

‘This isn’t science fiction’

Hossam Haick of the [Technion](#) has developed an inexpensive patch that detects a range of diseases early on and can also deliver personalized treatment

Gid'on Lev

Hossam Haick of the [Technion](#) – Israel Institute of Technology in Haifa, one of the country's most successful scientists, is really a frustrated karate fighter. Growing up in Nazareth, he joined a karate class and seemed to have found his calling. “I was incredibly competitive,” he says. “I went from one achievement to the next.” But in 10th grade, with a black belt around his waist, he reluctantly decided to quit and concentrate on his studies. “I regret it to this day,” he says, totally seriously. “I could have had a great career in karate.”

Prof. Haick, 51, whose fields of expertise are chemical engineering and nanotechnology, remains a fighter at heart. In the laboratory, too, he gives everything he has, sometimes to excess, to achieve his goals. Giving up on an idea is simply not an option. During our nearly four-hour conversation, he keeps returning to projects that should have fallen apart. But like a bulldog, Haick sinks his teeth into his projects and refuses to let go. Even when he fails, even when a technology he has worked on does not prove itself, as has happened along the way, he does not throw up his hands. Instead, he redoubles his efforts and pushes harder. He has no choice. It is his curse and his blessing.

“It probably comes from my childhood,” he says in a moment of self-reflection. “I grew up feeling that I had to win because, if I failed, there would be no one to back me up. That I had to succeed or I’d collapse. It was a matter of survival.”

Haick grew up in a struggling Christian family, the third of five children. “I didn’t know it at the time,” he explains, “but we were very poor, below the poverty line.” His drive to achieve came from his father, Jihad. “That word means ‘to give your utmost and struggle for a cause,’” he adds. His father died a year ago of lung cancer, a disease his son has devoted himself to fighting for nearly two decades.

Haick describes his father's determination. At 21, after his first son was born, his father decided to leave his village and pursue an education, without any support. Every morning, he got up at 6 and went to his teaching job in Nazareth to pay for his studies and support his family. In the evenings, he studied at the Technion. At night, he prepared lessons until 3 A.M.

“Try harder,” he told his son, again and again – after Haick completed his bachelor's degree at Ben-Gurion University, after he earned his doctorate at the Technion, and after he secured a faculty position following two postdoctoral fellowships, at the Weizmann Institute of Science and the California Institute of Technology.

