Exhibition Discovering science in Africa

Nanotechnology in Egypt

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Voyage-partage.fr

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PRESS CONTACTS

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Exhibition Discovering science in Africa

Nanotechnology in Egypt

A million times smaller than a millimeter, this is the size of the nanomaterials that Egyptian researchers work on. Graphene nanotubes, medical nanosensors, nanoparticles and nanowires are some examples of the many structures used in the composition of the latest generation products, from ultra-light tennis rackets to high efficiency photovoltaic panels, as well as cancer treatments.

Far from the stereotypes that reduce Africa to poverty, disease and war, researchers are leading cutting-edge work here, particularly in nanophotonics, the study of the interaction between light and matter on a nanometric scale. This exhibition aims to introduce you to nanotechnologies, and more specifically nanophotonics, through the words of Egyptian researchers and paints a picture of research here in Egypt.

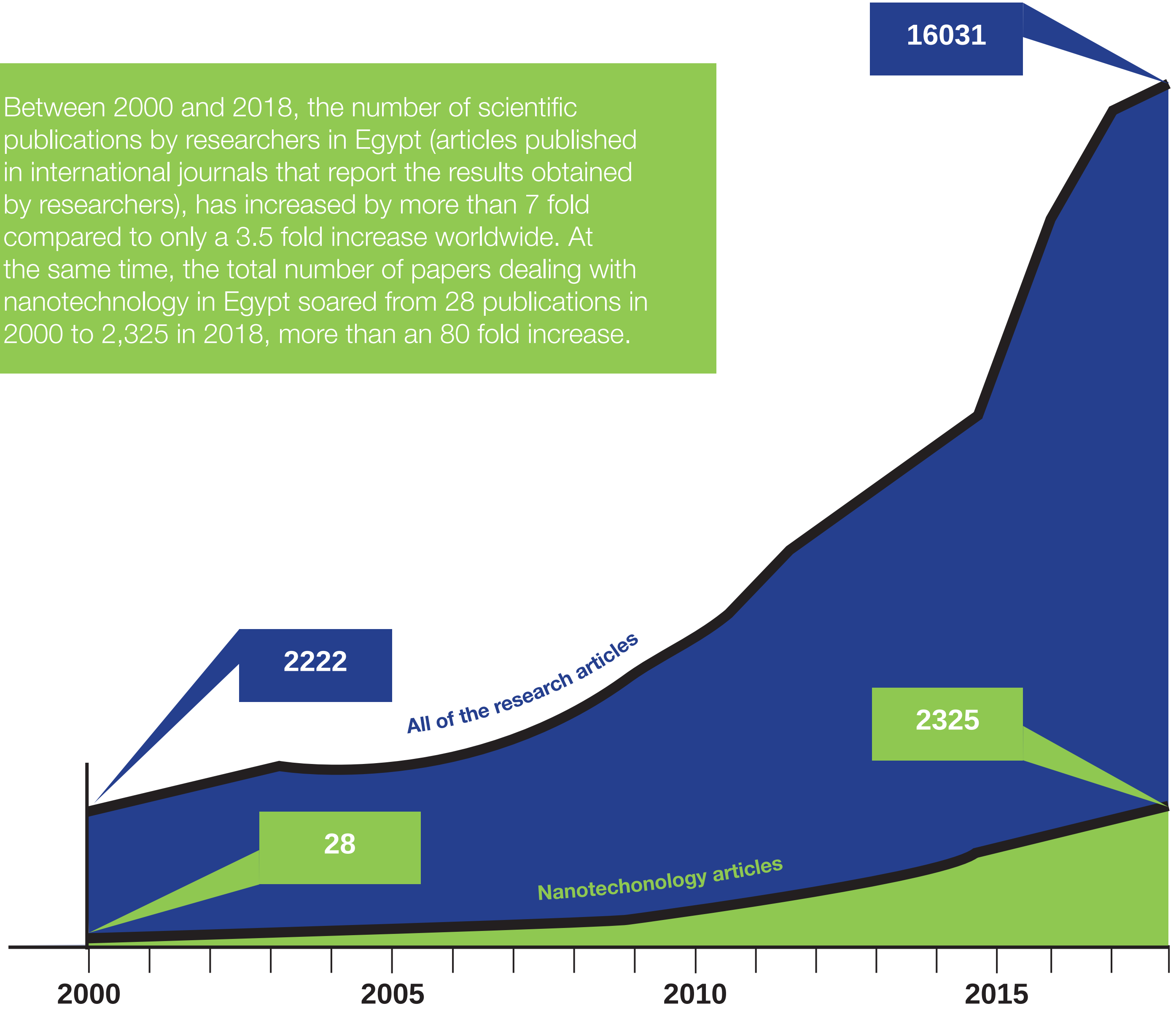
> **“Egypt ranks 30th worldwide in terms of publications of scientific articles (ISI web of knowledge)”**

