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"We Must be Able to Show How Science is Beneficial to Society"

Ben L. Feringa Interviewed on the Occasion of SCS Spring Meeting

Ben L. Feringa
Year of birth: 1951
Since 2003, Feringa has been Jacobus H. van 't Hoff Distinguished Professor in Molecular Sciences at the University of Groningen (NL)
In 2008, Ben Feringa was awarded the Paracelsus Prize of the Swiss Chemical Society.

SCS: Why did you study chemistry?
Ben Feringa: I decided to study chemistry because I very much enjoy doing experiments. This is what distinguishes chemistry from, say, mathematics. At high school, I had higher marks in mathematics than in chemistry or physics, and I liked all three of them. But the fact that I could do experiments and work with things you could feel, see or smell made me decide to go for chemistry.

What about the result of an experiment – was that less fascinating?
No, I liked to see crystals, to see something boiling, to see the beautiful colors… All these things made quite an impression on me. Another influence was the knowledge that what I was doing might have an impact in the real world.

"I still remember the thrill of excitement the first time I made my first new molecule."

What sort of impact?
I remember how fascinated I was with the idea that we could make, say, artificial fibers, or that people could design new drugs, something that could cure a disease. The whole conception that you could design or build something that had not existed before fascinated me. I remember the moment when I entered chemistry; the beginning is rather dull because you have to go through all this basic stuff. As soon as I began to get into research, I realized that chemistry could create a world that had never existed before. I still remember the thrill of excitement the first time I made my first new molecule… It was in the third year of my undergraduate studies, during a six-month internship, that I really started to get a taste for research. There, I could do research on my own for the first time in my life. That gave me quite a kick. And it went on from there, of course. I really love molecules… (Smiles.)

What do you do in your leisure time?
I own a piece of land, with horses on it, and a big garden where I grow my own vegetables. I love to spend what limited free time I have in the garden. I grew up on a farm. When I was a child, I dreamt of becoming a farmer. Chemistry is my hobby; this is why I can spend so much time on it… But I really love nature. The fact that you can grow a small seed and later eat the vegetable, or see the flower blossoming, really fascinates me. Besides this fascination, it keeps my feet firmly on the ground admiring what nature has accomplished. It makes me realize that what we are doing is rather primitive. And it is a good counterbalance to my activities in the lab and the lecture hall. It's just wonderful.

"Through natural sciences, we can go far beyond the limits imposed on nature by evolution."

Nature seems to be important to you.
It certainly is!

Today, many understand chemistry and nature as being opposed to one another.
For me, this is not an issue. If you look around yourself or look into your body, the molecular world is what makes a living being to a great extent. If there were no molecules, you wouldn't exist! And then there are the physical phenomena. Beyond that, of course, there may well be much more. But basically, when you look at nature, for me it is a world of molecules. On the other hand, we have the synthetic materials conceived by chemists. For me, this is not a conflict. It is not two separate worlds. Firstly, the natural world provides all the inspiration. Nature poses the tough questions. Then we have tremendous opportunities, *via* chemistry and all the other sciences. Through them, we can go far beyond the limits imposed on nature by evolution. Nature builds her systems using a very limited set of materials. She has done a tremendous job over billions of years to evolve the whole system to the complexity of what we call a living being today. Chemistry as we know it is still extremely primitive. On the other hand, we do not have the same limitations as nature. For example, using simple ethylene, we can make a common plastic bag, but also a bulletproof vest. For me, the simple fact that you can do this in a laboratory is thrilling. This example tells me that there must be a vast world out there that we haven't discovered yet.

Holland, although it has always been a small country, was once a world power. Why was this possible? Because our ancestors, with their wooden ships, left their country to discover new worlds. They were adventurers! They explored worlds for which no maps existed. What they did was often extremely dangerous – many of them didn't come back! As scientists, we too enter an unknown world. Chemists have had to learn how to make polymers, how to perform catalysis etc. Today, we are moving on into the large and unexplored territory of complex systems. There are tremendous possibilities, sometimes scary, because we might engage with, for example, self-replicating systems. I can well imagine that people are scared by self-replicating systems, because there are dangerous aspects! We have to be in control of these things. But on the other hand, we sometimes treat illnesses with toxic compounds. We have to know how to

dose and handle them. In chemistry, we also sometimes make materials that could be dangerous. We have to know how to use these safely.