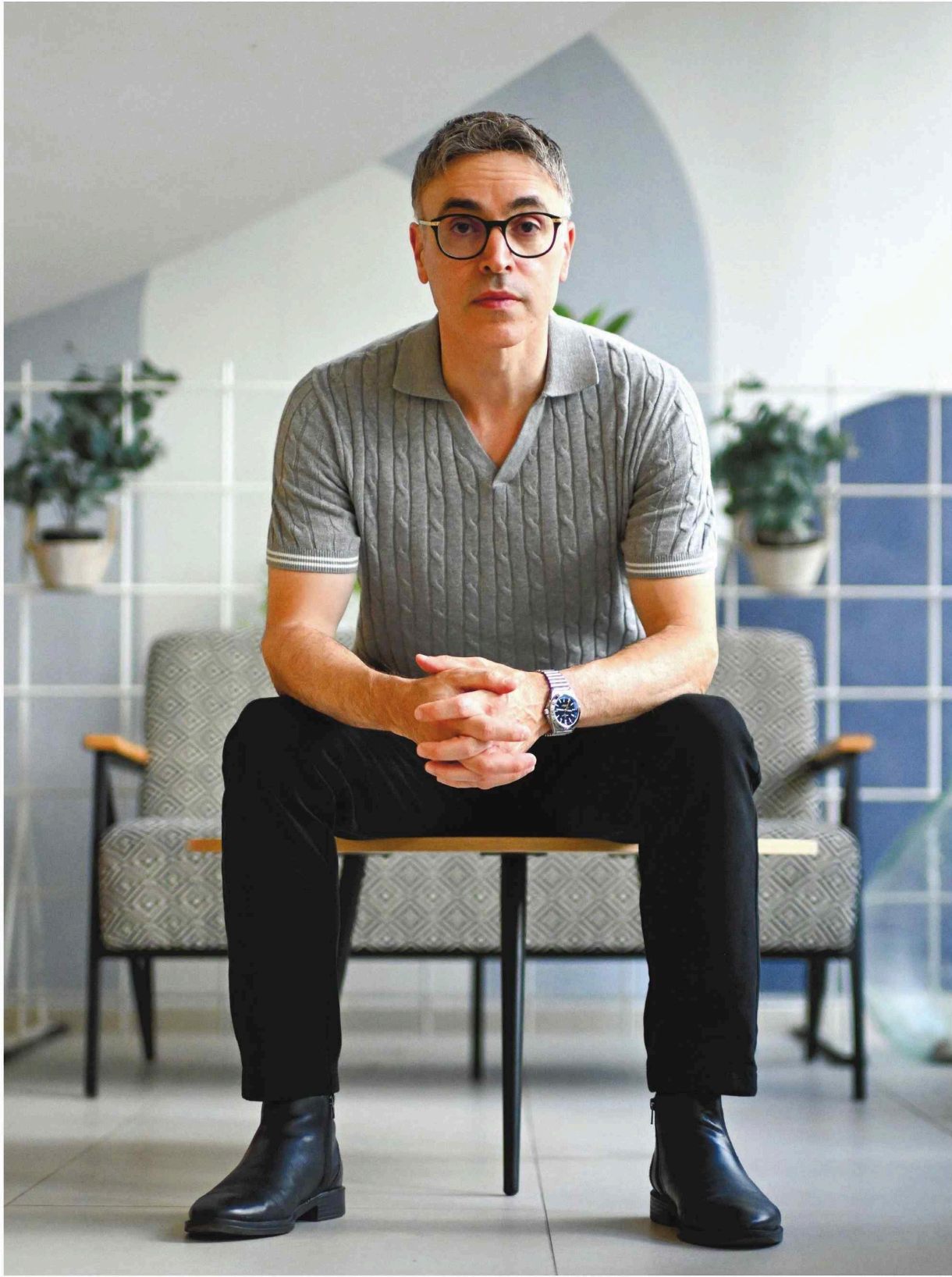
Haick keeps trying harder until this very day. After a series of breakthroughs, he seems to be getting closer to realizing his most ambitious vision: development of a tiny patch that adheres to the skin like a child's temporary tattoo, with sensors on its surface continuously monitoring the wearer's health. Within two or three years, he promises, the patch will be on the market and in commercial use. If that promise is fulfilled, it will initially monitor a small number of diseases. Later, he says, it will be able to detect many of the diseases that plague humanity at an early stage, and rapidly deliver drugs tailored to the person wearing it. All this for just a few dozen dollars per patch, whose effects will last for months.

That would complete the revolution Haick is working toward: a shift from medicine that responds to disease after it develops, using general treatment protocols, to medicine that can identify the early risk of a disease, track its progression and provide treatment for each person's conditions.

We meet in Haick's spacious office in the Technion's Faculty of Chemical Engineering. Two walls are almost entirely covered with certificates of appreciation and awards for excellence. I count them – there are 36. On a shelf opposite sits a large black metal sculpture of Sisyphus rolling his boulder. “I get an award, and two minutes later I'm back at work,” Haick says.

The first thing he talks about, however, is art. A few months ago, he completed two terms, six years in all, as dean of undergraduate studies at the Technion; he was responsible for several thousand bachelor's degree students. He proudly describes an initiative he introduced: an annual campus exhibition of students' artwork. “You can learn a lot from the way people think in art,” he asserts.

Another achievement he mentions involved changing the institute's admissions process. “When I started the job, I set up 12 committees, and we made changes at different stages of degree studies,” he says. Among other things, a special admissions track was introduced, allowing applicants to enroll with only a *bagrut*, (high school matriculation) certificate, even one with less-than-stellar grades. Whether students



Prof. Haick. “We have found that every disease has a distinctive chemical signature that sets it apart from the others. To me, that’s my greatest achievement: proving that there’s a scientific basis underlying Hippocrates’ approach.” Photos by Rami Shlush

can continue depends on their performance in the first semester.

