PER-INGVAR BRÅNEMARK
IN MEMORIAM
MAY 3, 1929 – DECEMBER 20, 2014

Nobel Biocare NEWS

Information for the Osseointegration Specialist

Special Issue 2015

The Man Who Made People Smile

The father of the modern dental implant, Professor Per-Ingvar Brånemark, now belongs to the ages.

Whether he was meeting a patient for the first time or entertaining a lecture hall full of eager—yet often skeptical—students, Per-Ingvar Brånemark brought smiles to people's faces. Describing and then documenting a world of clinical success that was beyond the imagination of most of his contemporaries, Brånemark was known for delivering "Aha!" experiences to patients and academics alike.

By Frederic Love

On December 20, 2014, Per-Ingvar Brånemark died after a period of extended illness in his hometown of Gothenburg, Sweden, leaving his family, his friends and his colleagues all over the world in mourning.

Without the work of Per-Ingvar Brånemark, the world might still be awaiting the advent of titanium implants. His observation, in the mid-twentieth century, that the human body would not only tolerate titanium, but even integrate it into living bone tissue (under carefully controlled conditions) revolutionized the fields of dental, maxillofacial and orthopedic rehabilitation.

> *"Surround yourself with some of the best minds in your field, and you're bound to succeed."*
>
> — Per-Ingvar Brånemark

Based on his original scientific insight—subsequently substantiated and rigorously documented—innovative bone-anchored restorative solutions have improved the quality of millions of people's lives around the world since then.

Choosing the right path

Students of science say that luck combined with unique circumstances often dictate the direction in which any research project ultimately turns. No one was more aware of this than Per-Ingvar Brånemark.

As a young researcher in his native Sweden in the 1950s, he was interested in neither titanium nor implants. He was working instead to advance the world's knowledge of the anatomy of blood flow, and found himself using an optical device that happened to be enclosed in machined titanium. Attached to a rabbit's leg, this device made it possible for him to study microcirculation in the bone tissue of rabbits through specially modified light microscopes. When it came time to remove the device from the bone, Brånemark was surprised to find that the bone and the titanium had become inseparable.

In a subsequent study of microcirculation, approximately 20 students who volunteered to have titanium instruments inserted into their arms for several months showed no signs of rejecting the titanium-enclosed optics. (See the article by Professor Tomas Albrektsson on page 3 about these halcyon days of discovery.)

At that point, Brånemark changed the direction of his work to investigate the body's ability to tolerate titanium.

Breaking down borders

Seeing that the body could peacefully coexist with titanium, perhaps indefinitely, Brånemark wanted to find out the reasons why. He realized that he would need to approach this new area of research from several different perspectives simultaneously.

To gain a proper understanding of *osseointegration*—the term Brånemark coined for the integration of titanium into living bone tissue—he realized that one would need access to expertise in physics, chemistry and biology, at the very least.

Under Brånemark's leadership, physicians, dentists and biologists would all investigate the interplay between bone and titanium. Together they developed careful, methodical techniques for the insertion of implants. At the same time, engineers, physicists and metallurgists studied the metal's surface and how

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Notable and Quotable

"Per-Ingvar long remembered the names of his patients, even those he treated very many years ago. He cared for them, supported them and was a much-beloved surgeon."

— Ragnar Adell

"Few, if any, scientists or clinicians in the world have contributed so much to patients' everyday well-being and oral rehabilitation as Dr. P-I Brånemark."

— Ulf Lekholm

"He showed us that many of the world's great movements begin with one person's work, often based on a single tenacious conviction."

— George Zarb

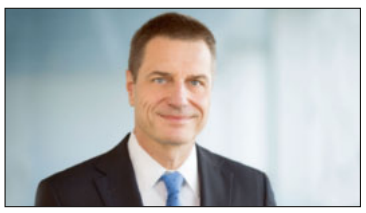
"P-I Brånemark was a man of ideas and ambition who never accepted any limits for what could be achieved."

— Tomas Albrektsson

"P-I always advocated interdisciplinary cooperation and lived as he taught, which served to expand knowledge in many fields simultaneously."

— John Brunski

From the CEO



Richard Laube, CEO

Had it not been for the pioneering work of Per-Ingvar Brånemark, we would not have the titanium implant fixtures that have become the standard in patient care today.

P-I was the foundation upon which Nobel Biocare established an entire industry. Observing that the body would accept titanium as if it were its own was a ground-breaking discovery, but the fact that he realized its potential for treatment—ranging from oral restorations to orthopedic applications—demonstrated not only creativity but a rare genius. A very demanding individual, he held himself, his work and all of us to the highest standards. His meticulous attention to detail and determination to prove his point were the driving forces behind his success.