Of course, there are major challenges! The worst thing, however, would be to shy away from invention and from trying to find out what lies beyond our present limits. I think there are tremendous opportunities for chemists. The more we learn about molecular biology and the complexity of living nature, the more we realize how poor our knowledge is. On the one hand we can look deeper into the world of biomolecules and molecular systems, and learn from it. On the other hand, we can try to build entirely new systems based on the principles we discover. That is what I am trying to do. It's thrilling!

"I try to understand both the complexity and the beauty of nature."

I agree. But how do you explain the fact that there are people who say that nature is entirely different from molecules, that the whole is more than the sum of its parts, or that nature is holy?
I think it has a lot to do with how people view their lives, their beliefs and knowledge, and how they feel about nature. Another factor may be that nature is so beautiful and so complex. The fact that nine months after two cells merge there can be a new and perfect human being is almost a miracle. Maybe it is a miracle. But as a scientist I feel like we should try to learn what those miracles are, how they work. I try to understand both the complexity and the beauty of nature. I am really excited about the possibilities and the future of chemistry. Today the molecular biologists, the biochemists, the medical and the materials scientists realize that a molecular approach is needed. I am convinced that in the future we will see dramatic changes in the field of medicine as it continues to move in the direction of molecular medicine. Scientists in the medical field will therefore depend heavily on chemists and vice versa. We need cooperation. Nobody can embrace all the disciplines. The same is true of physics. Only fifteen years ago, physicists and chemists barely talked to each other; they didn't even know each other's language. Today we have joint projects. Once you speak each other's language, a whole new world opens up!

"Once you appreciate each other's way of thinking, you can benefit a lot."

Has your vocabulary changed over time, or is it rather a question of dialogue?
The vocabulary is not so important. Of course you introduce new terms as the field develops, but generally you try to understand each other's language and the way you approach things. Once you appreciate each other's way of thinking, you can benefit a lot. Coming back to the issue of nature and ecology, I think there has been a tremendous change regarding the appreciation of chemistry. Of course there will always be people who focus on the bad aspects of chemistry. On the other hand, we have seen an enormous step forward in what has been achieved by the chemical industry, the way it deals with chemicals. I would challenge people to show me any other area in which greater effort and more advances have been made in environmental or safety issues than in the chemical industry. I think it is tremendous what has been achieved. People often forget that. I think we should be rather proud of what has been accomplished. There will always be the issue of the dangers associated with new technologies, but we should put them in perspective with natural dangers and try to keep control of them. And we should not avoid debate with the public.

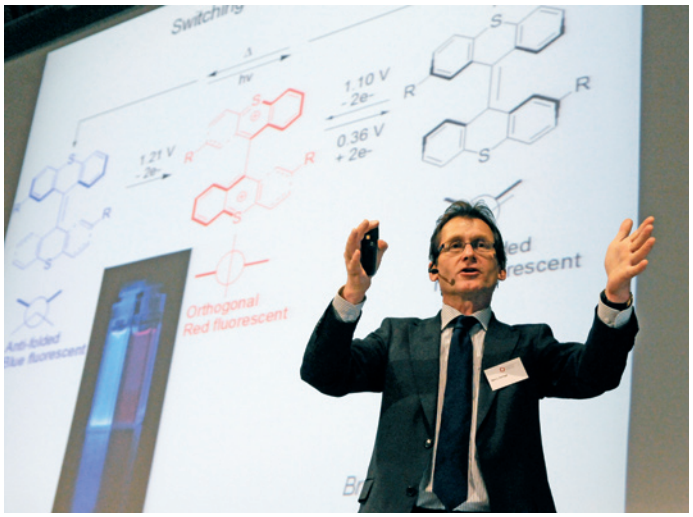
What, in your view, is the paramount duty of a chemical society?
It is important to have a forum for the chemical community. Chemists – be they teachers, young students or senior researchers – have to feel that this is our community. The chemical society must also represent them to the outside world, to society at large. It should communicate with government agencies, journalists, politicians *etc*. to carry the opinions of chemists to the outside world. There is a need to reach out to society because there is always a lack of knowledge, and hence misunderstanding. Chemical societies should talk about the benefits of and the problems related to chemistry. I think the feeling of belonging to a particular society and having common interests – be it the education of youngsters, the guidance of students in academia or offering the government scientific expertise regarding new regulations – is really important.