Haick: “Of the roughly 200 students admitted through this track each year, about a quarter meet the requirements and continue their studies. Their average grades are even higher than those of students admitted through the regular track. Maybe that comes from my childhood too, I don’t know, but I have this deep-seated need to improve access and equal opportunities.”

Yet the professor stresses that he does not believe in affirmative action: “To me, equal opportunities don’t mean advancing someone simply because they belong to a particular group. I believe in excellence and in advancement on that basis alone. People will tell me

Haick first developed an electronic nose – a portable device combining sensors and AI analyzes breath and detect early markers of disease. ‘The device is about 88 percent accurate – comparable to, and in some settings better than, standard imaging,’ he says.

that, for all sorts of reasons, not every group has outstanding candidates. Then I’ll empower people from those groups and invest more resources in them.”

If you spend more money on them, isn’t that affirmative action?

“I’m not giving the money to the students. I’m investing it in faculty who will help them succeed. For example, each of these students gets a mentor for their entire degree. Or I’ll set up a summer program before the first semester just so they can speak and hear Hebrew. Not grammar, not [the poet Haim Nahman] Bialik, just speaking and listening. Because some Arab students struggle with Hebrew.”

And it works. A brief article Haick co-authored, published in Nature in 2020, reports that since 2004, the number of

Arab students at the Technion rose by 200 percent, the number of Arab women students by 350 percent, and the number of outstanding Arab students by 1,800 percent. The dropout rate fell by 67 percent. Haick has also served as assistant to the Technion's senior vice president, responsible for equal opportunities.

Did you receive that kind of support yourself, or benefit from affirmative action?

“I never received any help. I went into academia, pardon the expression, like an idiot. Nobody cut me any slack, and I didn’t know the rules either. I don’t want to go into detail, but in some places... I want to put this carefully.” He pauses, for the only time during our conversation. “My life in this country hasn’t been easy.”

When, for example?

“A decade ago, I received threats and harassment because of who I am: an Arab working on sensors, a technology that can be used in missiles. I’ve spent my whole life conducting medical research, but sometimes success makes people feel threatened, or they see it as a threat. I was repeatedly humiliated at Ben-Gurion International Airport. Eventually, I got a ‘good Arab’ certificate” – a reference a general, fast-track passport control certificate issued by the Israel Airports Authority.

“To get something like that, to say, ‘I’m a good Arab, please let me through,’ is a low point. But there were years when I took 53 flights, and I had no choice.”

During the Gaza war, while serving as dean, Haick decided to move the venues for some exams to the Technion's Tel Aviv campus because of missile fire aimed at the north. He received phone calls threatening his life: “They told me, ‘We’ll slaughter you if you don’t change your decision.’ Those exact words. Violence and criminality have become widespread in our society. I’ve been through a lot of very difficult things that I don’t want to talk about. But that’s why equality matters so much to me.”

Last July, Haick received a different kind of phone call. President Isaac Herzog was on the line, telling him he would receive the Israeli Presidential Medal of Honor.

“I was elected a Fellow of the U.S. National Academy of Inventors and received the Order of Academic Palms from the French government, but recognition from the president brought things

full circle for me,” he says. “As a society, we have a very solid foundation in this country. There’s a lot of noise too, but eventually it will fade. The principles on which the Technion was founded, and the country was founded, are excellent.”

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Haick lives in Haifa with his wife, a food engineer, and their two sons, aged 18 and 13. His meticulousness extends beyond his scientific work. He is athletic. “I’m at the gym three or four times a week,” says Haick, who looks younger than his 51 years. His glasses and haircut are stylish, his clothes light-colored. He is warm and peppers his remarks with humor, often at his own expense. “One of the good things about me is that I don’t think,” he laughs.

Haick owes his big leap forward to the karate fighter within him. Toward the end of his time at Caltech, Prof. Yachin Cohen of the Technion's Faculty of Chemical Engineering called to tell him he had secured funding to establish a laboratory, and presented Haick with a challenge. There was a European Union grant, named after Marie Curie, Cohen said, that no Israeli scientist had yet received. The application deadline was

just a week away.

