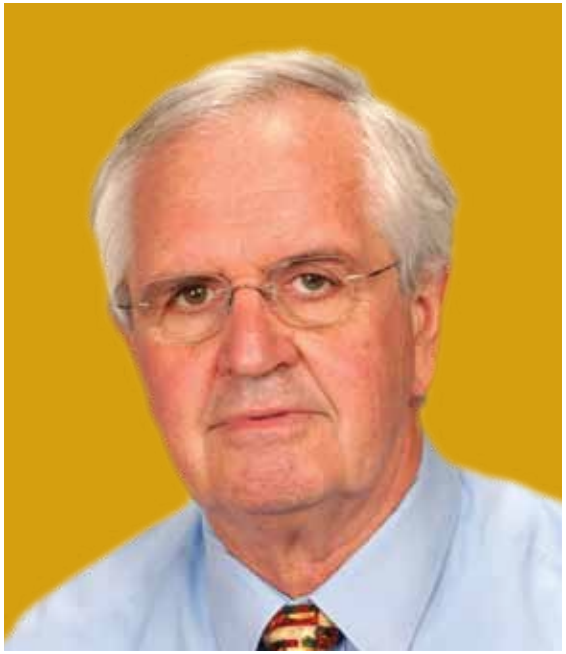
PIETER STREICHER STEYN



TOP THREE AWARDS

- National Order of Mapungubwe (Silver), 2011
- Academy of Science of South Africa Science-for-Society Gold Medal, 2007
- Gold Medal of the South African Chemical Institute, 1987

DEFINING MOMENT

Joining the National Chemical Research Laboratory of the CSIR in 1964. "This led to my career in biologically active substances, particularly mycotoxins."

WHAT PEOPLE DO NOT KNOW

Steyn has a potent toxigenic fungus, *Aspergillus steynii*, producer of the ochratoxins, a group of nephrotoxins, named after him. He also met the Emperor of Japan during the 125th anniversary of the Chemical Society of Japan (2003).

A MATTER OF CHEMISTRY

Chemistry is not always viewed as being relevant to society. In fact, a recent report by the Royal Society of Chemistry found that the public doesn't really care about chemistry and struggles to identify applications that are of personal relevance.

While other sciences are seen as more exciting and interesting, more 'complicated' sciences, such as chemistry, are largely taken for granted. However, chemistry is central to all types of science. Without it, other fields of inquiry such as molecular biology and environmental science would not be possible. One of the salient missions of chemistry is the creation of innovative substances that can improve the quality of life around the globe and contribute to the national and international economy.

Regardless of its importance, this dispassionate view of chemistry is prevalent and makes it particularly important to report on and support scientists who are making advances in the field of chemistry in ways that are relevant.

One such chemist is Professor Pieter Streicher Steyn, a recent retiree as Senior Director of Research from the Division of Research Development at Stellenbosch University (SU). His achievements in and contributions towards the chemistry and biosynthesis of mycotoxins have won him many accolades.

Steyn was born in 1940 in the agricultural town of Vryburg in the North West province of South Africa. At the local high school, he was inspired to pursue science by his teachers. "We had very good teachers," Steyn recalled. "Our science teacher at the time had a Masters in chemistry and a Masters in mathematics." He followed in the footsteps of his teachers and moved to SU. There he received his BSc in chemistry and geology in 1959, followed by an MSc from SU and later a PhD from the University of South Africa (Unisa).

His MSc with Prof Chris Garbers in Stellenbosch and his PhD with Prof Cedric Holzapfel at the Council for Scientific and Industrial Research (CSIR), Pretoria, formed the foundation for his career in organic chemistry and specialising in the chemistry of natural products, such as mycotoxins. Mycotoxins are toxic secondary metabolites of fungi. Not all secondary metabolites of fungi are classified as mycotoxins; a famous example is penicillin. Penicillin is an antibiotic that *Penicillium* fungi produce to kill off competing bacteria from the surrounding area that it is trying to colonise, a clear benefit to the penicillin fungus. However because penicillin is toxic to bacteria, it is considered an antibiotic rather than a mycotoxin. Steyn describes mycotoxins as "by-chance metabolites" that have vastly different chemical structures and biological activities. It is still not understood if fungi produce mycotoxins to protect themselves or if there is some other reason.

A mycotoxin is a chemical compound of a small molecular weight that is toxic to animals, including humans. The oldest observations of mycotoxicoses (diseases caused by mycotoxin poisoning) were in the Middle Ages in Europe. These 'epidemics' were described as divine punishment or bewitchment, where victims described the burning sensation in their limbs as Holy Fire or St Anthony's Fire. This was later linked to mycotoxins produced by ergot fungi, a group of fungi of the genus *Claviceps*. Contaminated bread or grain has been linked to the outbreak of similar symptoms up to the present day. Rye flour contaminated by *Claviceps purpurea* is thought to be the cause of an outbreak in France in 944 AD which killed 40 000 people. Mycotoxins may also have driven the Salem witch trials in the US, though this is contested in literature. While the scale of outbreaks has shrunk and instances have become more and more rare, the more subtle effects of mycotoxins on humans and other animals have, until recently, been largely neglected. In the 1960s, a mysterious disease called turkey-X disease killed over 100 000 young turkeys in Britain. It was soon linked to mycotoxins of the fungus *Aspergillus flavus* which had been contaminating peanuts imported from Brazil. The liver toxin was subsequently named aflatoxin to reflect its connection to *A. flavus*.

