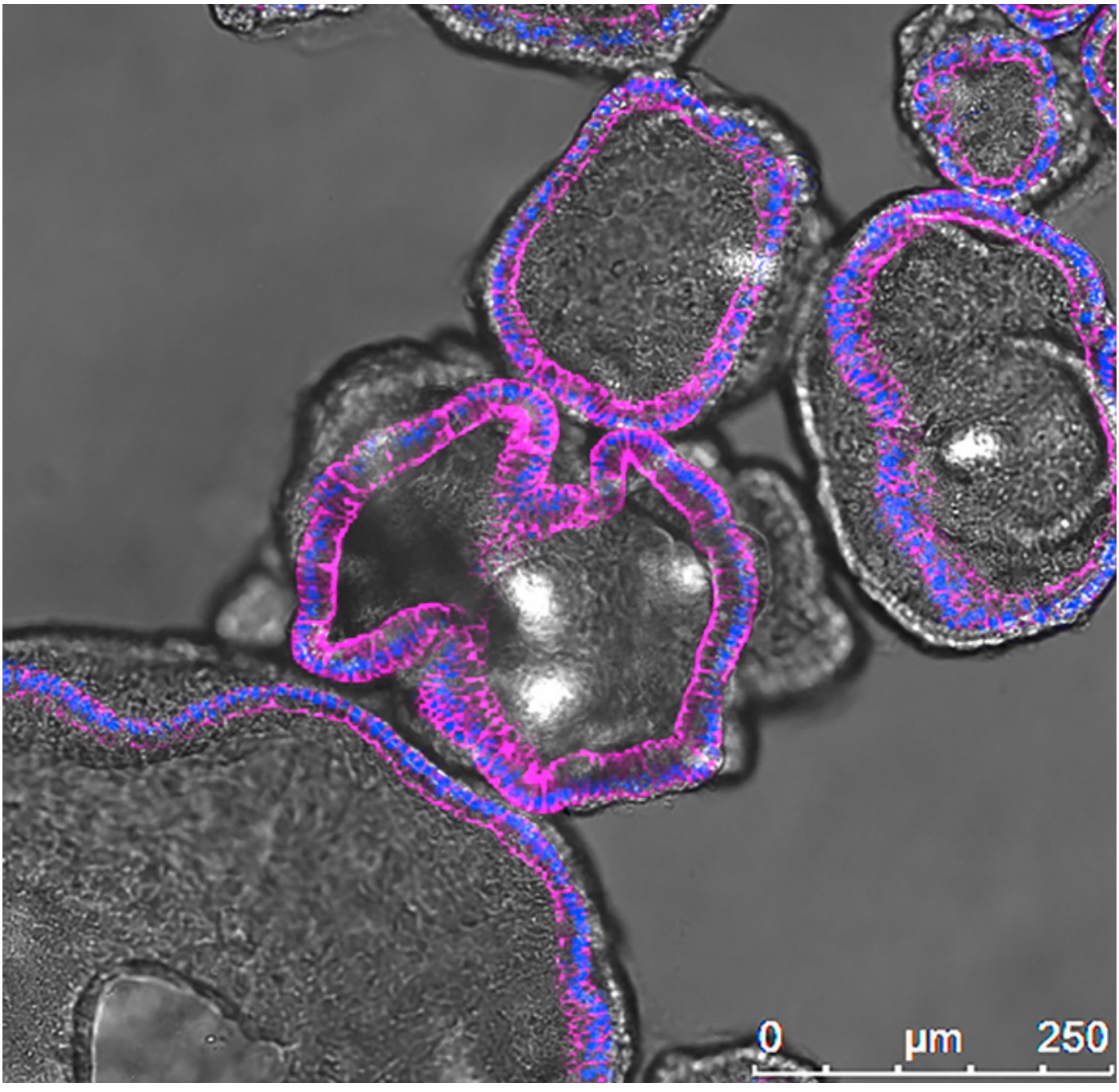
Photo © Christian Kielmann TU Berlin

Prof. Sina Bartfeld,
Head of the Department of Medical Biotechnology at TU Berlin

"In the Si-M building, scientists and engineers from TU Berlin and Charité will work side by side to develop new models in order to better understand the human body and its diseases. This is important to replace animal models, to understand human-specific pathologies and develop better personalized therapies."

"Our technology serves excellently the megatrend of multiplexed, easy to handle Point of Need or self-tests that do not need a lab or trained people to operate." SCIENION's dynamic growth is mainly based on sales of their precision dispensing systems and contract manufacturing. "Millions of Covid-19 POC PCR tests had been produced using our technologies," says Hein. Since SCIENION has grown tremendously in recent years, the team is now looking forward to moving into the new headquarters on a space of over 3000 m^2 in the Science Park of Berlin-Adlershof (see interview for more).

Single cell analysis in genomics and proteomics is another megatrend in diagnostics for which SCIENION already has



Stomach organoids © Sina Bartfeld TU Berlin

lots to offer. For instance with an automated platform that allows for gentle and high accuracy sorting, isolation and dispensing of living single cells. “This technology is the important link between precision diagnostics and precision medicine, especially in oncology and immunology research for truly personalized treatment,” Hein points out.

For the Berlin-based manufacturer of high-tech laboratory equipment ***KNAUER Wissenschaftliche Geräte GmbH***, the Corona pandemic has been a catalyst for innovation. The family-owned company with 170 employees is renowned for its liquid chromatography systems and components – equipment that is much needed at almost every modern analytical and diagnostic laboratory in the world. More recently, the company became famous for manufacturing the production equipment that successfully encapsulates lipid nanoparticles for Corona mRNA vaccines on a large scale. More than two billion vaccine doses of Pfizer/BioNTech’s Comirnaty have now been produced worldwide using KNAUER equipment.

Innovative ecosystem exploring novel paths for in vitro diagnostics

In the capital region, new ideas, products and diagnostic services can emerge from a highly dynamic innovation ecosystem. The high concentration of players in the in vitro diagnostics field is represented by the ***Netzwerk Diagnostik Berlin-Brandenburg e.V. (Diagnostik-Net BB)***. Founded in 2007, it bundles the competencies of diagnostics companies, users from clinics and laboratories as well as scientific research institutes predominantly from the Berlin-Brandenburg region. The network with its currently 75 members accelerates the turnaround of ideas to become marketable innovations along the entire value-added chain.

A new regional network aims at exploring a frontier in biomarker research: microRNAs. These small RNA molecules have great potential as indicators of neurodegenerative diseases as they show characteristic changes in individuals even before the first symptoms appear. The vision of the ***NeuroMiR*** alliance is to routinely measure microRNAs in blood samples of patients together with conventional protein markers. The joint project coordinated by Brandenburg-based ***GA Generic Assays GmbH*** is developing a platform based on videoscan technology that detects both protein and nucleic acid biomarkers simultaneously and highly sensitively. The regional focus of this RUBIN cluster funded by the Federal Ministry of Education and Research (BMBF) is in the Berlin-Brandenburg region with links to Thuringia and Saxony. The alliance partners include three research institutions in Cottbus, Potsdam and Berlin and six small and medium-sized companies.

Three questions to...

Dr. Frauke Hein

CEO of SCIENION GmbH

What megatrends in the diagnostics field determine research and development activities at SCIENION?

A continuing megatrend is the need for multiplexing, miniaturization and automation in the manufacturing of cutting-edge diagnostic tests and biosensors. SCIENION’s precision dispensing technology serves excellently the need for multiplexed, easy to handle Point of Need or self-tests. Another megatrend is single cell analysis in genomics and proteomics. Single cell handling strongly determines our R&D activities, with the priority on single cell proteomics – for academic research to industrial high throughput applications.

SCIENION has been located at the Science & Technology Park in Berlin Adlershof since its foundation in 2001. Now your new headquarters is constructed here. Why is the location such an ideal place for expanding your business?

Throughout all stages of our company development, we got the best possible support for flexible solutions from WISTA management. One dedicated advantage of Adlershof is that there is still space for expansion available. When it came to the decision to build a new SCIENION headquarters in Berlin, we all agreed – Let’s stay in Adlershof! We are really looking forward to moving into our new premises in 2023!

What makes the Berlin-Brandenburg region an attractive location to develop and commercialize next generation diagnostic solutions?

SCIENION’s founding story as a spin-off from the renowned Max Planck Institute for Molecular Genetics is exemplary for many companies in this region. Essential for our growth is that Berlin is highly attractive for people with a wide range of qualifications from all over the world. As we produce diagnostics and technical equipment for manufacturing them, especially our collaborations with local hospitals and medical universities such as the Charité are crucial to profiling and validating our products to the needs of healthcare professionals.

Photo © SCIENION GmbH

More players active in in vitro diagnostics and drug testing

Attomol GmbH Molekulare Diagnostika: develops, produces and distributes medical diagnostics in the field of molecular genetics, infectious and autoimmune diseases.

BASF Metabolome Solutions GmbH: Berlin-based expert service provider of mass spectrometry-based biological analytics for customers within and outside of BASF.

Berlin Cell Hospital: Network aiming at generating an AI ecosystem for cell-based medicine which is integrating data from single cell sequencing and organoid technology for early diagnosis and targeted therapy (see cell and gene therapy text).

BioGenes GmbH: service provider of custom antibody and immunoassay development, and an expert in complex analytical services.

biotechrabbit GmbH: supplier of ultra-pure enzymes and high-quality antibody services for diagnostics and reagents for molecular biology and proteomics.

BioTeZ Berlin-Buch GmbH: manufacturer of reagents and finished tests for the in vitro diagnostics market, recently acquired by BBI solutions.