This exhibition, presented in Cairo from April 22nd to June 30th 2019 in the French institute of Egypt, was created as part of the project Voyage-partage initiated by Taïna Cluzeau. It as been supported by the French association Fais ta science! with the aim of raising public awareness of scientific work in Africa. It was made possible thanks to the support of the French embassy in Cairo, the French Institute of Egypt and the Center for Photonics and Smart Materials in Zewail city. www.voyage-partage.fr

Exhibition route

The exhibition is divided into three parts. The first presents the recent evolution of scientific research in Egypt, the second a portrait of Egyptian researchers and the last, carried out in collaboration with researchers at the Photonics and Smart Materials Center of Zewail city, explains to the public what is nanophotonics, this field of nanotechnologies consisting of the study of the interaction between light and matter.

Between 2000 and 2018, the number of scientific publications by researchers in Egypt (articles published in international journals that report the results obtained by researchers), has increased by more than 7 fold compared to only a 3.5 fold increase worldwide. At the same time, the total number of papers dealing with nanotechnology in Egypt soared from 28 publications in 2000 to 2,325 in 2018, more than an 80 fold increase.

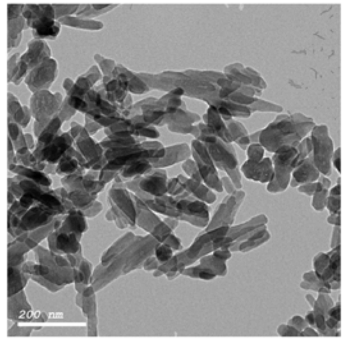


Egypt's Advances in Nanotechnology

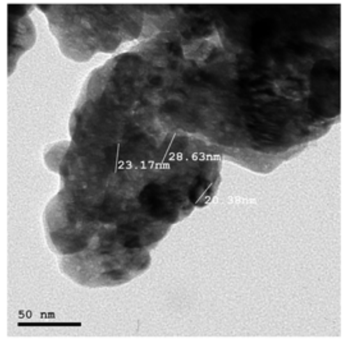
Solar panels, water purifiers and virus detectors are a few examples of the many applications Egyptian researchers have been able to develop and improve by taking advantage of nanotechnologies. This science allows, by manipulating atoms and molecules at a nanoscale (a million times smaller than a millimeter), the modification of the properties of different materials, such as color, strength, hardness, electrical conductivity , elasticity and heat tolerance.

In Egypt, nanoscience research is benefiting from recent government investment to develop science in the country. The constitution adopted in 2014 makes mandatory the investment of 1% of GDP for research and development. Even if this amount is not yet totally achieved, Egypt has nevertheless experienced in 2018 the second largest increase in terms of publications of scientific research articles worldwide, with a 15.9% increase compared to 2017 according to the scientific journal Nature. In addition to supporting researchers' innovation and in order to make the Egyptian economy more competitive, it is also necessary for the research to meet the needs of national industry, which to date has relied a lot on foreign expertise. The nanotechnology sector will certainly be one of the areas that will pave the way for cooperation between research and industry.

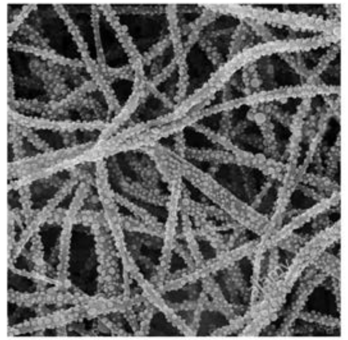
> **"The state guarantees the freedom of scientific research and encourages its research institutions as a means towards achieving national sovereignty and building a knowledge economy that supports researchers and inventors. (Article 23)"**



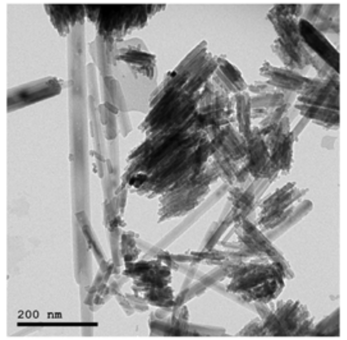
hydroxyapatite
Application :
dental repair