The discovery of aflatoxins led to a renewal of interest in mycotoxins as potential hazards present in food and feed that may cause illness and death in humans and livestock. Current research has identified more than 300 mycotoxins, each of which has its own host of deleterious effects. The problems associated with the ingestion of mycotoxins vary, just like the in-

gestion of any poison would vary depending on the concentration and composition of that poison, as well as the size and body mass of the victim. Mycotoxins have been known to cause cancer, change genetic material, disturb reproduction, and hinder development of a foetus or embryo. They can also cause haemorrhaging, liver and kidney problems, immunosuppression, skin damage, and nervous system damage. In the case of aflatoxins, not only do they affect turkeys, but they have also been classified as a human carcinogen linked to primary liver cancer. This link led to a series of global studies that correlated prevalence of liver cancer to the contamination of foodstuffs by aflatoxins. This research was particularly relevant to southern Africa since the highest incidence of primary liver cancer in the world occurs in some areas of Mozambique.

RENEWED INTEREST

The renewed interest in mycotoxins in the 1960s put Steyn's research at the forefront of chemistry in terms of importance and application. His research contributed towards the development of sophisticated methods of detection in order to accurately monitor their presence and to develop regulatory policies to reduce their impact. Steyn continues to work closely with the maize industry to ensure that safe maize is supplied to consumers, food and animal feed industries, and export markets. He explained that, although mycotoxin contamination of South African commercial maize is low, the quality of maize produced by subsistence maize farmers in poor rural areas is more variable and often contaminated with high levels of mycotoxins. "Unfortunately," Steyn said, "when they process the maize, they sell the best and keep the worst to use for themselves." However, strict regulation and the development of educational programmes could significantly reduce the impact of mycotoxins on the African continent.

As with many scientific endeavours, half the battle is understanding the subject. At the CSIR, where he worked from 1964 to 1993, Steyn's dedicated research team was involved in the extraction, isolation and characterisation of several new mycotoxins from mouldered material. Although "isolation and characterisation" of a mycotoxin might sound simple, it's not. Mycotoxins must first be extracted with a solvent. This is followed by a "cleaning" step involving liquid/liquid partition and column separations to remove residual chemicals from the extract. Because mycotoxins are so different, these methods differ drastically depending on the structure, polarity and stability of the mycotoxins. However, innovations in methods, materials and technology have made this process easier. "What previously took us years to accomplish can now be done almost overnight. In the case of structural elucidation, very high field nuclear magnetic resonance (NMR) spectroscopy and single crystal X-ray crystallography made a significant difference." While this part is easier now, some mycotoxins are still difficult to isolate. "I spent a good part of my life trying to isolate a unique toxin from *Stenocarpella maydis*. Now, 30 years later, researchers still have been unable to isolate the significant toxins from the moulded material."

Much of this work came from Steyn's time at the CSIR. "Some of the best research equipment in the world was available to researchers at the CSIR. We were leaders in the field of mycotoxin chemistry and biosynthesis and we enjoyed collaboration with research groups from all over the world."

Steyn's research group made significant contributions to developing the principles of biosynthetic architecture of secondary metabolites by applying stable isotope labelling experiments and very high field NMR spectroscopy to establish the labelling patterns and the structures of some fungal metabolites.

Once mycotoxins have been isolated and characterised, tests and regulations for food safety can then be designed and implemented. "You must be able to isolate the toxin in a very pure form and then develop an analytical method to test its presence in foods and feeds." There is strict legislation globally that governs what level of mycotoxin contamination is allowed for various products. The technology for detecting mycotoxins has also changed drastically. In the past, thin layer chromatography was used. Now more accurate techniques, called HPLC and UPLC/MS, are used. Researchers can now detect toxins in parts per billion, an incredibly high resolution.

The ease of international collaboration on this topic is partly due to the worldwide occurrence of the mycotoxins themselves. "What's nice about

working with mycotoxins is that they are internationally distributed thereby leading to international collaboration, whereas if you work with plant toxins, those plants might only occur in a certain area."

Steyn was the first person from Africa to be elected President of the International Union of Pure and Applied Chemistry (IUPAC), Research Triangle Park, North Carolina, USA. He was also elected as President of the International Association of Cereal Science and Technology (ICC), Vienna, Austria. This enabled him to play a leadership role in the international science community.

In his new roles, he moved away from practising chemistry and worked more for enabling collaboration. While he recognises the value of his role at facilitating international collaboration, he sometimes regrets his departure from lab work.

Steyn's contributions to science have been recognised by way of numerous awards. He also received an honorary PhD from Unisa in 2010 in recognition of his research contributions in chemistry and for services to the international scientific fraternity as President of IUPAC and President of ICC.

After a busy career, Steyn is enjoying his retirement. He has been able to travel more with his wife, Margot, and to spend more time indulging in the little pleasures of life – following current development in finance and politics, reading *The Economist*, and going to the gym more regularly.

However, retirement has not meant a complete departure from his participation in science. He still coordinates the mycotoxin research programme of the Maize Trust on behalf of the maize industry, and in addition he consults for Innovus, the Office of Technology Transfer at Stellenbosch University. He also serves as an Associate Editor for the *South African Journal of Science*, assists researchers with NRF rating applications, and reviews the occasional paper. "I am still not totally relaxed," he says, "it still feels like there are things to get done."

He is excited about the potential in South African research and has this advice for youngsters: "Create a clear vision of your future, work hard and follow your dreams".

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Legends of South African Science

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