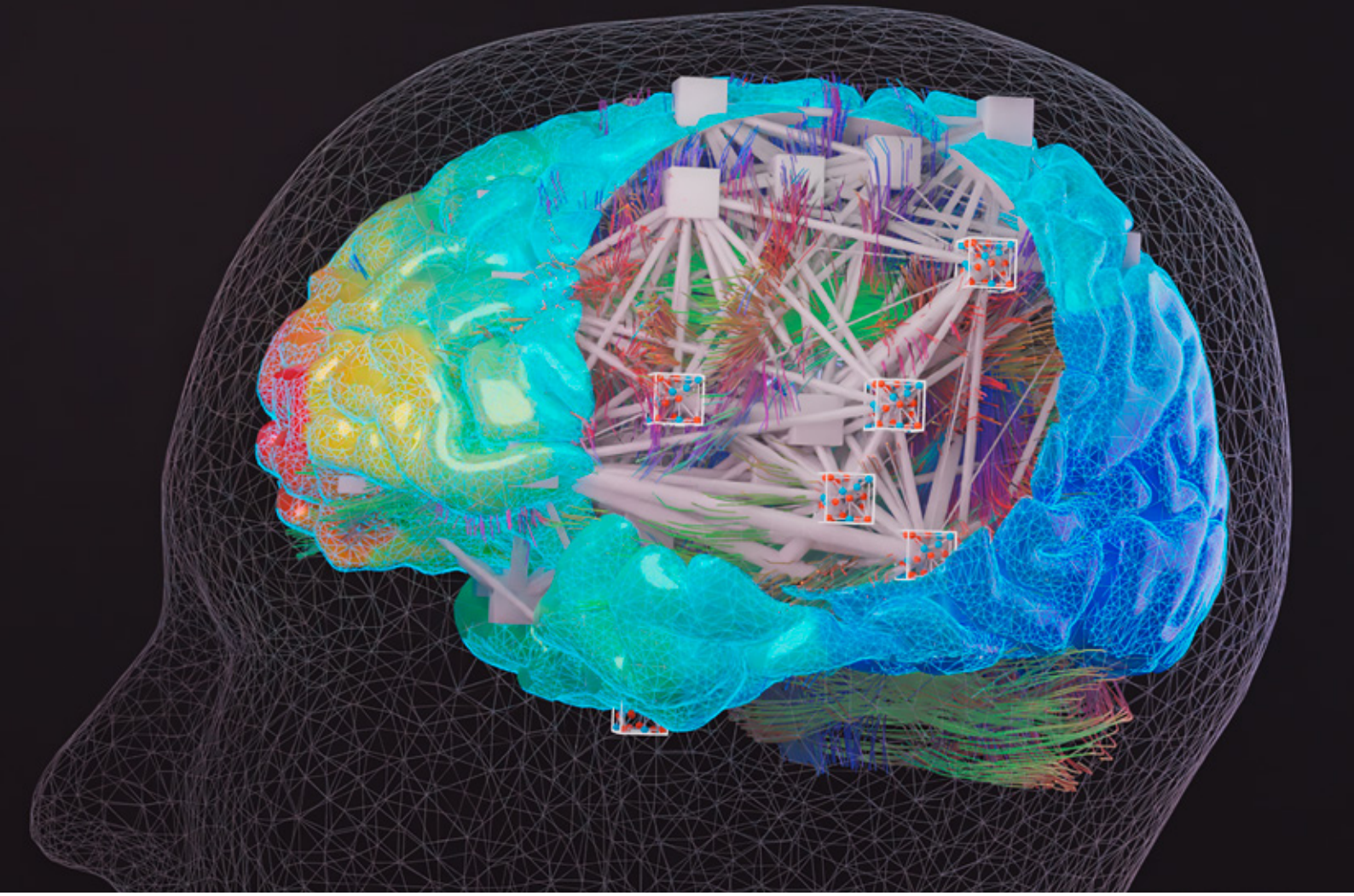
Charité 3^{R}: a Charité network that aims at fostering research, education and public understanding for alternative methods to animal experiments according to the 3R principle (Replace, Reduce, Refine).

Einstein Center 3R: Berlin-wide alliance founded in 2021 that has a 3R-driven research focus on 3D tissue models.

FyoniBio GmBH: Spin-out of Glycotope GmbH's bioanalytics service businesses for biopharma developers founded in 2022.

INVITEK Molecular: develops and commercializes tailor-made nucleic acid purification solutions, among others for liquid biopsy.

TissUse GmbH: biotech company that uses its human-on-a-chip technology platform for toxicity testing and drug development.



The virtual brain © Charité BIH, Sektion Gehirnsimulation, Petra Ritter

Unlocking the informative power of biomedical and health data

Digitization is transforming biomedical research and healthcare. Bioanalytic techniques such as genome sequencing and other high-throughput technologies, imaging and smart wearables deliver huge sets of data. Handling and processing of such big data sets requires new infrastructures and standardized IT solutions. Numerous research institutions and clinics in the Berlin-Brandenburg area are transforming into digital health.

Data Science, the extraction of relevant insights from data, has firmly positioned itself at the forefront of health and life science research. Machine Learning and Deep Learning have become disruptive technologies in translational research and personalized medicine applications. The key is the combination of laboratory research data of different kinds with real-world data – from bench to bedside. Innovative technologies and methods will pave the way for more precise predictions and personalized therapy.

In the life sciences, advances in experimental methods and modern high-throughput technologies play a significant role in the development of innovative new tools and ideas. Today, more and more quantitative, time-resolved measurements of cellular systems are being carried out. At the same time, the volume of digitized data in patient care and clinical research is growing at a rapid pace. This increases the need for new bioinformatics tools and intelligent algorithms that enable the efficient processing and analysis of the data obtained, as well as new methods for the mathematical modelling and simulation of complex biological systems.

With its mix of scientific institutes, biotech and IT companies as well as medical institutions, the Berlin-Brandenburg metropolitan region has become a hotspot for computational biology and medical informatics. The annual symposium ***Current Topics in Bioinformatics*** offers an excellent opportunity to connect with the local ecosystem. With the steering committee including representatives from Bayer, the Max Delbrück Center for Molecular Medicine (MDC) and the Max Planck Institute for Molecular Genetics, the event addresses interesting trends and attracts international speakers.

Bioinformatics and medical informatic capacities in research and healthcare

Integrating data obtained by high-throughput bioanalytics with large-scale computational capacities and powerful theoretical approaches – this is the profile of the ***Berlin Institute for Medical Systems Biology (BIMSB)***, an interdisciplinary department of the Max Delbrück Center (MDC) located in Berlin-Mitte. Research at the BIMSB focuses on understanding gene regulation and predicting its function in health and diseases.

An innovative educational initiative in this respect is HEIBRiDS – a joint graduate program in Data Science between the ***Einstein Center Digital Future (ECDF)*** and the Helmholtz Association. Molecular Medicine is one of the fields addressed by a number of researchers at MDC.

Another hotspot of Computational Biology is the ***Max Planck Institute for Molecular Genetics***. In the Bioinformatics department headed by Professor Martin Vingron, scientists develop computer models and bioinformatic tools to manage omics-based data to understand the regulation of gene activity.

“Machine Learning is a game changer for coping with massive amounts of biomedical data, but we also need other powerful bioinformatics resources and statistical methods to transform these data into knowledge,” says Vingron. “My team is also supporting the democratizing of applications, making them accessible to more researchers and clinicians.” For instance, the Max Planck team has developed a new statistical method that allows visualizing gene activity within a cell cluster. The new method facilitates identification of cell-type specific genes in single-cell sequencing data.

Prof. Dr. Martin Vingron, Director of Max Planck Institute for Molecular Genetics

"Machine Learning is a game changer for coping with massive amounts of biomedical data, but we also need other powerful bioinformatics to transform these data into knowledge. My team is supporting the democratizing of applications, making them accessible to more researchers and clinicians."

Photo © Ausserhofer

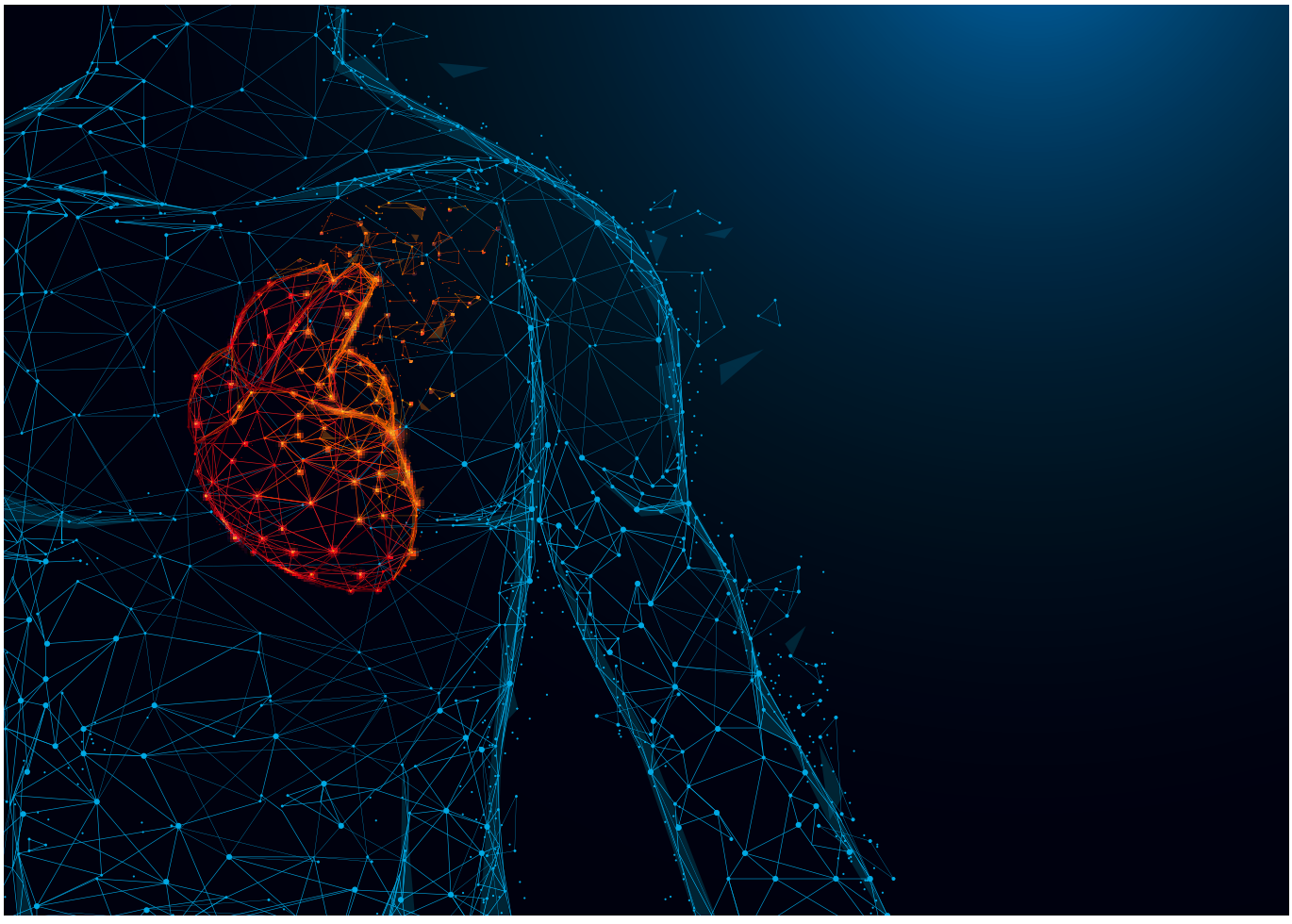
A "Medical Bioinformatics" working group is based at the ***Zuse Institute***, which deals with applied mathematics and data-intensive high-performance computing. The ***Fraunhofer Heinrich Hertz Institute (HHI)*** and the ***Robert Koch Institute (RKI)*** also have their own departments or research groups for computational biology.