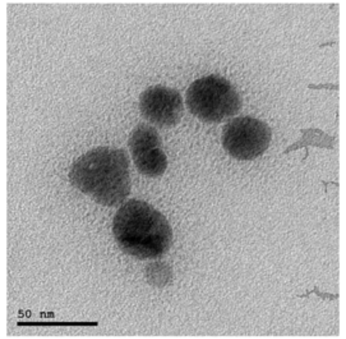
Copper oxide
Application :
chemical sensors



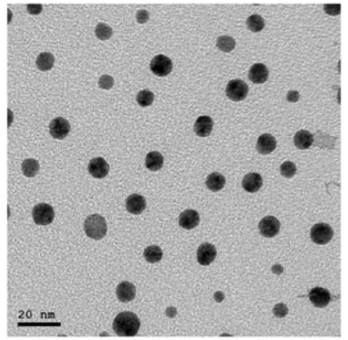
Nanowires



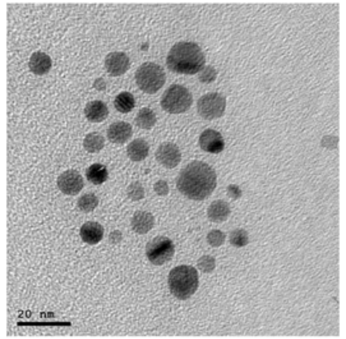
Hématite **الهيماتيت**
Applications : التطبيق
conductivité thermique التوصيلية الحرارية



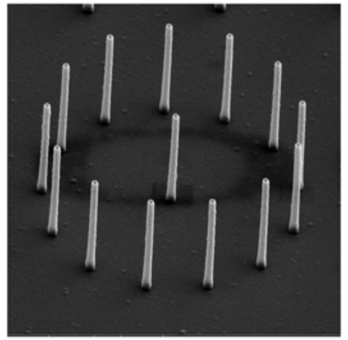
Selenium
Application :
Plant nutrition



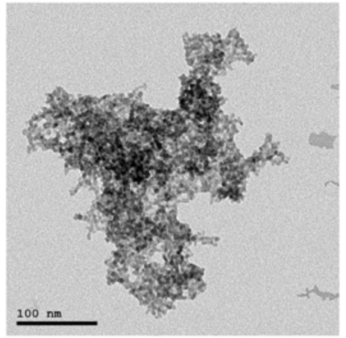
Gold
Application :
medicine against cancer



Silver
Application :
antibacterial agent



nano antenna



Cadmium selenide
Applications:
photovoltaic panels

Some of the latest Egyptian nano-inventions:

DNA fixer 2015

With a solution of nano-hydroxyapatite (hydroxyapatite is the mineral that makes up 60% of our bones), it is possible to repair damaged strands of DNA

Resistant dye 2016

Fixing nanoparticles improves the capacity of a dyeing pigment to stick to a textile

Waste water purifier 2017

Some nanoparticles are able to absorb heavy metals and are used to clean up wastewater.

Virus Detector 2018

By aggregating around the hepatitis C virus, gold nanoparticles modify the color of a blood sample to blue thus highlighting the presence of the virus.

High efficient solar panel 2018

Thanks to the insertion of nanogrids into the layers of a solar panel, the light stays trapped longer and produces more electricity.

NanoTech Focus

NanoTech is one of the still very rare Egyptian companies that combines production with research & development. Moreover, this company of about thirty people including 10 researchers, founded in 2009 by the industrial Ahmed Bahgat and the researcher Mona Bakr, has its own laboratory to develop and improve its nanoparticles and sells its products both to research centers and to Egyptian industries. Agriculture, medicine, energy, environment, and construction, are among the, different industrial sectors that NanoTech attempts to convince of the relevance of nano-technologies, for example, whether to filter and eliminate more effectively pesticides, to add additives in animal food, or to develop more resistant paints.

Research centers and universities

There are currently more than twenty research centers in Egypt, including the recent Egypt Nanotechnology Research Center. In addition, 16 new universities have been created in Egypt since 2009, bringing their number to 50 and thus helping achieve the government's «Egypt Vision 2030» sustainable development strategy. By 2030, there should be 64. Cairo University President Mohamed Othman al-Khasht also announced, in January 2019, the forthcoming creation of a new Faculty for Nanotechnology, the second in this area after the Faculty of Nanoengineering in Zewail city.