“So I sat down for a week, worked 22 hours a day, submitted the application 15 minutes before the deadline and went to sleep,” Haick recalls. He returned to Israel, took up a position at the Technion, and then war broke out. “It was the Second Lebanon War. I hid under this desk more than once,” he says with a smile. In October 2006, a letter arrived: He had won the Marie Curie grant. “I couldn’t believe it. It was 1.73 million euros, when Israel Science Foundation grants were \$200,000.”

The grant completely changed his point of departure at the institute. Instead of establishing a laboratory with two students, as his initial startup funding would have allowed, he set up a lab with 17 students and researchers.

Haick specialized in microelectronics and nanoelectronics, but after a close friend from university developed leukemia, he explains, he decided he wanted to treat cancer. For all his determination, even Haick understood that treating cancer was beyond him. But there was another realm in which he could sink his: early diagnosis.

At the time, a kind of urban legend was circulating that dogs could smell disease, an ability later established scientifically. Haick also heard that Hippocrates, the father of medicine, had identified kidney and liver diseases by smelling patients’ breath. He decided to try to develop a system that would diagnose diseases at an early stage by detecting volatile organic compounds, or VOCs, released in exhaled breath. The idea was that each disease produced a distinctive mixture of molecules that sensitive, sophisticated sensors might be able to detect.

He planned to test his pilot system on lung cancer.

“That’s because I don’t know anything about medicine,” he says. “To Hossam the engineer, lungs seemed connected to breathing. Today I understand that it’s not that simple.”

Haick thought his biggest challenge would be developing sensors capable of detecting chemical markers of disease in breath. It soon emerged, however, that the challenge was more fundamental: There was no clear evidence that such markers existed. To establish that, he launched a large-scale study at medical centers around the world, from China to Latvia to the United States. He collected samples from patients with 17 diseases, including several forms of cancer; neurological diseases such as Alzheimer’s, Parkinson’s and multiple sclerosis; and infectious diseases. The breath samples were analyzed to determine their chemical composition.

“Using data from thousands of participants, we found that each person has a unique chemical signature of volatile organic compounds in their breath, like a fingerprint,” Haick explains. “We also found that every disease has a distinctive chemical signature that sets it apart from the others. To me, that’s my greatest achievement: proving that there’s a scientific basis underlying Hippocrates’ approach.”

At the same time, Haick developed an electronic nose – a portable device combining sensors and artificial intelligence that can analyze a person’s breath and detect early markers of disease. “At first, it was a meter and a half long,” he says. “We gradually made it smaller.”

One of Haick’s first partners in developing the sensors was Silke Christiansen, a physicist at the Free University of Berlin.

“I’ve known Hossam for about 15 years,” Prof. Christiansen tells Haaretz. “He contacted me in 2009, saying, ‘I’ve read your work about silicon nanowires. We need those. I have an idea for a sensor. We’ve tried many things, and these nanowires would be the best.’ Then we started a collaboration. We produced the nanowires, and he did the rest: arranged them in sensor arrays and functionalized them.”

The sensors are based on densely packed nanowires with various mol-

ecules attached to their surfaces. These act as chemical coatings, each causing a nanowire to respond slightly differently to substances in the air. This produces a range of responses across the sensor array. The resulting pattern makes it possible to identify the VOCs present in the breath.

“I probably haven’t met many people as excited about what they’re doing, but also as driven and hardworking,” Christiansen says of Haick. “His vision was impressive from day one. He’s one of the most innovative people I’ve ever met. Nowadays, people work a lot more with data, and everybody has heard about AI. Back then, it was breathtakingly different. It was innovation on a different level.”

“The sensors Haick developed can detect the presence or absence of particular molecules in exhaled breath,” says Prof. Tal Dvir, who researches tissue and organ engineering at Tel Aviv University. “That’s an especially complex task because their concentrations in the body are extremely low. Detecting a specific molecule in a huge mixture of other molecules requires overcoming background noise and masking effects. Each sensor is tailored to a particular target molecule, and he has developed sensors for a range of applications.”