The Charité – Universitätsmedizin Berlin combines the bioinformatics and data analysis expertise at its translational research unit, the ***Berlin Institute of Health (BIH)*** with the ***Core Unit Bioinformatics (CUBI)***. Among other things, the scientists are researching genetic variations, biomedical challenges and how data can be converted into clinically applicable results. The ***Hub for Innovations in Digital Health (HiDiH)*** has evolved into one of Germany's leading hubs in digital health, boosting innovative developments and applications in the life sciences and clinical care.

Other academic ecosystems

Academic training in Computational Biology in Berlin-Brandenburg takes place at almost all universities and colleges. In order to close the interface between computer science and medicine, the ***Hasso Plattner Institute (HPI)*** at the University of Potsdam, for example, has developed the Digital Health master's degree.

All the major universities in Berlin and the Charité – as the joint medical faculty of the Freie Universität and the Humboldt-Universität – have their own bioinformatics degree programs. This is also the case at the Technical University of Wildau and the BTU Cottbus-Senftenberg. The Carl-Thiem-Klinikum Cottbus is currently being transformed into a university medical center and will assume the role of a Digital Lead Hospital in Brandenburg.



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A top academic institution for artificial intelligence (AI) research and big data management is the ***Berlin Institute for the Foundations of Learning and Data (BIFOLD)*** at ***Technische Universität Berlin***. It is one of five national AI competence centers receiving institutional funding as part of the federal-state AI strategy implementation funding program. Through a partnership with Charité, BIFOLD is set to become a cross-university central institute.

With the new ***WHO Hub for Pandemic and Epidemic Intelligence***, Berlin is getting a further boost for the utilization of health data using bioinformatics. The World Health Organization (WHO) hub was inaugurated in September 2021. With the help of the hub, future pandemic outbreaks are to be identified and prevented at an early stage. The Charité and the Robert Koch Institute as well as the Hasso Plattner Institute are partners.

Machine learning-enabled drug discovery

The need for speed in drug development, combined with the need to do things more efficiently particularly in drug discovery, explains why practically every player is adopting artificial intelligence and big data analytics to turbocharge their R&D. At ***Bayer AG***'s Pharmaceuticals Division, artificial intelligence is applied at all stages of drug discovery. That is true for disease stage modeling, lead selection and optimization through computational biology.

biotx.ai. delivers an example on how smart drug discovery can accelerate the hunt for better treatments. The start-up based in the Potsdam Science Park manages to recognize complex patterns in high-dimensional genomic data with its specifically designed machine learning algorithm, enabling it to make precise predictions on the causality of drug target genes. "With our platform, we mimic clinical trials based on our curated 2 million whole genomes databases," explains Chief Operating Officer Christian Hebenstreit.

The approach also called "synthetic clinical trials" has already demonstrated its potential during the pandemic:

Photo © Albert Covelli

"With our AI-powered platform we mimic clinical trials based on our curated 2 million whole genomes databases."

Christian Hebenstreit, COO of biotx.ai

Photo © Sebastian Runge PONC.tech

Prof. Dr. Roland Eils, Director of the BIH Center for Digital Health

"Through the HEALTH-X dataLOFT project, we want to increase the acceptance of digital health solutions and strengthen digital sovereignty. This will transform citizens from passive recipients of services to active partners in the healthcare system."

Within three months, the team was able to identify a COVID-19 drug target named CDK6 that can be addressed with a set of already marketed inhibitor drugs. "We were able to simulate the first phases of a trial and have now started a real-world clinical phase 2b trial with the Brandenburg University Hospital." Hebenstreit adds that biotx.ai's vision is to apply its technology to bring novel treatments especially for smaller patient groups, such as in rare diseases.

Potsdam-based biotech company ***Targenomix GmbH*** adopts a systems biology approach to analyze the metabolism of plants in order to identify bioactive small molecules.

Building-up interoperable data ecosystems

Healthcare data are increasingly being stored digitally and thus contain a treasure trove of hidden insights for research and quality assurance. Establishing an interconnected and standardized digital health infrastructure and transforming big data into clinically actionable knowledge is a major aim of medical informatics experts and data scientists in Berlin-Brandenburg, with the BIH at Charité being the epicenter of these efforts.

The ***Virtual Research Environment (VRE)*** at Charité is a data management cloud platform for biomedical research. It provides an infrastructure for researchers to store, process and share sensitive health data. "The VRE makes it easier to find and securely access health data – in particular imaging data," says Petra Ritter. The BIH Johanna Quandt Professor for Brain Simulation is responsible for implementing the VRE. On the European level, Ritter is coordinating the project VirtualBrainCloud. Amongst others, the project integrates the simulation platform ***The Virtual Brain*** in order to develop a decision support system for the personalized diagnostics and treatment of Alzheimer's patients.

The lack of standardization and shortcomings in the currently used coding systems prevent a targeted analysis of health data. A highly renowned advocate of interoperable information and standardization of health data is Professor

Sylvia Thun, who is the Director of the Core unit eHealth and Interoperability at BIH. She is striving to implement the international structural standard Health Level 7 – Fast Healthcare Interoperability Resources (HL7 FHIR) (more see interview).

Towards an European Health Data Space

Gaia-X is a joint European project laying the groundwork for the next generation of data infrastructure: an open, transparent and secure digital ecosystem that meets the highest requirements for digital sovereignty. This is the goal of the ***HEALTH-X dataLOFT*** project under the consortium leadership of Charité funded with 13 million euros by the Federal Ministry for Economic Affairs and Climate Action.

“HEALTH-X dataLOFT has set itself the ambitious goal of achieving a transformation in the healthcare sector,” says Professor Roland Eils, spokesperson for HEALTH-X and founding director of the BIH Center for Digital Health. “Citizens and patients are at the center of our approach. We will achieve this by enabling citizens to have access to all of their own health data. Through this, we want to increase the acceptance of digital health solutions and strengthen digital sovereignty. This will transform citizens from passive recipients of services to active partners in the healthcare system.” Sovereignty concerning data usage lies in the hands of citizens via a data wallet. This ensures the secure and trustworthy use of data in the European Health Data Space.

Roland Eils is also the coordinator of the ***HiGHmed consortium***, which is part of the federally funded Medical Informatics Initiative whose core element are data integration centers to facilitate analyses across different university hospitals. To support and strengthen the COVID-19 research effort, the Federal Ministry of Education and Research (BMBF) further intensified the networking of university hospitals by funding the National Network of University Medicine (NUM). A major achievement was developing a standardized data set named GECCO for collecting COVID-19-relevant research data within NUM. By using international IT standards, it enables interoperable processing of these data (see interview with Sylvia Thun).

The Berlin Institute for Medical Systems Biology (BIMSB) Photo © Noshe

Three questions to...

Prof. Sylvia Thun

Director Core Facility Digital Medicine and Interoperability at BIH

Striving for interoperability and implementing the communication standard HL7 in digital health, you are playing a leading role in the Interop Council for Digital Health. How is your team at the Charité contributing to this initiative?

At BIH, in the Core Unit eHealth and Interoperability, my team of 25 experts is working on the major research projects, such as NFDI4Health, German Network of University Medicine (NUM) and Medical Informatics Initiative on the core data sets based on the International Patient Summary and the FHIR (Fast Healthcare Interoperability Resources) specifications of HL7. New projects include the basic modules in GOLD and collaborations with the Interop Council for Digital Health, e.g., on the Oncology Dataflow.

How are you integrating nontraditional medical data (Smartphone/wearable data) into your standardization efforts?

We integrate device data into the Health Data platform and help companies convert the data into FHIR formats. Many device manufacturers already provide standardized HL7 data, e.g. the APPLE watch. We were able to convert these into the modern FHIR format and adapt them to German requirements. This makes it easier to analyze the ECG, for example.

How has the Corona pandemic fueled the standardization of medical data and how has your team contributed to this?

We have created the German consensus dataset GECCO for all BMBF funded projects in NUM. GECCO is thus the first initiative in Germany for a fully real-time evaluation of data, which contains not only FHIR resources, but also standardized and international terminologies such as LOINC and SNOMED. This work was continued in the project ORCHESTRA – Connecting European cohorts to increase common and effective response to the SARS-CoV-2 pandemic in Europe.

Other relevant players present in Berlin-Brandenburg:

AICURA medical GmbH develops ecosystem solutions to implement AI applications in hospitals and to use healthcare data for innovation and new business models.

Alacris Theranostics GmbH is a systems medicine company based in Berlin that uses – amongst other tools – digital twins to model the tumor response to specific therapy combinations.

ATLAS Biolabs GmbH is a Berlin-based service provider of complex bioanalyses in molecular genetics.

D4L data4life gGmbH is a nonprofit organization headquartered in Potsdam that uses digital engineering to make health data ready for research in public health and personalized medicine.

German Research Center for Artificial Intelligence (DFKI) is a leading national research center on AI applications with laboratories in Berlin.

Howto Health GmbH is a Berlin-based provider of Digital health consulting, research and development services.

MicroDiscovery GmbH is a provider of innovative and certified software solutions for innovative diagnostics, individualized medicine and molecular biology research.

Nostos Genomics GmbH has developed an AI-driven genetic variant interpretation platform to give more people with genetic diseases a clear and fast diagnosis.

Quantgene Deutschland GmbH combines deep genomic sequencing and AI to detect disease in cell-free DNA fragments in blood samples and is headquartered in Santa Monica/USA and Berlin.