National Research Center

This was established in 1956 as an independent public organization for the purpose of «promoting pure and applied scientific research. It publishes the most articles on nanotechnology in Egypt. (313 in 2017)

The Egyptian Petroleum Research Institute

Created in 1974 to provide the national oil industry with scientific research. France contributed to its construction by providing some of its scientific equipment.

The Egyptian Atomic Energy Authority

Founded in 1957, it conducts research to develop applications based on nuclear technology in the fields of agriculture, industry, health, environment, etc.

Cairo University

Cairo University opened in 1908. With more than 150,000 students, it publishes the most science articles in Egypt and the most articles on nanotechnology after the NRC (282 in 2017)

> **With more than 20% of the scientific publications in Africa, Egyptians are, along with South Africans (30%), leaders of research on the continent.**

Egypt's portrait

Capital: Cairo

Population: 97.55 million (2017) including 19.5 million in Cairo

Number of Egyptians living abroad: 9.5 million (2016)

Egypt's population under 25 years old: 52.23% (2017)

Economic growth: 4.18% (2017)

Countries that collaborate with Egyptian researchers

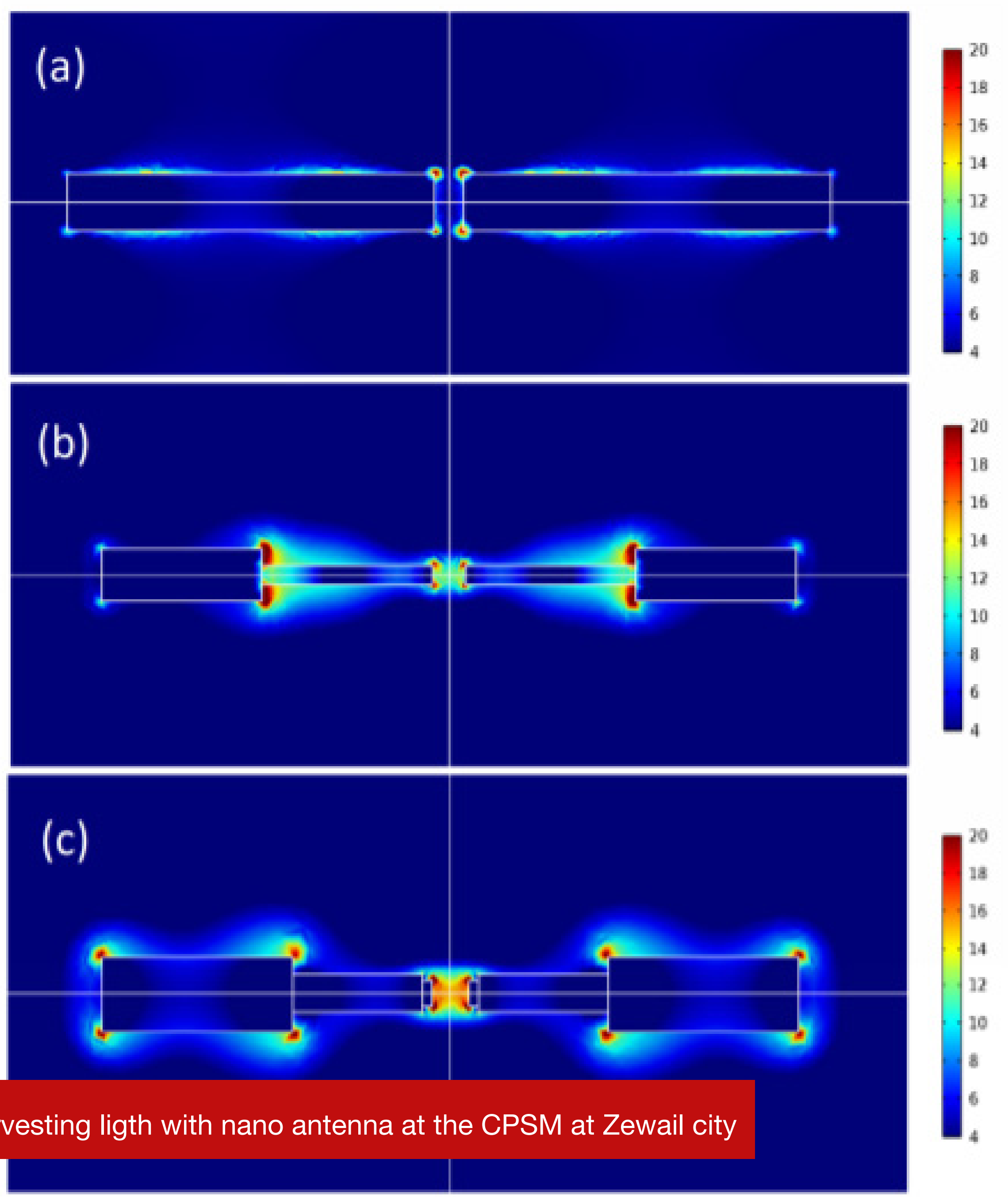
Top 10

1st	2nd	3rd	4th	5th
Saudi Arabia	United States	Germany	UK	Japan
6th	**7th**	**8th**	**9th**	**10th**
Canada	China	France	Italy	India