Sometimes it seems as though scientists don't dare to reach out, as though they prefer to stay in the laboratory…
I think we could do a much better job. We should train students how to explain what the value of a discovery is, what they are doing as chemists and why they are doing it. They should not be defensive. They should take an interest in the public perception of chemistry. They should prepare themselves for questions such as, hey, are you polluting, or what are you doing? Chemists should learn from astronomers for example. They are doing an excellent job passing on their fascination with astronomy to a wider public. Chemistry is of course a much more practical science, with a chemical industry and useful products in everyday life. We as chemists should emphasize the practical aspects of chemistry more, and engage in public debates. It wouldn't hurt us!

"Chemists should take an interest in the public perception of chemistry."

Doing this requires special skills, doesn't it?
We have to learn to communicate and not to be afraid. Let us look, for example, at the energy problem and the possibility of gaining fuels or chemicals from alternative feedstocks. To do this, we need new methods. We cannot directly transfer catalytic methods developed for the petrochemicals industry to green feedstocks, because the catalysts used for polymerizing ethene cannot be used to polymerize building blocks based on carbohydrates. So if we wish to produce fuel from crop waste, we have to develop completely new procedures. This has to be done by the chemical community. We should carry this message to society and to the politicians. This is an important task for scientists and for the chemical community at large, but also for the chemical societies.

You were the organizer of this year's Bürgenstock conference. What is special about this conference?
The Bürgenstock conference is really unique. It brings together the most outstanding creative scientists in the field of chemistry. Everybody knows it, and hardly anybody refuses an invitation to speak at it, because normally you only get the chance once in your life. You are in a gathering of 120 people in a superb setting. That is an important aspect; it makes you feel proud to be a chemist. Some chemists work in laboratories that are hard to compare with, say, fancy medical schools or business schools. So, the fact that we hold this high level conference in a prestigious setting sends out an important message to the chemical



Ben Feringa at the 2009 SCS Spring Meeting

community. What is unique about Bürgenstock is that there is ample time for discussion. The fact that we bring together people from diverse backgrounds in chemistry is extremely stimulating. It gives participants plenty of opportunity to pick up new ideas, to look at their own science from a different perspective.

> *"I would challenge people to show me any other area in which greater effort and more advances have been made in environmental or safety issues than in the chemical industry."*

Before you started an academic career, you worked at Shell Laboratories. Why did you leave academia after your PhD?
Actually I wanted to go to the United States for postdoctoral research, and had already had offers from a couple of places. But I was supposed to go into the army, which was compulsory in Holland at the time. By offering me a job, Shell kept me out of the army. I enjoyed working at Shell. Unlike nowadays, when most of the corporate research laboratories in the chemical industry have been closed, Shell had a huge laboratory in Amsterdam where it conducted petrochemical research. This laboratory was like an industrial university; it was a top place for research, comparable with Dupont Research or the BASF laboratories. All types of research were carried out there, from fundamental to applied research, and it had state-of-the-art equipment. For a young researcher like me, this was heaven. I learnt a lot. It was stimulating to be out of the academic environment and to work in a multinational company; to participate in the development of a new process or product. You learn to work within strict time constraints. It is quite a different way of working compared to academia. We hardly tell our students "You have six months and then we will publish a paper in *Angewandte Chemie* or stop the project…"
Usually, once you have spent several years with the same company doing fundamental research it is difficult to avoid changing over to applied research or process development. I had to ask myself whether I really wanted to go into development or whether I still enjoyed, for example, reading the latest news in the top journals. I realized that I really wanted to continue with fundamental research, to work on my own ideas and on important scientific questions. Furthermore, I like teaching and working with young people. When I had the opportunity of taking up a position as lecturer at the University of Groningen, I decided to go back to academia.