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Advancing precision medical imaging with artificial intelligence

Among the most promising clinical applications of artificial intelligence (AI) is diagnostic imaging. Supported by AI-powered interpretation of imaging results, physicians will be able to diagnose their patients with greater accuracy and precision. Bringing AI-based decision support systems into clinical application is a major aim of a dynamically rising number of players in Berlin-Brandenburg.

From prevention and early diagnosis to patient-focused therapy and beyond, artificial intelligence (AI) and self-learning systems have the potential to reshape medicine and to improve healthcare in general. Thanks to modern machine learning methods, AI-powered analysis of images and signals has reached human-level performance.

In recent years, AI-based solutions for medical imaging have increasingly been explored. Medical AI research has consequently blossomed in specialties that rely heavily on the interpretation of images, such as radiology, pathology, gastroenterology and ophthalmology. Although highlighted in this text, the potential of AI in medicine is not limited to image analysis – fed with molecular information, signals or multi-modal data, AI-based algorithms assist medical staff in the operating theatre and support physicians in disease prevention, diagnosis or monitoring and advance personalized treatment. They also increase the mobility of patients wearing intelligent prostheses or exoskeletons and bring life into digital communication aids.

Researchers, software engineers and clinicians based in Berlin-Brandenburg develop AI-based applications of the future and tackle challenges that currently limit their broader use. A bottleneck for the medical AI field is the lack of high-quality and large datasets annotated by experts. Apart from IT security and privacy issues, a key aspect is to understand how machine learning systems arrive at their conclusions. Initiatives in the capital region are tackling these issues – to strengthen trust of medical professionals, care workers and patients in this disruptive technology.

AI-based imaging enabling personalized treatments

Advancing personalized therapy is a major opportunity of AI-based applications in medicine. Researchers at the ***Charité Lab for Artificial Intelligence in Medicine (CLAIM)*** are working towards this goal. Within the federal government-funded project PREDICTioN2020 and the recently launched EU-funded consortium VALIDATE the team around Managing Director Dietmar Frey is enabling the first personalized stroke treatment. They combine imaging, clinical and longitudinal insurance data for the development of predictive computer models. "In the future, personalized treatment will increase the survival rate of stroke patients and significantly improve their quality of life," says Frey.

In pathology, AI has made major strides in diagnosing cancers and providing new disease insights. The lab of Dr. Dagmar Kainmueller is one of 15 research groups at the ***Max Delbrück Center for Molecular Medicine (MDC)*** focusing on data science and AI. Her team is advancing the field of "computer vision" by developing techniques for the automated analysis of high throughput microscopical images of human tissue samples. In collaboration with clinicians at ***Charité – Universitätsmedizin Berlin***, they develop machine learning tools for research on lung infections and intestinal cancer. "In the future, we might be able to use the microscopy image of a piece of tissue to predict the best therapy for individual patients," says Kainmueller.

Photo © Pablo Castagnola MDC

"In the future, we might be able to use the microscopy image of a piece of tissue to predict the best therapy for individual patients."

Dr. Dagmar Kainmüller, group leader 'Biomedical Image Analyses' at MDC

Exploring the genetic causes of chronic diseases

AI can extract information from vast amounts of medical images to facilitate disease diagnosis and even help to identify the cause of a disease. This is demonstrated by work of the research group Digital Health – Machine Learning at the Potsdam-based ***Hasso Plattner Institute (HPI)***, headed by Professor Christoph Lippert. "In one of our projects, we are analyzing full body scans and genomic data of 100,000 people to understand the genetic causes of common diseases such as diabetes, cardiovascular disease or neurodegenerative diseases," explains Lippert and adds: "It is fantastic that in the field of digital health and machine learning, we can use methodological and theoretical work to help people lead a healthier and better life."

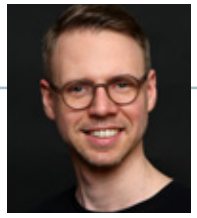


Photo © Heiko Marquardt Frischefotos Berlin

Prof. Christoph Lippert, group leader 'Digital Health – Machine Learning' at HPI

"It is fantastic that in the field of digital health and machine learning, we can use methodological and theoretical work to help people lead a healthier and better life."

A top academic AI institution is The ***Berlin Institute for the Foundations of Learning and Data (BIFOLD)*** at ***Technische Universität Berlin (TU)***. It is one of five national AI competence centers that receives institutional funding as part of the federal-state AI strategy implementation funding program. Through a partnership with Charité, BIFOLD is set to become a cross-university central institute. Fundamental research on AI and machine learning methods which will accelerate their translation into the clinic are focus topics at the Center for biomedical image and information processing (CBMI) located at the ***Hochschule für Technik und Wirtschaft (HTW) Berlin***, the ***Fraunhofer Heinrich Hertz Institute (HHI)*** and the ***Humboldt-Universität zu Berlin (HU)***.

Start-ups developing AI-based image analysis

The German capital region is not only a top IT location in Europe. The high density of excellent academic research institutions in the life sciences and hospitals in Berlin-Brandenburg has proven to be the optimal breeding ground for spin-off AI-companies in the healthcare sector.

The Berlin Institute of Health (BIH) supports innovators from Charité and the Max Delbrück Center to develop their concepts into digital products through its ***Digital Health Accelerator Program (DHA)***. One successful example is ***Aignostics GmbH***, a spin-off founded by scientists at the Institute of Pathology at Charité – Universitätsmedizin Berlin and TU Berlin. Their digital imaging analysis system evaluates microscopic images of suspicious tissue biopsies and the trained software has learnt to distinguish tumor tissue from healthy tissue. The system is already tested in the clinic and reliably identifies lung, breast and colon cancer as well as other diseases that cause visible changes in tissue.

The explainable AI approach in digital pathology

“An important advantage of the system is, that it ‘explains’ how it made a decision, allowing pathologists to understand and trust it. We call this approach ‘explainable AI’,” says Professor Klaus-Robert Müller, co-founder of Aignostics and Chair of the Machine Learning Department at TU Berlin. The software can also be used for the discovery and validation of biomarkers, thereby supporting the development of companion diagnostics for personalized medicine. “AI holds the key to drastically improve how cancer and other complex diseases are diagnosed and treated,” predicts co-founder Professor Frederick Klauschen, the Deputy Director of Charité´s Institute of Pathology.

Photo © Frederick Klauschen

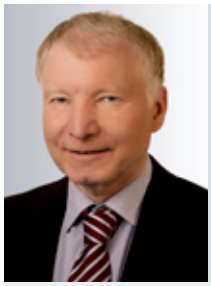
“AI holds the key to drastically improve how cancer and other complex diseases are diagnosed and treated.”

Prof. Frederick Klauschen, Co-Founder of Aignostics

Radiology meets machine learning

Another start-up for AI-based medical imaging supported by the BIH Digital Health Accelerator program is ***dentalXrai GmbH***. The team has developed an AI-based software for the diagnosis of X-ray images in dentistry. Self-learning algorithms developed and trained by ***mediaire GmbH*** have resulted in a software called mdbrain. It uses AI to extract quantitative information from radiological images of the brain and generates a report that assists radiologists in making well-founded diagnoses of diseases such as Alzheimer’s or Parkinson’s – even under time pressure. mediaire is supported by the High-Tech Gründerfonds (HTGF). The company was awarded “Digital Startup of the year 2021” by the Federal Ministry of Economics and Climate Protection.

Innovators and entrepreneurs can also find support for their ideas at ***Merantix AG***, a venture studio and incubator platform at AI campus Berlin that helps to build and scale machine learning businesses. Amongst its successfully built ventures is ***Vara***, a start-up developing machine learning-based web solutions for the automated diagnosis of breast cancer based on the analysis of radiological images.



Three questions to...

Prof. Peter Hufnagl

Head of Digital Pathology at Charité – Universitätsmedizin Berlin

What is the strength of the EMPAIA consortium that made it stand out in the AI Innovation competition to qualify for federal funding?

Its strength lies in the breadth of the approach, which deals equally with all hurdles on the way to the clinical use of AI applications and, on top of that, organizes continuous training for developers, users and partners with the EMPAIA Academy. The concept of an open-source reference implementation on a per se internationally usable platform has great potential.

How did the research and industry environment in Berlin contribute to its success?

Berlin has developed into an international hub for biomedical research. In order to cooperate with the first-class research institutions, more and more companies are opening branches in Berlin. This makes the distances short and direct.

Which AI-applications from EMPAIA might enter the clinical routine first?

Within the EMPAIA project itself, no applications are developed. The companies implement the EMPAIA interfaces and can thus make the AI applications available to a wide range of users. Applications for marker quantification are already accessible via the platform. An application for prostate cancer detection is currently being implemented.

Photo © Charité

Networks that cover AI-related challenges in health and medicine

At present, medical professionals cannot easily access approved and validated AI-based applications. “AI has the potential to revolutionize all areas of diagnostic medical imaging over the coming years,” says Professor Peter Hufnagl, Head of Digital Pathology at Charité. “But this potential is almost impossible to realize at the moment because we lack both infrastructure and standards, as well as clarity regarding reimbursement.”

He coordinates a high-profile consortium, that wants to change things in the field of digital pathology. Named ***Eco-***

system for Pathology Diagnostics with AI Assistance (EMPAIA), the alliance emerged as a winner of the "AI Innovation Competition" of the Federal Ministry of Economics and Climate Protection and secured funding of 11 million euros over three years and a further 6.2 million euros from industry partners such as Philips or Roche.

EMPAIA is pushing the creation of an ecosystem for the development and standardization, but especially the marketing, of AI solutions for pathology institutes throughout Germany. In addition to partners from industry and associations, Fraunhofer MEVIS and TU Berlin, the consortium consists of a number of clinical reference centers where innovative AI products will be pre-tested. "By creating this marketplace within a clearly defined legal framework, we want to enable physicians to routinely use approved AI-based solutions within diagnostic imaging," says Hufnagl (see interview for more).

Making medical data AI-ready

Availability of data is another key issue in the field of AI, which is essential, when it comes to training software with large datasets. But who owns medical data and who should be allowed to use it? These questions are being tackled by Berlin-based ***Hippo AI Foundation***, an open-source AI accelerator who pushes for open-source data platforms to fight global inequalities and to empower patients. "Paywalling data is poison for our healthcare systems which are based on solidarity. Data represents human life and should not be commoditized," says founder and digital health forward thinker Bart de Witte. The Hippo AI team collects, cleans and anonymizes medical data from private or institutional data donations and then make it freely accessible to everyone in the world. With their campaign Viktoria1.0 they aim at building the largest open database for breast cancer worldwide.