> **44% of publications (2011-2016) are based on international collaborations**

Imhotep Focus

Since 2005, through the « Imhotep » Hubert Curien program, France has invested more than €1.7 million in 191 projects of collaboration between French and Egyptian researchers, including more than €180,000 for 19 nanotechnology projects. Egypt has steadily increased its participation in this program and in total has dedicated 8 millions egyptian pounds. France also supports young Egyptian researchers, doctoral and postdoctoral researchers, by offering scholarships for stays of 6 to 12 months in France. In 2016, of the 271 Egyptian researchers who obtained a doctorate abroad, 11 obtained it in France.



Research on harvesting ligth with nano antenna at the CPSM at Zewail city

Researchers' portrait : Studying nanotechnology in Egypt

What is the life of a scientist in Egypt like? Five researchers in nanotechnology reveal to us the best and worst sides of their profession.

First contact with science

As an introduction, our researchers tell you about their first memories of science.

Dr Shaimaa Ali Mohamed, associate professor at Zewail city

The first time I knew I loved science was at high school in chemistry class. My chemistry teacher was exceptional. She let us do some simple experiments involving volcanoes, gas explosions and colored fire. It was real fun and I became curious to understand why these things were happening and that's why I wanted to keep studying chemistry. For me, studying science was much easier than any other topic at school. So it became my dream to continue my career in the field of science. I was lucky that my family supported my choice and encouraged me to follow my dreams.

Dr Ahmed Heikal, assistant professor at Zewail city

When I was a child I spent my time playing tennis and I was quite good at it. But I was involved in a car accident and so I had to stop tennis. Therefore I began to study more. I loved experimental work, especially electromagnetism and I worked on batteries and motors. I used to build small wooden cars with small motors in them. Then I took a liking to mathematics, geometry in particular. I began to make paper planes which I designed the structures for by myself. But all this doesn’t mean I was good at school. On the contrary.

Dr. Amany A. Mostafa. Head of Inorganic Chemical Industries and Mineral Resources Research Division, National Research Centre