What are your main activities as a Jacobus H. van 't Hoff Distinguished Professor in Molecular Sciences?
Part of my activity consists of running a large research group, which I built up from scratch. I have discussions with students and research teams about research projects on a daily basis. Then of course I write publications and send off applications for grants. The day-to-day guidance of the research teams takes up a lot of my time. The other part of my job is teaching. Apart from that, I sit on various committees. To be honest, what really drives me is the work in the lab with students and Post-docs. But when you move on in your career, you also have an obligation to keep programmes, editorial boards *etc.* going.

> *"What really drives me is the work in the lab with students and Post-docs."*

How many researchers work under your guidance?
About 40 individuals.

In how many teams?
I have five teams working on different topics. We all meet together once a week when we discuss new literature, and two members give an update on their research. Apart from this, I meet with each team once every two weeks, when we have intensive discussions about the progress of each team member's work, what he or she has done and what he or she will be doing in the coming weeks, with input from all participants. It's important to plan your experiments, including the chemicals and the equipment that will be needed. This saves time and makes the experiments more efficient. Of course I have also brought in a lot of expertise from outside my university, with Post-docs from different backgrounds.

Have you ever considered accepting a permanent university position outside Holland?
I have been offered some fantastic opportunities at prestigious schools, but so far I have decided to stay in Groningen. The main reason is my family situation. My wife has a job at the academic hospital, which she really enjoys, and my children are still at school … It would be difficult for them to make a big change at this age. Finally, the main reason is that I am addicted to chemistry and science; I could never do a nine-to-five job. I can only follow my heart thanks to my great family situation. My family needs a stable situation, which in turn gives me the opportunity to do what I am actually doing – traveling, working, spending evenings and even weekends in the lab. The second point is that I have fantastic colleagues, and the funding situation is fine. In our science faculty, people cooperate across the disciplines. That's also very important. Cooperation requires friendship and collective passion.

That's not something you can take for granted in a university environment…
Exactly. I have seen departments where people work alongside each other, but don't communicate!

I would like to talk a bit about your occupation as a teacher. What do graduate students need to succeed in research?
I think it's important that they are enthusiastic about unknown things, about adventures…

Curiosity…
The first and foremost prerequisite is that they are curious. Secondly, they need to show perseverance. They must work away

at a problem and not give up. I know that there are people who work on problems to which they know the answer. They know it can be done. I am convinced that it's more interesting to work on challenges where you don't know the answer. In chemistry, you should enter into an adventure with molecules. That is what I teach students, whether they do scientific or applied research. There are so many things that are still unknown, so many important problems that remain to be solved. I use to tell my young students that by coming up with solutions to some well-known problems, they can become famous, or multi-millionaires… Of course there are only a few who will make it to that stage. But if you don't challenge the students, not much will happen.

"If you don't challenge the students, not much will happen."

What do young professors need to succeed?
As I know from experience, it is extremely important to be a bit daring and not to pay too much attention to what your senior colleagues are doing. Go your own way! Of course, you have to build on what is known. We all build on what has been accomplished by those before us. But you must never forget that there are still so many fantastic questions and challenges. Pick out something that can make an impact! Look carefully! Also: have a second string to your bow.

What do you mean by that?
If you choose to follow a path which is extremely challenging, but which might only lead to any success, say, in ten years, you might not have these ten years, or you might become frustrated. It's always wise to have a second line of research where you know you can get decent results and prove yourself among your colleagues.

Which other personal strengths are needed to succeed as a researcher in an industrial environment?
The situation has changed. When I entered industry 30 years ago, people appreciated that a scientist works as a scientist, that he or she does not want to become a manager. Nowadays I see much greater emphasis on communication and managerial skills. Perhaps with our economic crisis today, managers might once more appreciate skilled, craftsman-like scientists. I think that in the future we will have to be very careful to value good scientists, good engineers, good experts. We need to be aware that there are people who are perhaps not so good at communication, but who will make real breakthroughs regarding new products or processes. We need people who are more than happy to be specialists.

"If you are not enthusiastic, how can you expect your students to be?"

What are the personal requirements for becoming a successful academic teacher?
As a teacher, you have to be enthusiastic. If you are not enthusiastic, how can you expect your students to be? It's important that you can share a bit of your passion. You must be able to demonstrate that there is a reason why the students should learn a specific thing. And you should lead them to the point where they want to know why something is the way it is, or why it might be completely different. Then they can learn even the most difficult things. Students should also understand the broader implications of what they are learning.