P-I faced well-established opposition and prevailed. He ultimately convinced the nay-sayers that osseointegration was the fruit of science and not conjecture. Treating his first patient in 1965, he brought about nothing less than a paradigm shift in dentistry.

When "A 15-year study of osseointegrated implants in the treatment of the edentulous jaw" was published in the *International Journal of Oral Surgery* in 1981, the science of osseointegration became irrefutable.

"No one should die with their teeth in a glass of water," he said.

Not on his watch, nor on ours. <

He Made People Smile

Improving patients' quality of life was the mission of his life.

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the design of the implant might have an effect on bone healing and growth.

In this context, the contributions of two men proved to be decisive for further progress. An American researcher, engineer and materials specialist, Richard Skalak, designed the first implants. Viktor Kuikka, a precision mechanic and watchmaker in Sweden, took on the difficult task of machining both the implants and surgical tools of titanium.

Meeting resistance

Brånemark found himself working in a headwind. His findings that the body would accept titanium over the long term, and even allow it to integrate in bone, flew in the face of conventional wisdom. In the mid-1960s, physicians and dentists were still being taught that foreign, non-biological materials could not be integrated into living tissue. Initial inflammation and ultimate rejection were considered to be inevitable.

Previous trials with implants had failed, after all, and caused patients considerable suffering. The academic world questioned Brånemark's research, partly because of the failures of others in the past and partly because he was working in so many different academic disciplines at the same time.

Funding from Swedish research organizations dried up. He was repeatedly turned down when he applied for renewed grants to study tissue anchored implants, yet he persevered. Eventually the US National Institute of Health stepped in and funded his research, which made it possible for him to repeatedly demonstrate the accuracy of his claims and the viability of osseointegration, but it wasn't until the mid-1970s that the Swedish National Board of Health and Welfare were finally prepared to approve of the Brånemark method.

For the benefit of the patient

In 1965 a Swedish man, Gösta Larsson, became Per-Ingvar Brånemark's first dental implant patient. Using a very cautious method that his research group had devised to show the greatest possible degree of respect to the living bone tissue, Brånemark inserted a set of titanium implants that Larsson would have for the rest of his life.

This remarkable patient had been born with a deformed jaw, and the four titanium implants that he received that day meant that a set of new teeth could be attached to his jaw. For the first time in his life, he could eat and talk normally. When he died in 2006, his implants had worked without problems as the foundation for a series of oral prostheses for 40 years. Since then, well over ten million people worldwide have benefited from Per-Ingvar Brånemark's discovery.

Both in Sweden and abroad, Per-Ingvar Brånemark's achievements in the field of osseointegration have opened up entire new areas of promising research, many of which have led directly to innovative products by Nobel Biocare. The company respects the Brånemark heritage of innovation grounded in good science and continues along that path today.

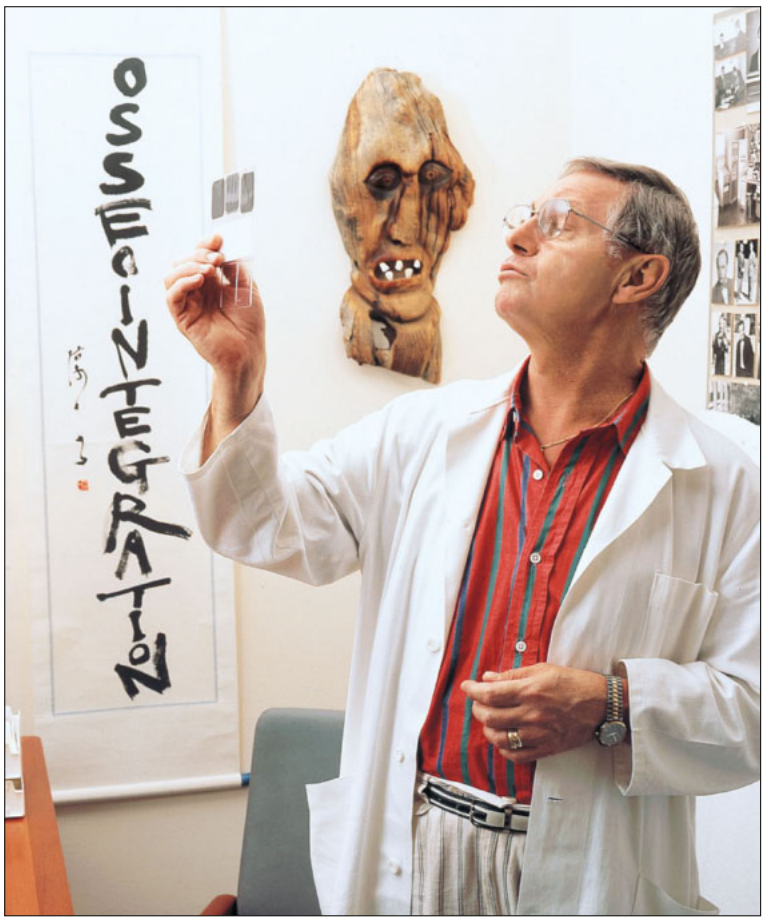
Some Brånemark-inspired research teams now focus on trying to better understand how the processes of healing and immune defense interact. Others focus on the surface structure and chemistry of titanium implants, in attempts to tweak the surface properties just enough to give the body an even better chance for rapid and safe healing.