The patch is still under development, but the health-monitoring revolution is underway, using available devices such as smart rings and watches. One researcher advancing it is Prof. Snyder, who practices what he preaches, or rather, wears it.

During a visit to one of his Technion laboratories, Haick shows me the latest electronic nose device – about the size of a hand. “The device is about 88 percent accurate – comparable to, and in some settings better than, standard imaging,” he says. While it can already identify 17 diseases, so far it has received Breakthrough Device designation from the U.S. Food and Drug Administration for only two: lung cancer and advanced liver fibrosis unrelated to alcohol consumption, a condition that is a major risk factor for cirrhosis, liver cancer and heart disease.

“It’s a lengthy process that takes several years,” the professor notes, with respect to regulatory approval.

The device is currently being used experimentally in hospitals around the world to diagnose those two diseases. Studies have already shown that it can identify lung cancer at an early stage, when the tumor may still be localized, sometimes before any clear symptoms appear. A laboratory study showed that it could even detect small numbers of cancer cells in blood.

Early trials were also conducted for a rare disease that is extremely difficult to diagnose: pulmonary arterial hypertension. Sylvia Cohen-Kaminsky, a specialist in the disease at Paris-Saclay University, took part in the trial.

“Diagnosis is often delayed by several years because it requires hospitalization and catheterization,” Prof. Cohen-Kaminsky she tells Haaretz. “There is currently no cure, and patients die an average of three years after diagnosis.”

Cohen-Kaminsky says she first learned about Haick while reading an article about his research in Le Monde on a beach in France. “I met him, and when I suggested applying it to pulmonary arterial hypertension, he immediately said, ‘Yes, let’s do it.’”

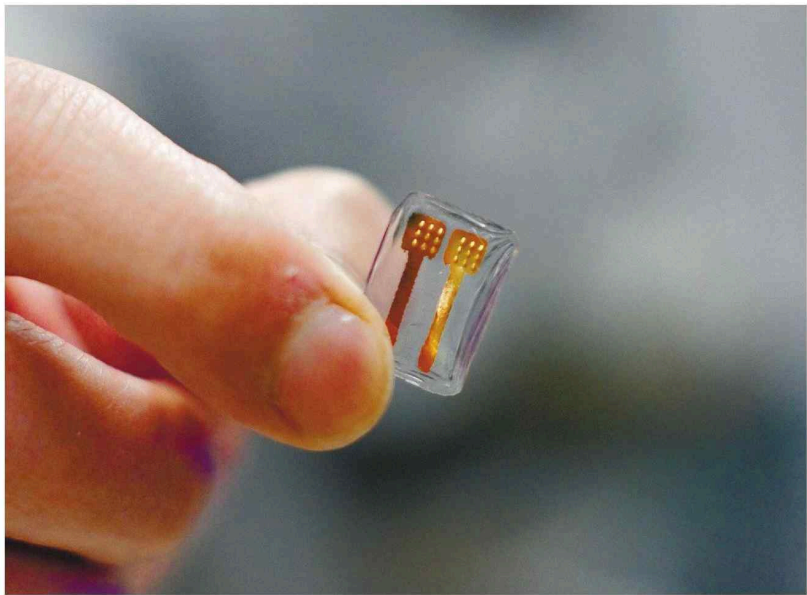
The two researchers established an international laboratory that operated for eight years. The initial results, Cohen-Kaminsky says, were remarkable: The electronic nose could distinguish between patients and control participants and identify those carrying a genetic mutation that increased their susceptibility to the disease.

The researchers did not receive follow-up funding, so their work has yet to progress beyond yielding those promising initial results.

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Nir Peled, head of oncology at Jerusalem's Shaare Zedek Medical Center and chairman of the Israeli Lung Cancer Foundation, is working with Haick to develop sensors that can precisely characterize lung cancer cells at the molecular level. Prof. Peled says their system can identify both the response to treatment and disease progression faster than other clinical methods.

