

GÖTEBORGBIO



Biomaterials and Cell Therapy



Göteborg Region – for rapid advances in biomedicine

The city of Göteborg, Sweden's second largest, boasts one of Europe's finest clusters for life sciences and biomedicine. As the site of numerous breakthroughs in research and medicine, our city is today a leading R&D cluster in both biomaterials and cell therapy and for treatment of cardiovascular and metabolic diseases. The key to Göteborg's strength is its combination of high-calibre academic research capabilities and a well-established industrial base.

"Mölnlycke Health Care is pleased with its location in Göteborg and the innovative academic research in the field of biomaterials."

Peter Hentschel
Vice President
Mölnlycke Health Care Group

Göteborg has an excellent record of achievements. Among its pioneers are Professor Arvid Carlsson, awarded the Nobel Prize in 2000 for his research on dopamine, and Professor Per-Ingvar Brånemark, who introduced osseointegration as a method for

attaching prostheses directly into bone. A formidable amount of research is done in Göteborg, often thanks to fruitful collaboration between Sahlgrenska Academy, Sahlgrenska University Hospital and Chalmers University of Technology. Research in Göteborg has also paved the way for successful medicines such as Losec™.

The Göteborg life science industry numbers some 8,000 employees and over 170 companies, including AstraZeneca, Astra Tech, Nobel Biocare and the Mölnlycke Health Care Group. AstraZeneca's research center in Mölndal is one of Europe's largest research sites.

What distinguishes Göteborg is the entrepreneurial spirit, the determination to make breakthroughs a reality for patients and constant work to create mechanisms that foster collaboration and commercialization. Examples include:

- The Institute for Biomaterials and Cell Therapy
- GIBBS, a 1.5-year full-time program for training and coaching bio-entrepreneurs and managers
- Expansion of the biomedicine cluster with 140,000 square meters of new research, education and business space.

A wide range of international life science firms already conduct research in collaborative efforts with research groups and companies based in Göteborg. Let us open our door to you, too.



Göteborg Biomedicine in brief

- A world leader in two disciplines:
 - Biomaterials and cell therapy
 - Cardiovascular and metabolic diseases
- 170 companies, 8,000 employees
- Base for two leading universities: Göteborg University, with the Sahlgrenska Academy, and Chalmers University of Technology
- Home of Sahlgrenska University Hospital, the largest hospital in northern Europe

Examples of research achievements

The role of dopamine in the brain
Professor Arvid Carlsson

The ability of living tissue to integrate with titanium
Professor Per-Ingvar Brånemark

The ability of the human brain to reproduce neurons
Professor Peter Eriksson

Autologous chondrocyte transplantation in cartilage repair
Professor Anders Lindahl and Professor Lars Petersson

A leading European center for R&D and commercialization in biomaterials and associated cell therapy



Tomorrow's implant: sustainable and sophisticated

- Delivery facets to transmit active molecules
- Sensing function for monitoring implant performance
- Rapid regeneration ability
- Sustainable for the lifetime of the patient

More complex and high-tech, but also simpler and cheaper

- New chemically and macro-, micro- and nano-topographically engineered surfaces
- New combinations of safe, clinically proven materials and biological components
- New, innovative production processes

The Göteborg Region offers expertise in all relevant disciplines

- Surface analysis
- Surface modification, topographical and chemical modification
- Cell engineering
- Biocompatibility
- Clinical evaluation

Biomaterials

Göteborg is among the world's leading biomaterials clusters, being home to both cutting-edge academic research and noted industry leaders.

Strong academic research tradition

Göteborg has had a firm position as a global center for biomaterials development since the 1960s, when Professor Per-Ingvar Brånemark conducted broad basic research to understand how the human body reacts to injury. His discovery of titanium's ability to integrate with bone tissue spawned very dynamic applied research activities, primarily in the load-bearing capacity of implants. During the 1960s and 1970s, Dr. Brånemark's laboratory was a hotspot of experimental research – some 20-25 persons who are now university professors began their careers in his laboratory.

Success in industry commercialization

Commercialization of the Brånemark technology began in the early 1980s, when the osseointegration process was finally endorsed by the international odontology community.

