SAND, CANCER AND THE POWER OF INNOVATION

FROM CHINA AND SOUTH AFRICA, TWO WOMEN SCIENTISTS DEVISE NEW STRATEGIES TO SOLVE PROBLEMS AND MAKE A DIFFERENCE IN THEIR COUNTRIES.

Zheng Xiaojing of China and Tebello Nyokong of South Africa work in dramatically different fields: mathematical modelling to understand the spread of sand dunes, and novel methods to combat human cancer. But both share a common determination: to understand profoundly complex problems that threaten human lives and human communities, and then to use science to develop potential solutions. Their scientific results were showcased at the 24th TWAS General Meeting in Buenos Aires.

STUDYING EVERY GRAIN OF SAND

Zheng Xiaojing, a member of the Chinese Academy of Sciences and TWAS Fellow since 2010, is an expert in the fields of elastic, structural and electromagnetic mechanics. By using mathematical simulation and complex algorithms, she has come up with a model that predicts the dynamics of dune formation in deserts.

As she explained: "To predict the speed of desertification we must have a good understanding of the formation and evolution of a dune field. But existing methods, such as field measurements and aerial photography, cannot reproduce this formation and evolution in a precise way. So we thought that the theoretical simulation was perhaps a better solution to our problem."

The model Zheng Xiaojing has devised is called the 'triple-jump model' and begins with the simulation of single particle's motion. It allows a precise schematization of the evolution of aeolian dune fields, sand dunes shaped by the combined force of wind speed, erosion dynamics and surface conditions.

"Desert-spread has dramatically increased in recent years, taking almost one-third of Earth's land surface", she noted during the lecture she offered at the TWAS General Meeting in Buenos Aires. "Even worse, the speed of desert spread is also increasing. Ten years ago deserts were moving three to four meters per year. Now they run as fast as eight to 10 metres per year, or more."

This trend is common to all the largest desert areas in the world, from Australia to South America, from Africa to North America and Asia. China, in particular, is massively affected; desert areas cover now almost one-third of the Chinese territory, with sand dunes invading villages, pastures and meadows resulting in severe degradation.

The model set up by Zheng Xiaojing takes into account several elements that may influence dunes' formation, such as the grain's diameter, the thickness of sand sources and the season, because the strength and direction of wind change massively during the year.

"To evaluate our model and confirm that the growth of dunes also depends on the thickness of the initial layer, we ran simulations across one century data and came to a formula that can be applied to predict the growth rate", explained the scientist.

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Using this formula, it is possible to predict that dunes move in response to the forces of wind at various speeds inversely proportional to their heights. For example, a two-metre dune under the influence of spring winds will, in principle, be able to cover 28 metres in as little as six months.

Sand-prevention methods such as fences used to block sand flows, and straw checkerboard barriers used to prevent the shift and flow of sand particles are currently employed. However, if correctly applied, the 'triple-jump model' could help people save money.

"Knowing the pattern of dune formation," Zheng said, "we may optimize the size and placement of checkerboard barriers. Instead of laying them following a continuous pattern, people should lay them as belts, optimizing the distance between stripes. Both layers have the same effect but the second coverage pattern is less expensive."

LIGHT THAT KILLS AND HEALS

It's hard to imagine using light to kill cancer cells. But this is just what happens in lab experiments performed on cells, in Tebello Nyokong's laboratory. Nyokong, a South African professor known for her ground-breaking work in harnessing light for cancer therapy, is currently engaged in finding new drugs that can recognize cancer cells and ultimately destroy them. And her strategy makes use of light.

According to recent figures, one in six South African men and one in seven South African women will get cancer during their lives. And the statistics are even worse in other countries, where one in three people could potentially develop this disease. Despite all cancers being common in the population, some cancers seem to affect espe-

TWAS Fellow Zheng Xiaojing of the Chinese Academy of Sciences discusses her research on sand dune dynamics. (Photo: Roque Silles)

South African Professor Tebello Nyokong discusses her work on combined cancer therapies at the TWAS General Meeting. (Photo: Roque Silles)

cially black South African women: cervical, breast, uterine and even lung cancer.

Nyokong, who is a determined advocate of the role of women in science, has been long pursuing an innovative strategy against the No. 1 enemy of human health. “I started the cancer research a long time ago”, she explained. “The therapeutic tool I’m trying to refine is, in principle, more effective than other anticancer therapies, because it targets cancer cells, sparing the healthy ones.”

Her strategy lies at the interface between nanotechnology, the discipline that works at atomic level, and standard cancer therapy. It is called ‘combination therapy’ because it applies more than one substance to cure one disease. As she points out, the approach is based on the so-called photodynamic therapy.

Therapeutic molecules enter the cancer vascular system and selectively target malignant cells.

“We irradiate a low-energy drug – a dye from the family of phthalocyanines – with red laser light, to turn it into a high-energy molecule. Then we combine this high-energy drug with oxygen naturally present in the body, to trigger its switch from a low-energy to a high-energy, excited status. This final compound kills cancer cells.”

But how does the therapeutic molecule tell healthy from cancerous cells? “Tumours need a highly vascularized environment to grow”, Nyokong explains. “And tumour veins are leaky, compared with healthy vessels. This feature allows therapeutic molecules to enter the cancer vascular system and selectively target malignant cells”, Nyokong said, pointing at recent results she and her collaborators obtained using animal models.

According to preliminary results, cancerous cells die within two to three months from irradiation. This approach is particularly good for inoperable cancers – such as brain, bladder and lung cancer – but also for small cancers like those found in the breast and oesophagus, and in the follow-up treatment of other types of cancer.

Nyokong, who won the Africa-Arab State L’Oréal-UNESCO Award for Women in Science in 2009, has positive comments on South African diagnostic tools.

“We have highly qualified hospitals that do biopsies”, she said. “The problem is that poor people do not have access to these facilities: money, distance and even culture are still a problem.”

Indeed, Nyokong’s therapeutic strategy, given its low costs and easy applicability, could help reduce the gap in medical care between people of different economic classes.

Still in its infancy, her research is moving fast in the direction of human clinical trials, which will start as soon as the scientist solves some side effects – induced photosensitivity – and clarifies more precisely the mechanism of action of her strategy.

“In my research”, Nyokong said, “I apply what my father used to advise. He used to say: ‘You can do everything.’ This belief is what still moves me, also in my training activities with young women scientists to help them escape the still-existing gender bias.” ■

Cristina Serra