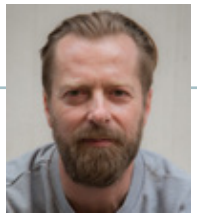


Photo © Hippo AI Foundation

Bart de Witte, founder of Hippo AI

"Paywalling data is poison for our healthcare systems which are based on solidarity. Data represents human life and should not be commoditized."

The newly formed ***Artificial Intelligence in Digital Health (AIDHeal) Network*** aims to bring together expertise on data science, machine learning, artificial intelligence and digital health in Berlin-Brandenburg. It is comprised of the University of Potsdam, the Hasso Plattner Institute, the big Universities of Berlin, the MDC, the Weierstrass Institute for Applied Analysis and Stochastics, Berlin Research 50, the Helmholtz Information & Data Science Academy and numerous industry partners.

„AI is a technology driver for modern medical imaging", says Professor Thoralf Niendorf, who heads a research group at the MDC. "That is why we link developers and users in the AIDHeal network to increase the international visibility and competitiveness of ‚Digital Healthcare, made in Germany.'"

More examples of the broad spectrum of AI-based applications for the healthcare sector developed in Berlin-Brandenburg:

Ada Health GmbH is a Berlin-based start-up in the field of AI-based health apps, that helps people actively manage their health and medical professionals to deliver effective care.

Caresynthax GmbH offers a software that analyzes risk factors during surgery and assists surgeons in their decision making.

Lindera GmbH is a start-up company which developed an app for motion analysis and fall prevention in elderly.

Ottobock SE & Co. KGaA develops intelligent prostheses that use AI to learn from the user and allow them to intuitively control their prostheses in real time.

scalable minds GmbH is a software engineering company with a strong focus on solutions utilizing powerful AI methods and are experts for large-scale image analysis.

Töchter und Söhne GmbH is a Berlin-based e-health company which developed the first chatbot for caregivers, that – with the help of AI – is continuously learning and improving.

x-cardiac GmbH is offering an AI-based software for the prediction of postoperative complications after cardiothoracic surgery.

Photo © Felix Noack TU Berlin

How 3D- and bioprinting shape the future of medicine

Berlin-Brandenburg-based enterprises and research institutions use and improve 3D printing technologies to manufacture tailor-made medical products such as implants, orthoses, prostheses or dental fixtures. They also explore the foundations of bioprinting thereby shaping the future of precision medicine.

Additive manufacturing (AM) technologies – also known as 3D printing – have the potential to revolutionize patient care by delivering highly personalized products. Implants or other medical devices are manufactured using computer-aided design and objects are built on a layer-by-layer basis through deposition of printing various materials and even living cells.

A number of players in the Berlin-Brandenburg region are developing and manufacturing state-of-the-art 3D printers and advanced 3D products for the medical sector. Their products find broad biomedical and clinical applications such as personalized implants or medical models used in orthopedics and the dental field.

Researchers and companies are working closely together to improve current printing processes and develop functional and biocompatible materials suitable for medical applications. With its strong networks and innovative expertise in the fields of life sciences, engineering and IT, the German capital region offers the ideal conditions for fully exploiting 3D printing technologies. Local policy makers and initiatives are building up on this potential with the aim of developing Berlin into the 3D printing capital of Europe by creating an ecosystem and supporting start-up companies in the field of AM. The initiative ***Additive Manufacturing Berlin Brandenburg (AMBER)*** is intended to connect players from research and industry to develop new application fields and business models in this context. This will make the Berlin-Brandenburg region both a test field and a showroom for innovative production technologies and value networks, and a catalyst for the rapid transfer of research results into sustainable and competitive innovations.

The network ***Mobility/Medical goes Additive (MGA)*** unites over 140 players from all areas of the market to jointly boost AM. The internationally leading network for industrial additive manufacturing consists of R&D institutes, consul-

tants, machine and material manufacturers, service providers & software vendors and cooperates with other relevant networks. To foster a local ecosystem in the field of AM, MGA founded the ***Industrial Additive Manufacturing Hub (IAM Hub) Berlin***. Located at the Marienpark, the IAM Hub houses co-working spaces, event and meeting venues and plans to establish production labs. This '3D printing campus' will bring together companies, start-ups, innovators and institutes from the AM industry to develop their ideas and implement groundbreaking 3D printing projects.

"By using 3D printing and electrospinning, we will be able to produce tailor-made implants, such as artificial pericardium, heart valves, blood vessels or tendons, which could save the lives of heart patients waiting for donor organs."

Dr. Wolfdietrich Meyer, project leader at Fraunhofer IAP

Photo © Fraunhofer IAP

Developing innovative materials and printing procedures

The outstanding scientific landscape in the region contributes to the development of the 3D printing technology. Researchers at the ***Fraunhofer Institute for Applied Polymer Research (IAP)***, ***Technische Universität Berlin (TU Berlin)*** and the ***Federal Institute for Materials Research and Testing (BAM)*** are working on novel materials and procedures for additive manufacturing for medical applications.

Customized products from the 3D printer are already being routinely used in dentistry and orthopedics. The development of implants for the replacement of human elastic tissue is particularly challenging. Due to the high demand on materials used for products that are in permanent contact with the body they need to be highly robust, durable and biocompatible.

For these challenges researchers at the ***Fraunhofer IAP Potsdam*** investigate novel functional polymers for medical applications. Joining forces with national partners from industry and research, their project PolyKARD aims to develop biomimetic photopolymers that can imitate the mechanical properties of pericardial tissue – a collagen-containing tissue surrounding the heart. Project leader Dr. Wolfdietrich Meyer at Fraunhofer IAP says: "By using 3D printing and electrospinning, we will be able to produce tailor-made implants, such as artificial pericardium, heart valves, blood vessels or tendons, which could save the lives of heart patients waiting for donor organs." In the future, Meyer's team plans to focus more on the development of renewable raw materials that are both biocompatible and environmentally friendly.

Exploring suitable materials for 3D printing is also a focus of researchers at ***TU Berlin***. Here, interdisciplinary teams develop techniques for the fabrication of hard tissue implants and explore materials such as bioactive glasses, bioresorbable ceramics, or metals, which could be used as bone replacement solutions. The bioprinting team, headed by Professor Jens Kurreck is developing 3D bioprinting techniques for the generation of organ models, such as lung and liver models with vascular structures. These can be used as an alternative to animal testing.

Novel processes for additive manufacturing such as laser beam melting for metallic components are explored at the 'Competence Centre Additive Manufacturing' at the ***BAM***. BAM engineers also work on process optimization and materials testing to promote the industry-scale use of AM for safety-relevant applications such as medical technology.

Expanding medical 3D printing capacities in Berlin

Berlin-based enterprises and start-ups are at the forefront of developing 3D and bioprinting applications – launching the newest generation of 3D printers and customized products for medical use. ***Eckert & Ziegler*** for example recently received the CE approval for the world's first 3D-printed applicators for the treatment of gynecological tumors. ***Orion Additive Manufacturing GmbH*** produces 3D printers for industrial manufacturers, research institutes, aerospace companies and medical device manufacturers. These printers use high performance polymers such as medical-grade PEEK and PPSU that can be used to print patient-specific implants and surgical instruments.

Stefan Holländer, Managing Director at Formlabs GmbH

"Our headquarters are in Boston, but our EMEA location in Berlin has been growing rapidly since 2015, thanks to the high availability of young international talent here, as well as the excellent start-up ecosystem and the distinctive 3D printing community."

Photo © Formlabs GmbH

Making 3D printing available to everyone is also the mission of the US company ***Formlabs GmbH***. “We are a young, innovative company that produces user-friendly and affordable 3D printing systems. These are used worldwide in mechanical engineering and manufacturing, dentistry, education, and research,” says Managing Director Stefan Holländer. One of their customers is the Charité – Universitätsmedizin Berlin, which uses 3D printing to build models for preoperative planning and training. Over the years, the company has significantly expanded its product range and its facilities in Berlin. “Our headquarters are in Boston, but our EMEA location in Berlin has been growing rapidly since 2015, thanks to the high availability of young international talent here, as well as the excellent start-up ecosystem and the distinctive 3D printing community,” adds Holländer.

Eco-friendly, compostable, or recyclable orthoses for humans and animals are offered by the printing service provider ***Think3DDD***. Their spin-off ***3D-Medico*** supplies a production system for orthoses, prostheses, and individual orthopedic insoles. It enables health professionals in any specialist company to print customized products according to the doctor’s prescription.

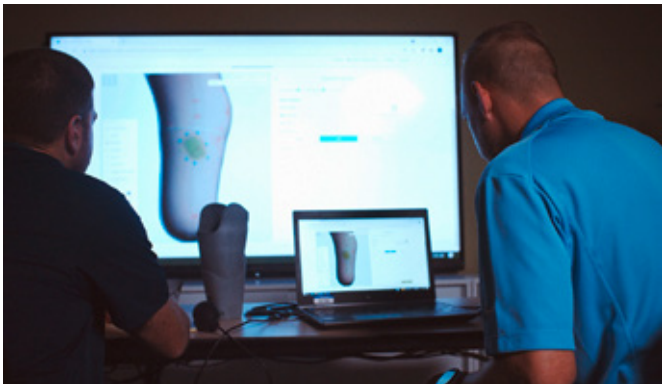
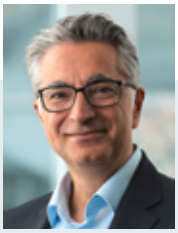


Photo © Ottobock

Customized orthoses and prostheses from the 3D printer are also developed by the orthopedics specialist ***Ottobock SE & Co. KGaA***. With their iFab (‘individual fabrication’), the company has digitalized the entire fitting and manufacturing process of orthopedic technology, using 3D scanners and printers. The Duderstadt-based company is systematically expanding its presence at its Berlin site. “We are convinced that we can attract talented and creative people there. The aim is to advance future topics such as the digitalization of orthopedic technology,” says Güngör Kara, Chief Digital Officer at Ottobock. At the areal of the former Bötzow Brewery, the company established its Digital Office. Here, developers are working on software and sensors to digitally scan the residual limb after an amputation, create digital twins of patients and models for 3D printing prosthetic parts. They analyze the gait of users, virtually connect the prosthetics and digital platforms and optimally adapt it to the body.