“We’ve expanded its use to several types of cancer and other parts of the world,” he notes. “In other words, we’ve shown that the technology works across cultures and can filter out local influ-



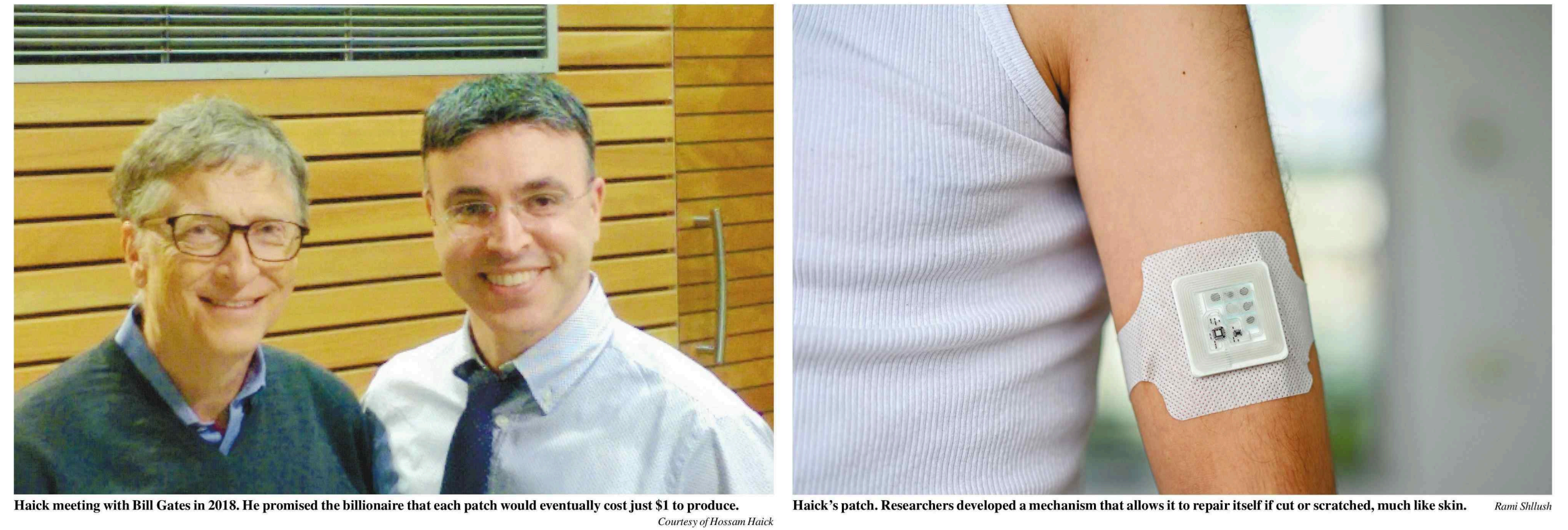
Sensors embedded in a patch developed by Haick at the Technion. “Within a few years we’ll see commercial use of patches capable of detecting lung cancer, tuberculosis and hormonal changes in women.”

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ences on volatile compounds, including differences in diet.”

Peled explains that for each cancer, researchers need to identify a signal indicating early-stage disease, another reflecting more advanced disease, and signals indicating the response to treatment. Such information is currently available, he says, for seven common cancers: lung, breast, stomach, colorectal, head and neck, ovarian and kidney cancer. “The vision is for the system to be an inexpensive, accessible and accurate tool, but introducing new things takes a long time in medicine.”

For his part, Jonathan Sleeman, a cancer biology researcher at Heidelberg University, tells Haaretz that Haick’s sensors offer a way to tap a rich reservoir of biomarkers that has barely been used until now. Clinical validation of the technology, he says, is likely to be a lengthy process requiring large groups of patients. One question is whether the VOC signals are sufficiently specific, since several disease states could produce the same positive result. Prof. Sleeman is currently participating in a trial designed to test the new approach.

“Haick is an excellent scientist and he has a big vision,” he says. “The arguments he presents are compelling, but that has to be shown in the real world, and that’s where we’re going.”

Innovative as it was, Haick did not stop at the electronic nose. His next goal became clear during a taxi ride from Mumbai’s airport.