The company founded on Dr Brånemark's invention is today Nobel Biocare, the world-leading dental implant maker with headquarters in Göteborg and one of the biomaterials cluster's most prominent firms. In all, the cluster comprises some 20 companies active in five areas.

Biomaterials companies in Göteborg

Implants for hard tissue applications (dental)
Astra Tech, Nobel Biocare

Implants for hard tissue applications (orthopaedic, ENT)
Anatomica, Artimplant, Astra Tech, Entific, Integrum

Wound care and implants for soft tissue applications
Mölnlycke Health Care Group, Entific, Appeartex, Biopolymer Products

Diagnostics and monitoring of implants
Integration Diagnostics

Cell therapy and active molecules to augment clinical performance
Cellartis, Cell Matrix, OraSolv

Other
Q-Sense, Arcam

Excellence in research and clinical activities

Biomaterials research at the Faculties of Medicine and Odontology at the Sahlgrenska Academy, at the Faculty of Natural Sciences at Göteborg University and at Chalmers, has resulted in well above 150 PhD dissertations over the years. Expertise covers all relevant fields:

Clinical product development

Göteborg has a proven ability to transfer experimental know-how into clinical products. The noted Professor Tomas Albrektsson contributed to the development of the first bone-anchored dental implant, the first bone-anchored hearing aid implant system and Astra Tech's orthopaedic implant, currently being tested in clinical trials.

Implant surgery, implant prosthetics and implant follow-up

Impressive work has been done by Sahlgrenska's orthopaedic surgeons on hip, knee and vertebral body implants. Ear, nose and throat specialists at Sahlgrenska University Hospital have pioneered the development of the bone-anchored hearing aid in surgical practice.

Basic medical research

Professor Peter Thomsen, who carries out basic medical research, focuses on the interface between material surfaces and cells using modern methods in cell and molecular biology to help in our understanding of the reactions of living tissue to biomaterials. In 2003, Professor Thomsen was awarded the George Winter Award, the highest recognition of excellence in biomaterials research in Europe.

Basic technological research

New materials, modification of materials and characterization of materials are other Göteborg specialties. Professor Per Flodin and co-workers developed the slowly biodegradable polyurethaneurea, a material later manufactured by Artimplant for orthopaedic and dental applications. Another world-leader in research is Professor Bengt Kasemo, whose work focuses on nano-scale surface phenomena and properties. Professor Kasemo was the first Swede to receive the George Winter Award. Kasemo is a co-founder of Q-Sense, a supplier of an instrument based on quartz crystal resonance frequency used to study molecular binding events that take place on various surfaces. This interest is shared by Professor Hans Elwing, an authority on molecular surface interactions.

There are also three research institutes in Göteborg that offer long-standing expertise in evaluating materials for the medical device industry – SP (the Swedish National Testing and Research Institute), IFP Research and IVF Industrial Research and Development.

Basic odontological research

The Faculty of Odontology has an international track record in research on the prevention and treatment of several oral diseases. Professor Jan Lindhe pioneered the modern treatment of periodontitis on the basis of scientific discoveries. Professor Ann Wennerberg is an international authority on techniques for the characterization of material surface topography and its role for implant success.

Stepping up industry/academia collaboration

The Institute for Biomaterials and Cell Therapy (IBC) was established at Sahlgrenska Science Park in mid 2005 to serve as a catalyst for research between companies and between academic and corporate researchers. IBC sponsors include Nobel Biocare, the Mölnlycke Health Care Group and Doxa, an innovative bioceramics company based in Uppsala. A number of internationally competitive R&D projects are now being led by IBC. IBC is headed by Professor Peter Thomsen and is open to international collaboration.

One of the most recent examples of fruitful cross-collaboration is in the treatment of patients with chronic wounds. On the basis of R&D at Mölnlycke Health Care and Sahlgrenska Academy, the company has launched



Göteborg researcher pioneers osseointegration for bone and arm implants

Following in the footsteps of his father, Dr Richard Brånemark has introduced a technique for direct skeletal anchorage of amputation prostheses and is commercializing the technology through Integrum. Thanks to his invention, people who have suffered leg, arm and finger amputations may now lead lives of much higher quality.

www.integrum.se www.branemarkintegration.com

products such as Xelma, a novel treatment for hard-to-heal wounds, primarily venous leg ulcers.