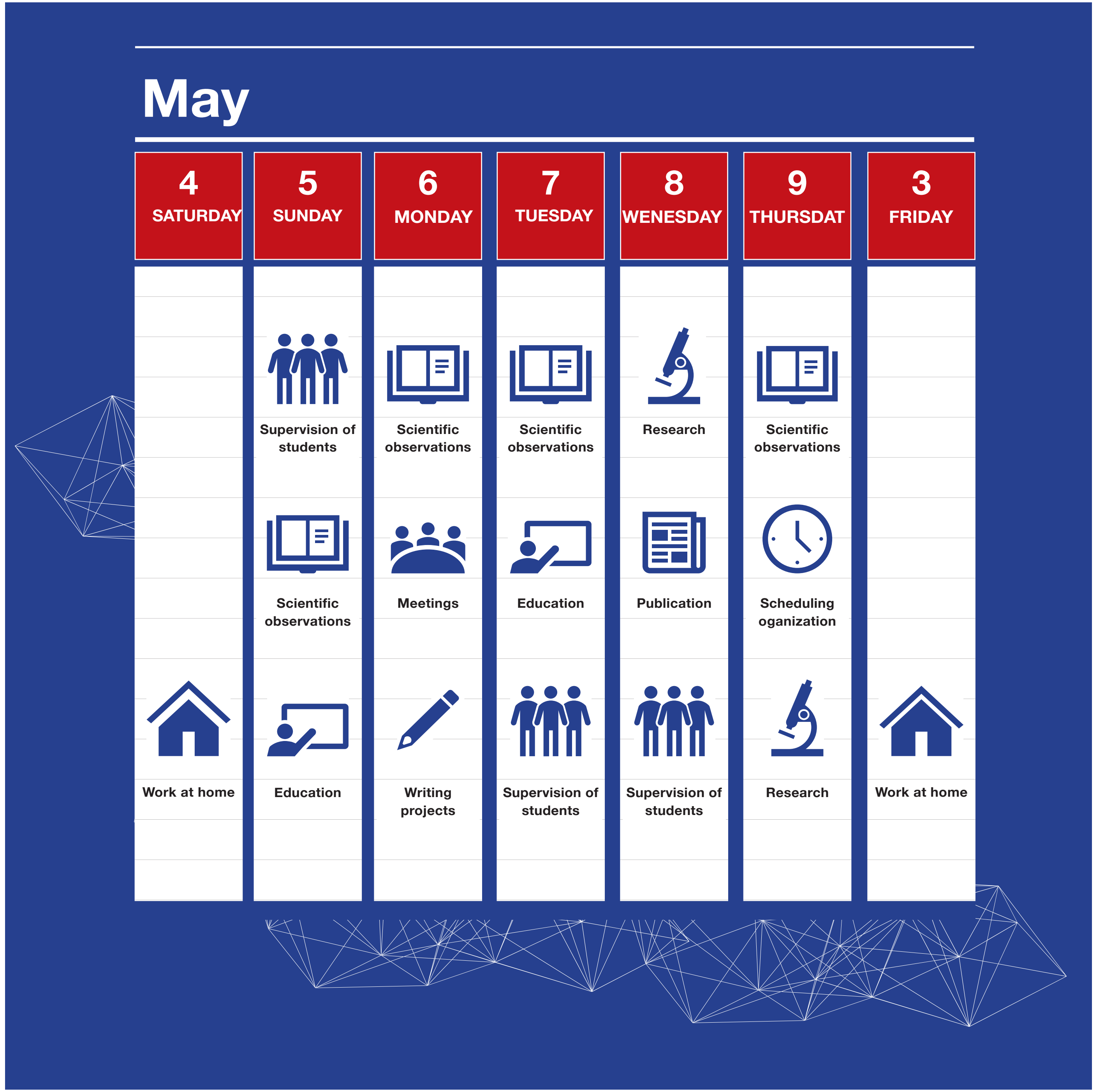
When I was a child, I was fond of study of science. I really liked science classes, laboratory experiments and exposure to different aspects of life and the environment. For example, even today, I still remember very well the biology teacher drawing all the circulatory, respiratory and digestive system on the black board. It amazed me. Many times I was selected for awards in primary and preparatory schools. I remember that my science teacher told me, « Amany you will have a great career in science when you grow up ».

Dr Mohamed Farhat Hameed, associate professor at Zewail city

My interest in science comes from my father, who taught me mathematics when I was young. He was highly qualified in mathematics and my mother also always encouraged me. Actually, today, my father is now teaching mathematics to my son and daughter while I teach them physics.

Dr Inas Kamal Battisha, Professor of solid state physics, National Research Center

As far back as I remember, I always loved maths. When I was in primary school, a private one, we had a very severe French teacher. All the class had to stand up and to and answer multiplication and division problems, such as 2 by 2, 3 by 3 or the reverse, etc.. Whoever made a mistake had to sit down and the last one standing got a small present. I liked this game a lot. However, because of this teacher I learnt to do division using the French method but when I went to college, everybody was using the Arabic method. This was a big problem for me !vv



A researcher's schedule

The work of researchers is far from being limited to scientific research. Here is a brief overview of their typical activities throughout the working week :

- Supervision of students
- Scientific observations
- Education
- Meetings
- Writing projects
- Research
- Publication
- Scheduling organization
- Work at home

Why do you remain in Egypt ?

I think it's important to do research in my own country because this way, my research publishing will help my university to get a higher rank internationally. As I studied freely from the beginning in Egypt I think it is a good idea to now repay the benefits of this free education to benefit my home country. It's important to me to work on my field in Egypt in order to find solutions to specific Egyptian problems in energy power. *Dr Mohamed Farhat*

In spite of the challenges, the great land of Egypt is inspiring, full of promise, inspiring and rewarding. The wheel of civilization started from this land and it will continue on this land. This is what I believe. *Dr Amany A. Mostafa*

I love Egypt so much. I can't leave it. I can go for 1 month, 10 days but I cannot leave my country.
Dr Inas Kamal Battisha

What is your goal today ?

Really, I dream and work hard to help contribute to the solution of national problems. I want contribute to the realization of a new Egypt as led by our president. I want my country to reap the benefits of our research and eventually even apply our results at an international level. *Dr Amany A. Mostafa*

I would like to establish my own education center in Mansoura to spread out what we have done as not all people can travel to Zewail city.
Dr Ahmed Heikal

I am not aiming just to keep publishing research articles more and more as we have already have more than 100 publications in good academic journals. Actually, every time I have published a paper I 'm happy about it for 5 minutes at most and then I have to forget it to get started on the next new idea. The main target for me is now to transfer my knowledge to my students to help them start their career. *Dr Mohamed Farhat*

What do you think about international collaboration ?