“Our aim is to advance future topics such as the digitalization of orthopedic technology.”

Güngör Kara, Chief Digital Officer at the Ottobock Digital Office Berlin

Photo © Ottobock

Fabricating human tissues and mini organs

Precisely printing living cells or biomaterials in 3D patterns – so-called bioprinting – is another fascinating but challenging field of research and development. It allows fabrication of living tissues or even simple organ systems. The printing process requires the use of living cells as well as a nurturing environment for them to stay alive.

“The technology is advancing gradually – simple tissues such as soft tissue, cartilage or skin will be built first and as the technology develops, life-supporting or life-sustaining prints and even the printing of entire organs could become reality,” says Dr. Lutz Kloke, CEO and founder of ***Cellbricks*** (see interview for more).

The spin-off from the TU Berlin uses 3D bioprinters to replicate human tissues. Several years of research went into the development of the cell printing system and especially into finding a bio-ink – the adhesive connecting the cells. Cellbricks supplies the technology to researchers and biologists, who use the miniature organs or tissues for drug testing – thus offering an alternative to animal models. The cell printing technology has sparked numerous collaborations with a focus on engineering bone, cartilage and vasculature tissues.

The development of blood vessels is one of the biggest challenges in tissue engineering and regenerative medicine, which is tackled by researchers at BIH in collaboration with the ***Max Delbrück Center for Molecular Medicine (MDC)*** and Cellbricks. The alliance develops a 3D bioprinting strategy which allows the controlled engineering of vascularized network within a hydrogel and contributes to research on scaffolds for vascular structures.

In collaboration with Cellbricks and the German Aerospace Center (DLR), researchers at the Julius Wolff Institute of Biomechanics and Muscoskeletal Regeneration at the ***Berlin Institute of Health (BIH)*** are developing the first personalized biological wound closure to be used by astronauts in space.

Three questions to...

Dr. Lutz Kloke

CEO and founder of
Cellbricks GmbH

Cellbricks is still one of a few pioneers commercially active in the field of bioprinting. What is its major potential and where do you see current challenges for enterprises in this field?

Bioprinting will certainly be integrated into the medical canon and will definitely be part of daily treatment routines. The technology has the potential to fundamentally change organ replacement therapy. However, development and approval of such a product are very time and cost intensive. For this reason, an appropriate funding and financing landscape is essential.

Currently, bioprinting is mostly used for the production of miniature organ structures as an alternative to animal testing. How long do you think it might take to produce functional human tissues or even organs for clinical applications?

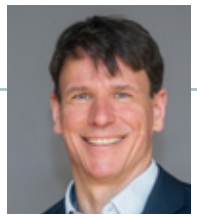
This is one of the most frequently asked questions. The successful production of mini organs structures lays the technical foundation and demonstrates the capacities of the technology. I firmly believe that bioprinting will hopefully come into medical use sooner rather than later. I think that the first applications will not have a life-sustaining function, but rather come from the fields of wound management, oral and maxillofacial surgery, or cosmetic surgery.

How important is the Berlin-Brandenburg ecosystem for the development of novel bioprinting applications?

Berlin is an attractive environment for start-ups. Within the field of 3D printing, a technically driven field has been able to stand out in particular in recent years. A strong ecosystem has formed here that benefits from each other across the board.

Photo © Philipp Arnoldt

"The novel 3D bioprinter developed by Cellbricks prints patches that are composed of gelatin-like biomaterial and human skin cells. Together, we are developing a platform that could offer personalized wound care far away from any hospital," says Professor Georg Duda, BIH Chair for Engineering Regenerative Therapies. Bianca Lemke from Duda's team is improving this 3D printing technology to pave its way into application – also on Earth. "In the future, the patch might provide a good option for the treatment of severe burns as it can be personalized by incorporating the cells of patients into the material," says Lemke. In the long-term, the team plans to achieve a better imitation of the skin architecture by embedding blood vessels into the patch.



Prof. Georg Duda, Chair for Engineering Regenerative Therapies at BIH

"With its focus on life sciences, Berlin has great expertise in understanding the „medical need", i.e. deciphering the problem. There is also a very innovative start-up scene including various approaches in biotechnology. These two competencies of technology development and medical research are at the heart of the potential of Berlin."

Photo © Charité

Photo © Formlabs GmbH

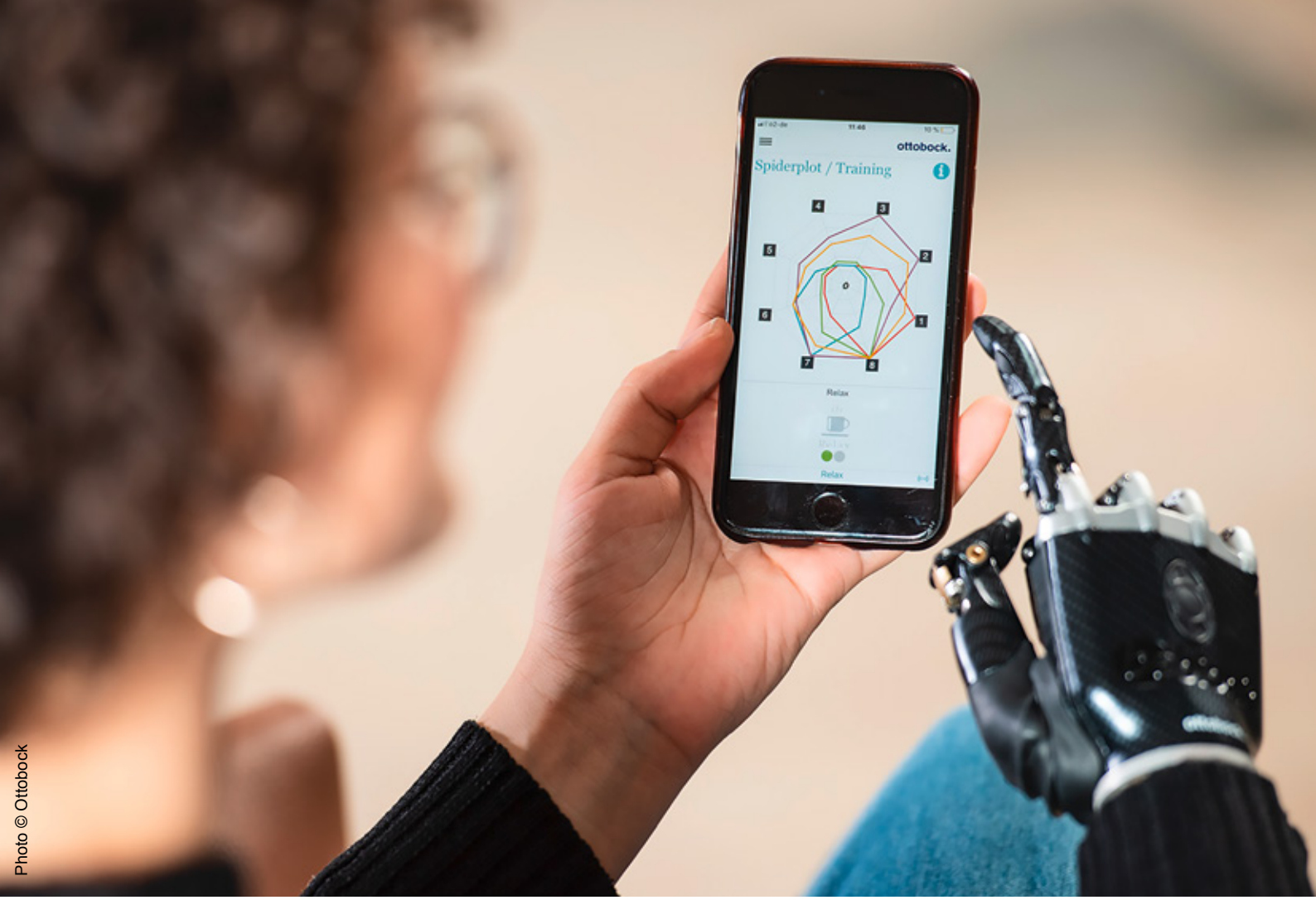


Photo © Ottobock

Sensor technology players on the verge of a quantum leap

The high concentration of expertise in the fields of electronics and photonics makes Berlin-Brandenburg a vibrant ecosystem for the innovation of sensor technology applications in the medical field. Regional players are particularly strong in the development of optical sensor systems. A great diversity of research institutions, hospitals, universities, and enterprises are closely working together to develop novel sensor solutions for the healthcare sector and advance diagnosis, monitoring and treatment of disease.

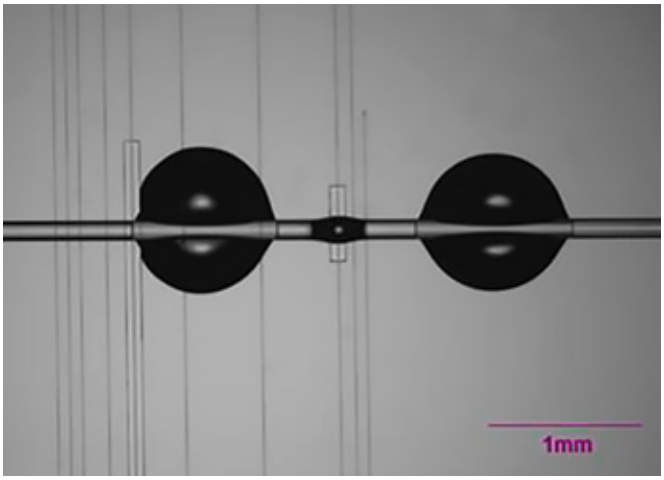
Digitization and telemedicine place new demands on medical technology systems and the need for innovative devices is growing rapidly. The development of novel sensor technology is a key driver in this innovation process and has the potential to drastically improve the way diseases will be diagnosed and treated in the future.

The next generation of sensors is being developed and manufactured in Berlin-Brandenburg: innovative photonic biosensors, radar technology or quantum sensors have the potential to reduce patient burden and to maximize patient outcome. They improve accuracy and speed of diagnostics, allow doctors to monitor heart patients in their home and help patients with impaired mobility to move.