“I passed through a very poor area, where people live with almost no infrastructure,” he recalls. “I thought: How can the electronic nose help them if there’s no reliable electricity here? And more importantly, how can we help them monitor their health at a price they can afford when they live on less than a dollar a day?”

Haick racked his brains, then had a eureka moment: Could the organic compounds released in breath also be emitted through the skin? His team set out to test the hypothesis and found that VOCs released through the skin could indeed be measured and analyzed.

Laboratory engineer Walaa Saliba shows me the next generation of monitoring technology. He places a small patch, four centimeters by four centimeters, on my arm. It contains electrical circuits and six tiny sensors that continuously pick up substances released by my skin and transmit the data to a phone app.

“The product monitors you all the time and compares your readings with statistical databases of people with and without a range of diseases,” he says. “If it detects a shift toward illness, it sends an alert.”

The patch is still under development, but the health-monitoring revolution is already underway, using readily available devices such as smart rings and watches. One of the researchers advancing it is Prof. Michael Snyder of Stanford University. Snyder practices what he preaches, or rather, wears it: He has no fewer than nine watches, rings and sensors on his body. During a video call with Haaretz, he turns his left cheek toward the screen to reveal the latest addition: a small metal sensor called Temple, attached to his temple and monitoring his small blood vessels.

“I look like a cyborg,” the professor says with undisguised delight.

Snyder’s laboratory uses AI to analyze vast amounts of data from participants wearing all sorts of devices, looking for signs of health and disease. Devices currently on the market measure heart rate, heart rate variability, blood oxygen levels, blood pressure, respiratory rate, the skin’s electrical conductance and sleep patterns. Snyder is already using the data to detect infectious diseases, respiratory viral infections and abnormal heart rhythms, including atrial fibrillation, at an early stage. A new line of research involves identifying markers of mental health problems: anxiety, depression and stress.

What would you recommend that an ordinary person, someone who isn’t a tech geek, do today?

“You need to get a glucose monitor. You put it on your shoulder as a patch. They’re very powerful. You’ll never eat the same again, and I mean that in a good way. We’ve run studies showing that if you wear one of these devices, you’ll improve your eating habits within 10 days because it’s real-time feedback.”

Snyder notes that about 40 percent of U.S. adults have prediabetes, and 80 percent of them do not know it. Because most people with prediabetes will develop diabetes, identifying problems with glucose regulation early is important. He hopes that in 10 years, everyone will wear one or two of these devices to monitor physiological measures and perhaps take biochemical measurements too. “There are a lot of people working on trying to measure some of these things continuously,” he explains.

Back to one of those researchers. The first disease Haick’s patch diagnosed was tuberculosis, the world’s deadliest infectious disease, which particularly affects populations in countries with limited access to advanced diagnostic tools. Haick received funding from the Bill & Melinda Gates Foundation. He says Gates himself took a personal interest in the project, apparently because the patch was easy to use and Haick promised an extremely low manufacturing cost: \$1 per patch. So far, the team has managed to develop a patch costing \$1.50.

The patch was tested on about 2,000 people in India, South Africa and Latvia, achieving approximately 90 percent accuracy in detecting active tuberculosis compared with a control group. It achieved similar results in detecting latent tuberculosis, which has no symptoms but can develop into active disease.

One problem was that the patch was so thin it could be cut or scratched. Haick came up with a solution: patches that would repair themselves when damaged or malfunctioning, just as skin does. The researchers developed a polymer whose chains are connected by chemical bonds that allow them to reconnect after the material is cut.

“As soon as there’s a cut, the molecules on either side can bond with each other again. They do it on their own in about 30 seconds, without heating, ultraviolet radiation or any other external stimulus,” Haick explains. “That alone accounts for a lot of patents.”

In total, he says, his laboratory has already generated nearly 100 registered patents.

“We already have all the components of the technology: the sensors, the algorithms for processing the information and the material’s ability to heal itself,” he adds. “The patch already exists, it costs a little over a dollar to manufacture, and it keeps working for months. Now we need to test its performance in real-world conditions and demonstrate that it can reliably identify diseases.”