Collaboration creates bridges, super technology highways and windows for cultural and technology interactions. New ideas are very beneficial for both countries in collaboration. I have been exposed to different "schools of science", different cultures, different methods and ways of thinking. This has helped me a lot in my career. Of course we welcome expertise from outside Egypt in new areas which are demanded by our growing industry. *Dr Amany A. Mostafa*

You have to collaborate with other people because you cannot properly develop your scientific work if you just work in isolation. If you keep your ideas to yourself, you won't learn a lot. It is worth spreading your knowledge and networking with people if you want to improve your science. The greatest successful discoveries in science are always achieved by serious collaboration.
Dr Shaimaa Ali Mohamed

International cooperation is indispensable. For example, we cooperate with a lab in Malaysia to design our medical sensor for glucose concentration. We can't work in isolation from others. It's essential to collaborate with experts from all over the world in order to complete your work. It permits you to use equipment that is not available in Egypt and also to pass on some of your expertise to your collaborators. *Dr Mohamed Farhat*

Best and worst at work

The facilities

Dr Inas Kamal Battisha
We always worry about the equipment and ensuring all necessary materials are available. It is therefore difficult just to focus just on our research.

Dr Ahmed Heikal
The big challenge in Egypt now is to get competitional facilities. For example, for simulations we need to adapt the method used to reduce the data that the computer has to process.

Dr Shaimaa Ali Mohamed
Not being able to access the facilities you need is so frustrating.

The administration

Dr Inas Kamal Battisha
I always have to propose new projects to get more funds.

Dr Ahmed Heikal
Bureaucracy is really heavy. It took me 7 months to transfer from the physics and maths department to communication.

The students

Dr Mohamed Farhat
'm happy when I feel my students are satisfied with my teaching and when they graduate or publish their papers in a good academic journal.

Dr Ahmed Heikal
I like teaching how to solve problems with the techniques we developed here in our lab.

Dr Inas Kamal Battisha
I love my students as my children because thanks to them I can keep working. I am too old to work by myself for ten hours with my hands now

Dr Shaimaa Ali Mohamed
love to be able to see what "normal" people cannot see. I wish my research could change the world. And I take my teaching very seriously because transferring my knowledge will also permit my students to have an impact on the society.

The research

Dr Mohamed Farhat
The most difficult requirement to become a good researcher is to the need to keep reading about all the new developments my field. Every day I need to review new published articles to keep up to date. It takes me a lot of time.

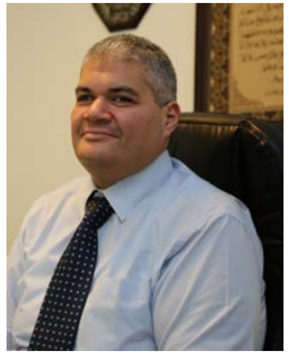
Dr Ahmed Heikal
I don't like to describe in writing the results of my work. I feel I have finished my work once I got the results, once I have solved the problem. It is enough for me to be satisfied. But I can't escape the need to get my research results published.

Dr. Shaimaa Ali Mohamed
Travelling in Africa and Europe for study exposed me to many cultures and I learned a lot about people and tolerance. It's a very good way to expand your knowledge.