The concentration of all of Sahlgrenska's musculo-skeletal orthopedics in one location also creates great opportunity for co-localization of pre-clinical and clinical research and development. The new facility, to be hosted by Sahlgrenska's sister hospital in Mölndal, will be an attractive environment for new development and evaluation of existing methods.

Cochlear: Acquires Entific to strengthen product portfolio

In 2005, Australian-based Cochlear acquired Entific Medical Systems, a six-year-old company that produces an innovative bone-anchored hearing implant system called BAHA®. Over 25,000 patients suffering from conductive hearing loss and single-sided deafness have been treated. "Entific is an ideal acquisition for Cochlear," says Dr Chris Roberts, Cochlear CEO. "There are exciting synergies from the distribution and the customer bases of both companies which will enhance growth in our respective markets." Cochlear, a global leader in implantable hearing solutions, had annual sales of AUD 350 million in 2004/2005.

Entific remains an independent division within Cochlear, with corporate headquarters, manufacturing facilities, marketing department and principal research and development activities located in Göteborg. Entific will try to maintain past years' pace of an annual growth of 30 percent and at the same time focus even more strongly on research activities.

www.entific.com

Cell Therapy

Gothenburg has a history of firsts in stem cell research and is today a leader in the use of stem cell technologies in drug discovery and tissue engineering.

Pioneer in stem cell research

Gothenburg is home to one of the world's most successful human embryonic stem cell programs. Behind Gothenburg's success in human embryonic stem cell research lies a long history of practical *in vitro* fertilization work. A Gothenburg research group headed by Professor Lars Hamberger was behind the first successful IVF effort in Scandinavia in 1982.

Professor Peter Eriksson has demonstrated that the human brain contains cells with stem cell-like properties and has shown that the adult human brain retains its ability to generate new neurons from progenitor/stem cells.

Advancing clinical tissue engineering

In 1994, Professor Anders Lindahl and his group published data on autologous chondrocyte transplantation in cartilage repair. Professor Lindahl has since further pursued this research area and is co-founder of Cell Matrix, which is commercializing the technology. Dr Lindahl today also conducts clinical research in differentiated cardiac muscle cells.

Corporate activity

Two stem cell companies – Cellartis and Cell Matrix – are located in the Gothenburg Region. Cellartis is a globally prominent stem cell company. Cell Matrix develops, produces and markets transplantation products and laboratory services for cartilage cell therapy. Vitrolife develops advanced nutrient solutions and devices for the preparation, cultivation and

preservation of human cells, tissues and organs. Swemed is another company that delivers tools to this specialized area.

Convergence of cell therapy and biomaterials

In recent years, research in cell therapy and biomaterials has converged in studies of cell surface reaction mechanisms. The regional strength in both areas is a considerable advantage. Gothenburg's knowledge base in cell function is also important for developing new advanced biomaterials.

An exciting new area of research is capitalizing on the human body as a bio-reactor, avoiding cell cultivation and building organs outside the body. Researchers in Gothenburg are already involved in experimental research in this area and clinical trials are planned for the near future.

Gothenburg hosts two GMP facilities, one for human embryonic stem cell cultivation (Cellartis) and one for human cartilage cell cultivation (Cell Matrix).



Cellartis: World leader in cell knowledge

Cellartis has the single largest source of defined human embryonic stem cell lines in the world. Founded in 2001 by a group of scientists from Gothenburg University and Sahlgrenska University Hospital, Cellartis is devoted to the commercial application of human embryonic stem (hES) cell technologies derived from fertilized eggs not used for *in vitro* fertilization. Cellartis' core focus is the use of stem cells in drug discovery and toxicity testing. In addition, the company is involved in a number of research projects in regenerative medicine. The company is one of seven providers in the NIH Human Embryonic Stem Cell Registry with at least two lines, in early passages, available for shipping.

In the course of its short history, Cellartis has created important industry collaborations and received numerous international grants, of which sponsorship by the NIH and the Juvenile Diabetes Research Foundation (JDRF) are two examples. The Japanese pharmaceutical company Tanabe Seiyaku has teamed with Cellartis to develop new cell therapies for Parkinson's Disease. "Sweden has pioneered cell therapies of Parkinson's Disease, and has performed clinical research in regenerative therapeutics for many years", says Yasushi Kondo, Senior Scientist of Tanabe's Advanced Medical Research Laboratories. Cellartis aims to offer its clients the ability to more accurately predict human safety and efficacy profiles based on functional human cells. Another objective is to develop a xeno-free protocol for deriving clinically applicable hESC lines.