Outstanding infrastructure for photonic sensor development

The trend towards the early detection of infectious and non-infectious diseases is driving research into new technologies based on biomolecular recognition. Optical sensors represent a promising technology, as they offer not only high sensitivity but also label-free and multiple detection of biomolecules delivering more accurate results. Moreover, a high degree of miniaturization can be achieved to provide practical and lightweight portability.

At the forefront of developing cutting-edge sensor technologies for life sciences applications are a number of research institutions and universities in Berlin-Brandenburg.



Optical microsensor © Zamora Gomez, Fraunhofer IZM

As a prime example, scientists at Berlin-based ***Fraunhofer Institute for Reliability and Microintegration (IZM)*** have been developing a new generation of diagnostic systems offering point-of-care diagnostics for multiple infectious diseases in less than 15 minutes. “We are working to get our label free photonic sensing platform PoC BoSens ready for commercial use, which includes scaling up of the system, conducting clinical tests, and qualifying for CE classification,” says Dr. Alethea Vanessa Zamora Gómez, who coordinated the work of the transnational project consortium at Fraunhofer IZM.

Photo © Fraunhofer IZM

“Our label free photonic sensing platform PoC BoSens can detect multiple infectious diseases in less than 15 minutes. We are now optimizing it for future commercialization.”

Dr. Alethea Vanessa Zamora Gómez,
Team leader at Fraunhofer IZM

Microring resonators are transducer elements used in photonic biosensors. They combine several advantages like label-free detection, high sensitivity, ease of fabrication and the capability for multiplexing. Their small diameter enables sensitive detection in the smallest volumes. Within the optION consortium, Fraunhofer scientists at the ***Heinrich Hertz Institute (HHI)***, Charité scientists and the companies Eschweiler and SCIENION develop microring sensors that will significantly reduce the amount of blood needed for quantifying electrolytes and thus help to diagnose disease particularly in babies and small children.

Scientists at the ***Leibniz Institute for High Performance Microelectronics (IHP)*** in Frankfurt (Oder) in collaboration with the TH Wildau have developed a universal analysis tool for liquids – such as water, urine or blood – for the detection of viruses, bacteria, toxins or proteins. The technology developed within the start-up project HyPhoX is based on a versatile photonic sensor system, that might soon be used in applications such as the detection of COVID-19 or in hygiene monitoring to detect legionella in water.

To build on the strong expertise in technical research at universities in the German capital region, ***Leibniz IHP*** has formed ‘Joint Labs’ with universities including the ***Brandenburg University of Technology (BTU)*** Cottbus, ***Humboldt-Universität Berlin***, ***Technische Universität Berlin***, ***University of Potsdam*** and ***Technical University of Applied Sciences (TH Wildau)***. Within their numerous joint projects, they develop intelligent sensor technology for various applications.

Revolutionizing the treatment of brain disorders

How sensor technologies could revolutionize the way neurological and psychiatric diseases are treated in the future is demonstrated by the groundbreaking work of Einstein Professor Surjo Soekadar, who leads the research group Clinical Neurotechnology at the ***Charité – Universitätsmedizin Berlin***. His team develops brain-computer Interfaces (BCIs) that help paralyzed stroke survivors to gain more independence. In this context, sensor technology is used for the assessment of brain activity.

Electrodes placed on the scalp of a patient sense their brain signals which are then translated into control commands of a hand exoskeleton. Soekadar and his team are still working on improvements of this system and investigate novel sensor technologies, such as quantum sensors. “Provided these sensors will work in clinical and everyday life environments, they have the potential to revolutionize the field,” says Soekadar (see interview for more).

Photo © S. Soekadar, Charité - Universitätsmedizin Berlin

Three questions to...

Einstein Prof. Surjo Soekadar

Head of research group Clinical Neurotechnology at Charité – Universitätsmedizin Berlin

Which sensor technologies are the most promising for the future of neurotechnology and how could they advance the field?

Neurotechnologies aim at assessing and analyzing brain activity at the highest possible precision, for example in the context of diagnostics, treatment or innovative medical applications such as brain-computer interfaces (BCIs). The most promising sensor technologies for such applications are certainly quantum sensors because they are portable, work at near room temperature and will provide much higher spatial resolution compared to existing technology, such as EEG. These sensors may fundamentally change human-machine interaction, also beyond the medical field, where they could advance the versatility of brain-controlled assistive devices.

Could you give one or two examples on how next-gen brain-computer interfaces (BCIs) might benefit patients in about 10 years' time?

While BCIs are already now changing how we deal with severe paralysis, the next-generation BCIs will tap into other domains such as cognition, emotion and memory. Combining quantum sensors with adaptive closed-loop brain stimulation might be a critical step forward. Such bidirectional next-gen BCI could improve quality of life in patients diagnosed with depression, addiction or obsessive-compulsive disorder by suppressing specific clinical symptoms.

Which Berlin-Brandenburg-based academic institutions or companies are you collaborating with and how important are these partners for the success of your work? The Berlin-Brandenburg region provides the optimal ecosystem to advance both the field of neurotech and quantum technology. I have been closely collaborating with the Physikalisch-Technische Bundesanstalt (PTB), a global leader in metrology and quantum technology. Together with the TU Berlin, we are developing the first quantum-BCI that aims at tackling the burden of severe paralysis, supported by the Einstein Stiftung Berlin (ESB). Partners such as eemagine GmbH and Ottobock are just a stone's throw away from us and are crucial for the clinical translation pipeline from bench to bedside and beyond.

Photo © Pablo Castagnola Einstein Stiftung Berlin

Enabling feeling prostheses

Feeling prostheses might soon become reality, due to the work of companies like ***Ottobock SE & Co. KGaA*** – a global leader in the development of medical technology for people with limited mobility. Their product range includes exoskeletons and intelligent prostheses, many of which are equipped with state-of-the art sensor technology and microprocessors. Modern prostheses already allow movements to be controlled by nerve signals – which patients control with their thoughts.

"In the future, Human-machine interfaces based on quantum sensors could be easier to use, as they are more intuitive and powerful compared to conventional myoelectric interfaces," says the Head of Ottobock's research and development, Bernhard Graimann. The combination of better control and meaningful feedback from intelligent prostheses aims to make everyday life easier, says Graimann. "These developments will become possible thanks to new invasive and non-invasive Human-machine interfaces that are clinically and commercially viable."

Vital sign monitoring – at home and in the clinic

Enabling physicians to monitor certain aspects of a patient's health from their own home has become an increasingly important aspect of telemedicine. Such monitoring systems support healthcare professionals in managing acute and chronic conditions and help patients, especially in rural areas, by reducing the need to travel to a healthcare center.

Roberto Belke, Managing Director of BIOTRONIK Sales Germany

"Studies – also in collaboration with the Charité – have shown that with BIOTRONIK Home Monitoring the mortality of patients with heart insufficiency can be reduced by more than 60 %."

Photo © BIOTRONIK

Home monitoring systems for patients with cardiovascular disease are developed by ***BIOTRONIK SE & Co. KG***, a leading global healthcare company manufacturing cardiovascular and endovascular medical technology. The company has joined forces with another established organization in the cardiological sector – the ***GETEMED Medizin- und Informationstechnik AG***. In 2021, they introduced a digital care management platform inCareNet HF for telemonitoring

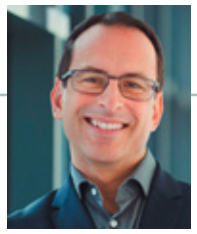
patients with cardiac insufficiency. The platform gives doctors a clear overview of telemonitoring data from both external sensors and cardiac implants. “Studies – also in collaboration with the Charité – have shown that with BIOTRONIK Home Monitoring, the mortality of patients with heart insufficiency can be reduced by more than 60 %,” explains Roberto Belke, Managing Director of BIOTRONIK Sales Germany.

A novel generation of contactless cardiological monitoring systems based on radar-technology is developed by the Brandenburg-based start-up ***smedo GmbH***. Their device can detect vital signs from about seven-meter distance. Currently, it is used for the monitoring of babies with an increased risk of sudden infant death syndrome, but the start-up sees its future in the clinical field. “Our technology can be used for continuous ECGs or as an early warning system for heart attacks. We are also developing it for contactless blood-pressure measurements,” says Thomas Grellner, founder and CEO of the start-up.

Patient monitoring solutions for use in the operating theatre are developed by the ***SectorCon Ingenieurgesellschaft mbH***. Their monitoring system ConCardiac AIR assists medical staff during an operation, by alerting them of impending complications. Several sensors non-invasively record vital parameters of the patient and analyze them in real-time via a wireless connected platform. SectorCon is closely collaborating with international and local partners such as the Charité and Deutsches Herzzentrum Berlin (DHZB) to develop novel sensor technologies for the operating theatre.

High-potential ecosystem in optics and photonics

Many novel sensor technologies based on optics and photonics are developed in the Berlin-Brandenburg capital region. Here, a high-tech sector with global appeal has emerged around the medium of light. “With a dense, yet broad research landscape and about 400 small and medium sized enterprises working in these fields, Berlin-Brandenburg is very well positioned in the fields of photonics and optics. The future world market leader for one of these topics could easily come from the capital region. I think that Berlin-Brandenburg is already second or third,



Prof. Harald Schenk, Head of the chair Micro and Nano Systems BTU Cottbus-Senftenberg

“With the iCampµs at the BTU Cottbus-Senftenberg, we have created a regional focal point with national appeal in the fields of electronics and microsensorics. In the second project phase, we will significantly expand our range of application-specific solutions to enable sustainable innovations for our partners and all future interested parties.”