As the number of successfully treated patients explodes around the globe, yet other centers scientifically evaluate both new and well-established component designs to ensure that the highest possible standards of safety and efficacy continue to be maintained in the future.

Per-Ingvar Brånemark's greatest legacy may be the fact that medical and dental schools now teach the use of osseointegrated implants as a routine part of their normal curricula.

The pursuit of learning for the sake of constant improvement was paramount in his professional life and reflected in this often repeated maxim:

"We must never forget, that from the patient's point of view, the criteria which differentiate between success and failure are always the key issues we face as a team." <



Awards galore. Among the hundreds of honors Brånemark received over the years, three were especially dear to his heart: the Swedish Society of Medicine's Söderberg Prize in 1992, (also known as the "little Nobel"); the Swedish Royal Institute of Technology's Great Prize in 1997; and the European Inventor Award for lifetime achievement in 2011.

Something of a dental superstar even in his later years, Per-Ingvar Brånemark attracted admirers wherever he turned. Always prepared to offer a word of encouragement to young clinicians and scientists, Brånemark participated in global symposia like this one in Gothenburg, Sweden, well into his eighties.

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"His was a truly innovative mind that inspired others."

Few people know as much about the early years of Per-Ingvar Brånemark's research as Swedish Professor Tomas Albrektsson. In this commemorative issue of *Nobel Biocare News*, Albrektsson recounts some of the lesser-known, yet very interesting episodes which led up to the advent of osseointegration.

By Professor Tomas Albrektsson

Tomas Albrektsson began work as part of Per-Ingvar Brånemark's research team in Gothenburg, Sweden in 1967. In the years that followed, he earned his PhD in anatomy and a Swedish professorship in the subject of handicap research. One of the most quoted scientists in his chosen field, Albrektsson lectures around the world and often moderates symposia and conferences on subjects related to osseointegration-based treatment and research.

Although a graduate of the University of Lund, in the far south of Sweden, Per-Ingvar (or "P-I", as he is generally known) Brånemark founded his Laboratory of Experimental Biology at the University of Gothenburg in the early 1960s.

As a young medical student I became a most junior researcher at P-I's lab at the Department of Anatomy at the end of the same decade.

At this time, most of the research activities of his laboratory were still devoted to microcirculation, particularly in the field of vital microscopy. Although the first fixture patients had already been treated in 1965, implant research was not going to dominate the laboratory until a later stage.

In fact, one of my first memories relating to the implants was a lecture P-I gave in southern Sweden in 1969.

Not well-received

Back in those days, the use of oral implants was not an accepted form of treatment and the audience needed to be convinced.

Immediately after P-I's presentation, one of the senior academics of Swedish dentistry at the time rose and referred to an article entitled "Microcirculation—A New Frontier for Research" that had presented P-I's vital microscopy work for the subscribers of *Reader's Digest*.

This pundant then said sardonically, "This may prove to be a popular article, but I simply do not trust people who publish themselves in *Reader's Digest*."

Now, this same senior academic had become known to the Swedish public as the authority who recommended a certain brand of toothpicks. P-I rose without hesitation, striking venomously as a cobra with the reply, "And I don't trust people who publish themselves on the back side of tooth-pick boxes!"

P-I won that battle, but it would take him almost another decade to win the war of attrition, breaking down the resistance of the conservative, senior Swedish academic establishment, and making it possible for the country's health-care community to accept his oral implant concept.

There were many below-the-belt blows in those days. One was referring to P-I as "only a teacher and an M.D., completely without any odontological knowledge."