Why the Göteborg Region is a great place to do business

Outstanding academic research environment

Sahlgrenska Academy at Göteborg University and Chalmers University of Technology are among Europe's foremost research institutes. Clinical expertise available at Sahlgrenska University Hospital, the largest hospital in Northern Europe, is a major advantage for product development. Together, Sahlgrenska Academy and Chalmers have nearly 3,500 full-time students in medicine and biotechnology.

A history of making discoveries a reality for patients

Swedish research emphasizes the need to be close to patients, and basic research activities are often integrated with clinical research. The Göteborg Region has a solid track record in developing blockbuster drugs as well as innovative tools and technologies.

Everything within walking distance

"Medicine Hill" is today one of the largest medical research and development centers in Northern Europe, housing businesses, academic research, education and Sahlgrenska University Hospital in one distinct area. Its unique compact geography facilitates both collaboration and commercialization. Some 140,000 square meters of research, education and business space will be added in a coming phase of expansion.

A region committed to innovation and enterprise

The city of Göteborg, the Västra Götaland region, and the universities and businesses in the region have jointly formed the "Biomedical Development in Western Sweden" program, an effort that seeks to double the number of jobs in the region to 15,000 by 2015. The program is supported by the federal agency Vinnova. The strategy builds on developing tools, platforms and processes for translating cutting-edge academic research into industrial innovations and health care applications. Companies that choose to set up business here will find it an accommodating environment. Availability of land and office space, special tax relief for foreign experts, and access to skilled and multi-ethnic staff are among the Göteborg Region's advantages. In all, the Västra Götaland region has 1.7 million inhabitants.

Master's level program in bio-entrepreneurship

Göteborg recently launched the Göteborg International Bioscience Business School, a collaboration between CIP (Center for Intellectual Property Studies) and Sahlgrenska Academy. GIBBS offers the only Master's level program for bio-entrepreneurs in Europe focused on creating new ventures. GIBBS is part of a start-up infrastructure that includes the campus-located Sahlgrenska Science Park and Chalmers Innovation incubators.

Strong life science industry

There are some 170 companies and over 8,000 employees in life science companies in the Göteborg Region. The largest employer is AstraZeneca, which has one of its largest research sites and its global headquarters for cardiovascular and gastrointestinal research in the suburb of Mölndal. The biomaterial/cell therapy cluster includes leading companies in dental implants, polymers for implantable prostheses, wound care and incontinence applications and osseo-integrated prostheses. Göteborg is also strong in clinical trials, thanks to its clinical research capabilities, outstanding international networks and university-affiliated CROs, such as Scandinavian CRI and NMCT.

Base in advanced manufacturing, logistics and high-tech R&D

Vehicle manufacturers Volvo Cars and Volvo Trucks, the roller bearing specialist SKF, and technology companies such as Ericsson Microwave Systems and Saab Ericsson Space are among those that call Göteborg home. An excellent transport infrastructure explains Göteborg's position as a major Scandinavian logistics hub. Some 1,750 foreign-owned companies are based in the Göteborg Region, which was named "Sweden's Growth Region of the year" in 2004.

High quality of life

Göteborg is a city with international flair and relaxed charm. Some 860,000 people live in and around the city, which offers a wealth of entertainment, shopping and cultural activities. In fact, Göteborg is one of Sweden's most popular tourist destinations. Stunning scenery and a magnificent coastline are other trademarks of the Göteborg Region. You'll find one of Europe's finest archipelagos no more than a tram ride away from the city center. Boating and wildlife activities are very popular. The Landvetter Airport serves all major European cities with direct daily flights.

Sweden – a world-class business location

Sweden is considered to have one of the world's most innovative, competitive and financially sound economies. Conducting biomedical research in Sweden makes great business sense – industry executives typically put Sweden's cost advantage relative to the US in the range of 40 to 50 percent. Moreover, Sweden tops biomedical research output per capita in the EU.



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www.goteborgbio.se