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Having demonstrated the technology in tuberculosis, Haick is now conducting large-scale trials involving tens of thousands of people to identify the chemical signatures of a range of other diseases: malaria, COVID-19, degenerative and infectious diseases, and several cancers. The trials are being conducted through EU-funded consortia involving numerous partners, including laboratories, hospitals and commercial companies. Haick will soon complete one such lung cancer trial involving 5,600 participants and 20 research partners, funded by a grant of 14.8 million euros. Another consortium, with 3,700 participants, 18 partners and a budget of 8 million euros, is working on early detection of schizophrenia.

“We’re monitoring a population experiencing psychosis for a year and a half to three years to identify initial signs before the disease develops,” the professor explains. “The earlier schizophrenia is treated, the more its progression is slowed.”

A few days before our meeting, Haick was notified that he had won another consortium grant of 8 million euros, this time to detect Parkinson’s, with 6,000 participants and 20 partners. “We know that detecting Parkinson’s and administering medication in its early stages can ease the symptoms,” he says.

The disease results from a combination of environmental and genetic factors. Exposure to pesticides, pollutants and certain metals may play a role in its onset. The researchers will monitor participants at risk of Parkinson’s, such as farmers exposed to pesticides over long periods, who are known to have high rates of the disease. They will use a two-sided patch: One side faces the body, while the other monitors the environment.

Over the past five years, Technion researchers have won six grants to lead consortia, three of them headed by Haick. According to Israel Innovation Authority figures, Israeli researchers received 58 such grants in total during those five years. Before that, Haick led another five successful consortia, studying colorectal cancer, melanoma and lung diseases, among other conditions.

Haick: ‘If the patch detects a signal indicating a risk of Parkinson’s, for example, we could attach a tiny cartridge containing a drug to slow the disease’s progression. It would work for many diseases, you’d just configure the cartridge.’

“Applications have a success rate of 2 to 3 percent,” he says. “Leading a consortium means developing a scientific vision, securing funding and bringing together many researchers to realize it. Behind every successful grant application are countless hours of work, conferences and meetings.”

Can you distill your vision?

“The goal is personalized, precise, noninvasive medicine. All these technologies together will tailor diagnosis to the individual, taking their body and their environment into account.”

If that vision is realized, anyone will be able to attach an inexpensive patch to their body that continuously monitors physiological and chemical signals and detects changes in their health – from fatigue and dehydration to a viral infection or early signs of cancer or Parkinson’s. The vision does not end with diagnosis. Haick wants to turn the patch into a complete medical system that can also deliver tailored treatment and track its effects.

“The patch will build an ongoing picture of a person’s health,” he explains. “If, for example, it detects a signal indicating a risk of Parkinson’s, we could attach a tiny cartridge containing a drug to slow the disease’s progression. It would work for many diseases, and you’d configure the cartridge according to the signal indicating the risk.”

Such targeted drug delivery would also allow more precise adjustment of the dose and treatment duration, reducing the risk of side effects.

“Today, a drug may treat the problem it was prescribed for while also affecting healthy organs and tissues,” Haick says. “I saw firsthand the treatments my late father received in the hospital, and that experience brought home to me the need for more precise, personalized treatment. Many treatments today follow a uniform, predetermined protocol, even though not all patients respond the same way. If we can measure how effective a treatment is in real time, we may eventually be able to give each person the treatment that is exactly right for them. We’ve tested the principle in animal experiments, and the initial results were very promising.”

Is there anything that could stop you?

“The technology’s main building blocks have already been developed and demonstrated. We’re there. This isn’t science fiction. I estimate that within a few years we’ll see commercial use of patches capable of detecting lung cancer, tuberculosis and hormonal changes in women.

“Realizing the full vision will take longer. First, we’ll need extensive clinical validation. Then we’ll have to navigate regulation, adapt the technology for industrial production and bring it to market. At the end of that process, I believe we’ll have a patch that simultaneously monitors markers from the body and environmental risk factors that could affect the development of diseases, and protects us against them.”