P-I responded with characteristic, tongue-in-cheek humor: "It's true that I'm not a dentist but, on the other hand, I do find it satisfying to train them."

Later, I should add, he received his formal academic degree in dentistry as Doctor of Odontology from the University of Umeå in Sweden and also became a member in good standing of the Swedish Dental Society.

But let me return to the Laboratory of Experimental Biology, which under P-I's leadership, became one of the most dynamic concerns of any University, anywhere.

In a time when academic titles had become much less lucrative in comparison to clinical ones, and other laboratories were searching for PhD candidates with binoculars, P-I (much to the envy of many colleagues) ran an extremely popular laboratory where he only accepted the best junior researchers (myself, of course, excluded) for training.

Exciting times

By the end of the 1970s, P-I had supervised the writing of thirty PhD theses—quite impressive considering the things he was achieving in his "spare time". There were few questions concerning his favorite subjects—microcirculation and implants—that were not tackled by gifted people at his lab.

Even if he sometimes directed the work in the manner of a field marshal, his staff accepted it. After all, not only did he have the highest rank, he was also a natural authority to us all.

Some problems were bound to arise, of course. At one point, P-I recruited "volunteers" from the staff when he discovered that his interests in microcirculation and implants could be combined by inserting a titanium chamber in the upper arm of his subordinates.

Personally, I avoided participating in this truly heroic series of experiments by referring to the fact that my elder brother, Björn, already was a victim—pardon me, I mean a "participant". Obviously, it was therefore essential, scientifically, to allow me to remain in the control group to prevent the Albrektsson genes from adversely affecting the outcome of the research.

Making the news known

While the 1960s and '70s were a time of struggle for P-I, his time of success would come when his implants would be accepted all over the world.

It's one thing to do excellent research and develop a superior product, quite another to make the news known.

Here, P-I received invaluable help from Professor George Zarb, who had learned about the Swedish implants through prosthodontic colleagues. Zarb and his team came as the first guests from abroad to be trained in the Brånemark System in Gothenburg. That was before the end of 1978.

It's hard to imagine now, but all of those who came to our remote country to learn about implants before the breakthrough of recognition that came in 1982 subjected themselves to a degree of risk.

Becoming clinically involved with oral implants at that time was not regarded as the best way to promote one's career as a clinical scientist.

Therefore, these pioneers remain our dear friends to this day.

Even though he had up to fifteen-years of clinical follow up at the time, P-I himself was hesitant to present his research to the public in Toronto in 1982. He felt, quite simply, that it might be premature.

In fact, at three different times in the spring of 1982, he gave the order that the battle was to be postponed. We, his soldiers, had become so used to gun smoke by that time, however, that we "didn't hear" our supreme commander.

Due in part to the top-rate organization supervised by George Zarb, and in part due to the contents of the meetings themselves, I believe that almost everyone who participated at the Toronto conference—and that included P-I himself—agreed that the meeting was a real breakthrough for osseointegration.

P-I Brånemark's success was further documented a few years later when the Brånemark System (still sold and supported by Nobel Biocare today) became the first implant to receive recognition by the American Dental Association.

In the meantime, he had been awarded so many odontological decorations that he couldn't wear them all at one time, no matter how formal the occasion.

P-I Brånemark was a man of ideas and ambition who never accepted any limits for what could be achieved.

His was a truly innovative mind that inspired others. He performed wonderfully as a guide for young people and—in the best sense of the word—P-I was a visionary leader.

Working with imagination, insight, and boldness, he presented his colleagues and students with a series of challenges that called forth the best in them as they pursued a shared sense of purpose. He taught us to keep our eyes on the horizon, not just on the work at hand. We are all richer for having known him. May he rest in peace. <

→ To pay your respects

To send your condolences to the Brånemark family for their loss or to share a short eulogy, please send a message to:
news.editors@nobelbiocare.com

Millions of Smiles – Millions More to Come

One man's groundbreaking discovery and life's work are just the beginning for the people of Nobel Biocare.

A true pioneer and innovator, Professor Brånemark continues to inspire friends and colleagues at Nobel Biocare. He taught us to put patients first as he unrelentingly pushed the limits of rehabilitation from oral and maxillofacial solutions to ever more advanced uses of osseointegrated implants.

By Jim Mack

For all of us at Nobel Biocare, the life and work of Professor Per-Ingvar Brånemark embodies everything our company stands for. He set the standards, gave us the guidelines and challenged us to be good stewards of his legacy.