How would you try to persuade the child of a good friend to study chemistry?
That's a tough question. It depends very much on the child's personality, their interests and their motivations. If they have an interest in materials or molecules, it makes it a lot easier to generate enthusiasm in them. If this interest is lacking, you can perhaps build a bridge to something they are already interested in. Today it is not enough just to appeal to an interest in science. When I went to high school, the Americans went to the moon. At that time, everything about science was interesting. Science was in the air that we breathed! Today, we must be able to show how science is beneficial to society. Consider for example the energy problem, or health problems. Students must have the feeling that they are involved in interesting and important problems. We must not forget that they might look at science in a different way to us.

What are the main skills required to successfully direct a research institute?
There are several ways to look at it. Obviously, a research institute needs to focus on a particular area of research. It must know what its core business is – people sometimes forget that in academia. The core business of my institute is to train students! Then it must produce exciting research results, so that it can compete with the best in the world within the same area. The students must be excited about what they are doing. Another important thing is to hire the best staff you can get. The people you select to work as teachers or research staff are paramount. Of course an Institute's chances of getting the best people also depend on its reputation.

"Academic research should focus principally on fundamental research."

What do you do to get the best?
We look for talent at a very early age, *i.e.* when students finish their theses or are doing postdoctoral research. The number of positions at Universities is very limited. By the way, this can be a serious problem. You need to be a certain size to do proper research. You need colleagues and staff with diverse interests and expertise. In the past 10 or 15 years, many University departments in our country fell below the sub-critical mass. Students need exposure to professors with different interests in chemistry and different approaches to teaching. Otherwise, they will not make it to a high level. There is a reason why all of the top institutes worldwide have a sizeable number of staff.

What is needed for a fruitful and sustaining cooperation between academia and industry?
At my Institute, as you may know, we work a lot in cooperation with the industry. That's fine. But you should never forget why you are in academia. Academic research should focus principally on fundamental research. We should not do too much research that is of direct benefit to industry, because the planning periods in industry are much shorter. We have seen very bad examples in past years where industrial policy was to a great extent dictated by shareholder values, rather than by what the position will be in ten years' time. I think academics should not be afraid to stick with one main aspect of their core business which is fundamental research. Of course they should be open to engage in strategic cooperations. But the worst thing we can do is to go too far in the direction of short-term industrial research. That is no good for academia, and no good for industry either. This is a serious issue.

Jumping into application-based research is quite fashionable…
I know; it's easy money.

Personal ambition can either help or hinder in the pursuit of a professional career. How can a young scientist develop the useful side of his or her ambition?
What do you mean by hinder?

If you are too ambitious, you probably won't reach your goal because you are too anxious, or too competitive with your colleagues…
I think you should be realistic. As a scientist, you are only a very small part of the whole scientific community. You cannot solve all the world's problems! That is why I say have a second string. That means that you also aim for some ambitious goals. But if you do only that, you might end up in a very bad situation, because after four or five years you still don't have a decent publication. As a consequence, people will attack you for your over-ambition; you won't get grants, or grants will not be renewed, or you might even lose out on a permanent position. On the other hand, I think it is very important that people see that you are able to put your own stamp on chemical research.

"Don't forget that as a scientist, you are only a very small part of the whole scientific community!"

How can you control personal ambition from inside?
You must be careful not to be completely preoccupied with your own scientific work. You also need to relax and stand back from what you are doing. If, for example, you really want to make a career or become a professor, it is difficult to know how to go about it. My supervisor, Hans Wijnberg, once told me that you can talk to so many people, and everybody will give you different advice. But the only way to write a book is… to write. I think he was right; at some stage, you just have to go for it. You have to have the courage of your convictions. You also have to know your weak points, your limitations. But don't be too scared. Don't immediately think, I have to be like this or that eminent chemist – because they too started at an early age, with ambition, and they too had to build their way up to become that eminent chemist.

Prof. Feringa was talking to Lukas Weber, Executive Director of the Swiss Chemical Society.

SCS Paracelsus Prize 2008

Ben Feringa was awarded the 2008 Paracelsus Prize of the Swiss Chemical Society, in recognition for his groundbreaking research in the fields of metal-catalyzed stereoselective organic synthesis and supramolecular chemistry.