Photo © Fraunhofer IPMS

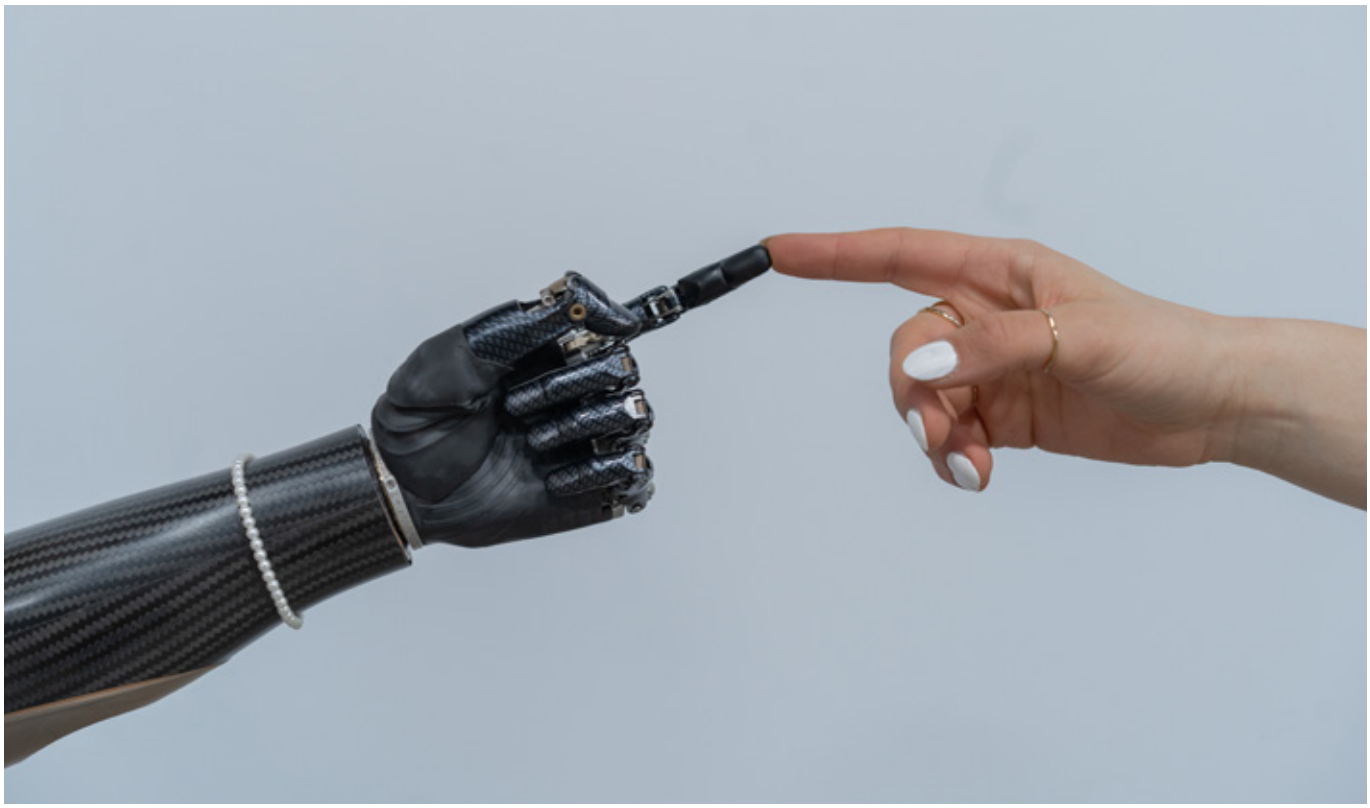


Photo © Ottobock

behind Silicon Valley and the Tokyo region," says Professor Martin Schell, Head of Fraunhofer HHI.

The federally funded RUBIN-alliance ***PolyChrome-Berlin*** wants to create further unique selling points for the region and open new potential. The consortium of 12 partners is dedicated to photonics and includes research institutions like the ***Fraunhofer HHI*** and industrial partners. Their goal is to establish a technology platform for the realization of hybrid optical components, which will find application in sensor technology or analytics.

Similar goals are pursued by the association ***Advanced UV for Life e.V.*** Founded in 2021, it bundles the expertise of 26 partners from industry and science. Their aim is to promote and accelerate the development of UV radiation sources and UV sensors also for applications in the medical field.

Regional focal point in the field of microsensorics

Federal funding to support structural change in the Lusatian region of Brandenburg enabled the birth of the ***Innovation Campus Electronics and Microsensors*** - ***iCampµs Cottbus*** – a joint project of the ***BTU Cottbus-Senftenberg*** as consortium leader, and five non-university research institutions. Its aim is to develop and establish products in the field of microsensor technology and digitization together with small and medium-sized enterprises in Lusatia. This summer the project launched into its second phase and will receive 20 million euros of funding over the next five years.

"Berlin-Brandenburg is very well positioned in the field of photonics and optics. The future world market leader for one of these topics could easily come from the capital region. I think that Berlin-Brandenburg is already second or third, behind Silicon Valley and the Tokyo region."

Prof. Martin Schell, Joint Head of Fraunhofer HHI

Photo © Fraunhofer HHI

„With the iCampµs at the BTU Cottbus-Senftenberg, we have created a regional focal point with national appeal in the fields of electronics and microsensorics. In the second project phase, we will significantly expand our range of application-specific solutions to enable sustainable innovations for our partners and all future interested parties," says Professor Harald Schenk, head of the chair Micro and Nano Systems at BTU Cottbus and Executive Director at Fraunhofer IPMS. The medical radar developed in Cottbus is an illustrative example of the collaboration. The radar is capable of contactless detection of vital parameters such as heartbeat or respiration rate in both stationary and mobile medical care environments.

Further players in the growing market of sensor technology:

Fraunhofer Center for Digital Diagnostics based at the Fraunhofer Institute for Cell Therapy and Immunology in Potsdam-Golm develops new telemedical solutions and fields of application for the Potsdam model region.

AKmira optronics develops miniaturised 3D scanners used in 3D endoscopy and medical technology which are based on digital, optical holography.

First Sensor AG is a supplier in the field of sensor systems for industrial, medical, and mobility applications.

PicoQuant GmbH is a develops and manufactures high-quality photonic components and instruments for a broad range of scientific applications.

Quantiox GmbH was founded as a spin-off from the Humboldt University Berlin and develops custom semiconductor devices with focus on Quantum Lasers.

ReWalk Robotics GmbH builds robotic exoskeletons for patients with spinal cord injury and exo-suits for the rehabilitation of stroke survivors.

Talk Tools GmbH develops customized wheelchair controls and communication aids especially for people with neurological or neuromuscular disease and stroke survivors.

TRAINALIZED GmbH are using near infrared spectroscopy (NIRS) in their non-invasive technology measuring important parameters (e.g. lactate) for performance diagnostics during training.

VISSEIRO GmbH developed a smart seat cushion for the measurement of vital parameters (heart rate and heart variability, respiration frequency) and the recording of sitting habits in an actigram.

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Cover Photo
Winner of the Best Scientific Image Contest 2022: Andy Warhol Kidney.
It shows structures of a rat kidney obtained with magnetic resonance imaging MRI.

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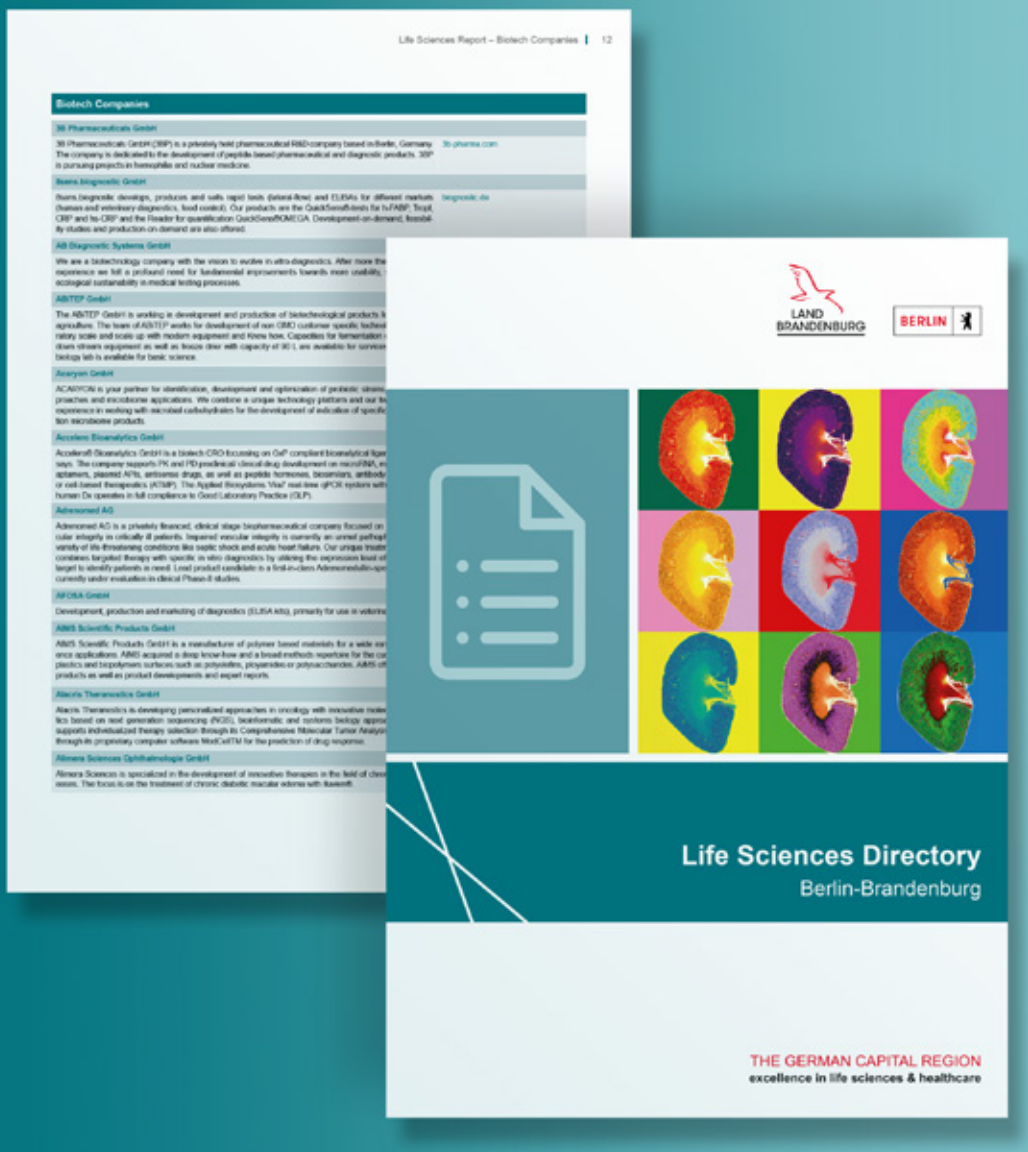
Life Sciences Directory Berlin-Brandenburg



Here you will find an overview of more than 670 players of industries, startups and research institutions in the HealthCapital region Berlin-Brandenburg

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