"P-I never stopped thinking about how his invention could be used in applications for helping people in one way or another," reflects Berit Adielson, one of the original nurses responsible for training and certifying early Brånemark System adopters. "He was a very warm person, interested in everyone around him." After a moment of thought she adds. "And he was, without question, a very curious man."

Where would it lead?

It was that curiosity of his that turned a temporary setback into a gigantic long-term breakthrough.

Magnus Persson, VP Global Sales Effectiveness explains. "When his optical chambers, made from titanium, integrated with the bone of rabbits and were difficult to remove, most people would have been upset or would have tried to manufacture the chambers in a different material to avoid the trouble. Not Brånemark!"

Instead, this annoying incident led to a discovery that "opened a path to body-part reconstruction", as Miho Onodera, Marketing Specialist, Japan, puts it.

Professor Stefan Holst, Global Head, Research, Science & Regulatory Affairs, sees the professor's greatness in slightly different terms. "As curious as P-I was, his most prominent trait was certainly his social responsibility and his focus on the well-being of the individual patient.

"The way he made the transition from a scientific observation to a global treatment concept, made him a living icon for millions."

An inspiration in many ways

While Brånemark was inspired by his patients, he in turn inspired many people working at Nobel Biocare.

"I have always found it immensely worthwhile to share a few of P-I's patient stories with new employees," says Dr. Ramya Narayanaswamy, Training & Education Manager for the Asia-Pacific region. "It gives them a feel for what our company is all about. This part of the training usually leaves them both inspired and proud, and accentuates our ultimate goal: improving the quality of life of our patients."

> *"Helping to implement his vision to help other human beings improve their quality of life was a great privilege. It still is."*
> — Melker Nilsson

Dr. Alexandra Rieben, Head, External Studies & Clinical Evaluations, has always been impressed by the professor's tenacity.

"What inspires me most about P-I is the entrepreneurial spirit he personified and the imperturbable vision he pursued to improve the lives of millions of edentulous patients. Although the path he chose was full of trials and tribulation, he stuck to his goals. As a result, after decades of struggle, he gained worldwide acceptance."

Passing the torch

Brånemark set the standard for how Nobel Biocare approaches treating more patients better: Bold innovation backed by research, development, meticulous clinical follow-up and scientific validation.

Anders Glansk, VP Global Marketing, explains. "Due to the original novelty of osseointegration, P-I knew that only if his research was absolutely definitive and flawless, would he stand a chance to convince people. As a result, the methods he and his colleagues developed in the 60s and 70s are still the golden standard today."

Hans Geiselhöringer, Executive VP, Global Research, Products & Development expands on the same thought. "It is our responsibility to maintain these standards now and in the future. It has been my personal objective to secure the scientific procedures and standards promoted by P-I and ensure that Nobel Biocare innovates with focus on patient relevance while using a fact-based approach."

Working together

According to Thomas Kaup, Group Manager, Product Development, Brånemark had a great grasp of two specialties: engineering and medicine. "While he was supervising every technical detail he also ensured that the results were based on strong clinical evidence. One could say that he was a cross-functional team all by himself!"

From start to finish, Brånemark's primary concern was always the best interest of the patient. To that end, he advocated teamwork at every stage of the treatment process. Nobel Biocare maintains that commitment today.

"He emphasized the importance of collaboration and exchanging information on every possibility and option to simplify and improve procedures," says Camilla Billström, Marketing & Products Manager, Sweden. "That certainly permeates everything we do at Nobel Biocare."

The professor lives on

Like the millions of patients who have benefited from Brånemark's dedication and achievement, everyone at Nobel Biocare can also smile knowing that he touched our lives significantly, too.

"Like so many others," says Joe Day, VP Marketing, North America, "I owe him not only my career, but many brilliant life experiences and wonderful friendships all over the world."

Melker Nilsson, Executive VP, Head of Global Sales and Customer Development, is of the same mind. "From the first time I heard P-I speak back in 1993, it was clear that working for Nobel Biocare would be more than just a normal job," he says. "Helping—if only on a very modest scale—to implement his vision to help other human beings improve their quality of life was a great privilege. It still is."

P-I's spirit obviously runs deep within Nobel Biocare. "We are very proud of carrying on his pioneering legacy and continue to build on this unique heritage," says Dr. Pascal Kunz, Global Head, Business Unit Guided Surgery & Digital Dentistry. "It is our mission to continuously challenge the *status quo*, to carefully observe and improve our products and solutions, and to continue to develop meaningful and ingenious innovation." <

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