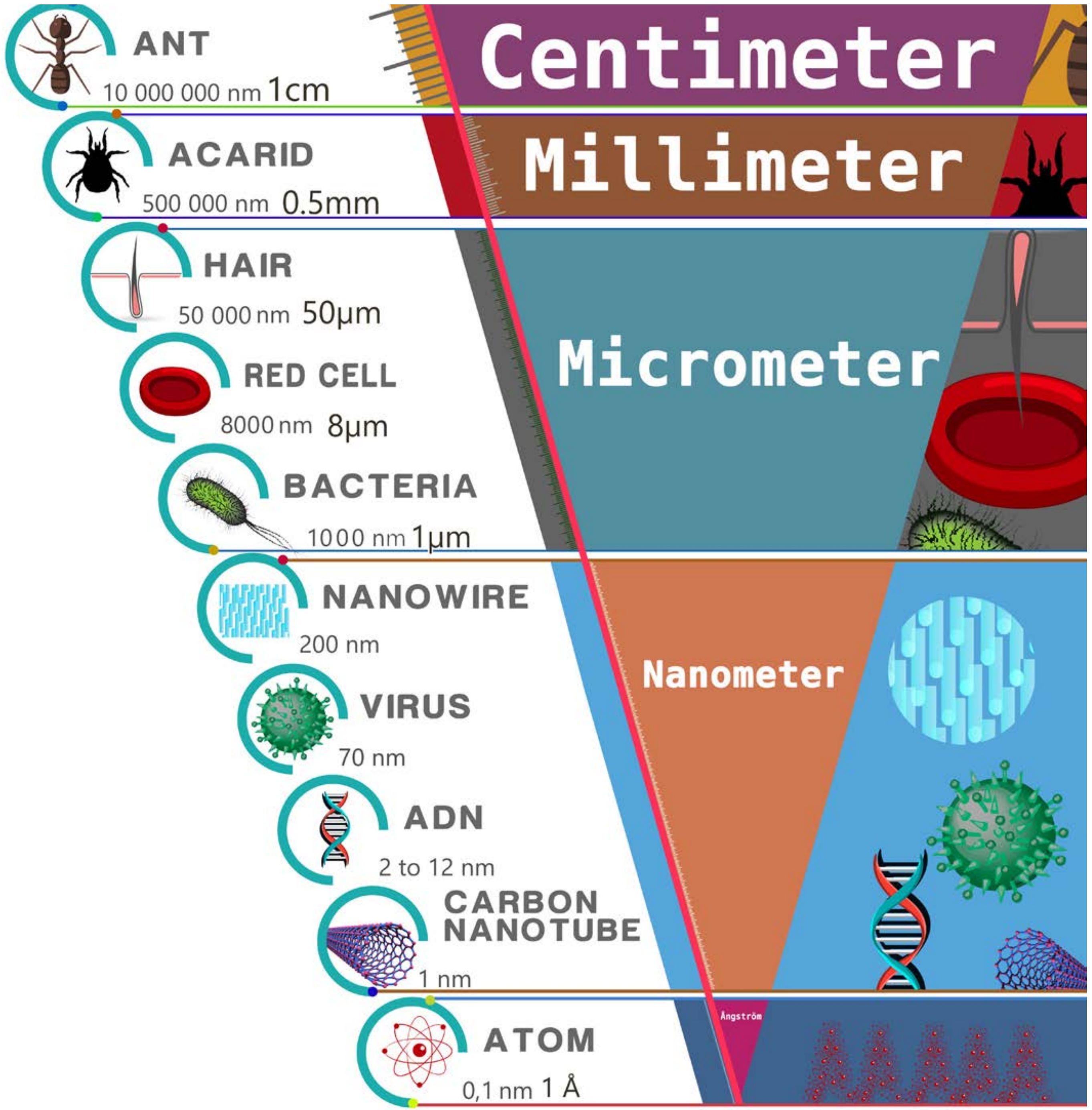
The project for Zewail City of Science and Technology was presented in 1999 by Nobel Prize laureate Ahmed Zewail, to President Mubarak. The project was eventually started in 2011, in recognition of the fact that Egypt would only be able to develop a knowledge economy if it could foster a technopreneurship culture led by projects such as Zewail's and the complex was declared a National Project of Scientific Renaissance. In April 2014, President Al-Sissi decided to allot 200 acres to the Zewail City of Science and Technology for its permanent campus in the Sixth of October city, situated about 32 km from central Cairo. Once completed, Zewail City for Science and Technology will have five constituents: a university, research institutes, a technology park, an academy and a centre for strategic studies. (Source UNESCO Science Report: Towards 2030)

Between light and matter: nanophotonics explained by Egyptian researchers

Nanophotonics is the study of the interaction between light and matter at nanoscale, an extremely small scale. Although this exotic name can make you think of some science fiction novel, nanophotonics is actually a booming research area. It started to be investigated in the early 1990's and has the potential to improve our everyday life with its many applications. In fact, knowing how light and matter interact together at nanoscale scale allows researchers to create all type of nano devices, including the trapping light solar cells, sensors deducing gas concentration from light reflection and new methods of encryption. The advances made in nanophotonics research, especially by Egyptian teams like the Center for Photonic and Smart Materials, impact directly on the development of solutions for specific Egyptian problems such as the construction of cheap solar cells or the design of nanosensors to measure glucose concentration in diabetic patients. The team from the Zewail Center for Photonic and Smart Materials explain to you what nanophotonics is and how it works in their answers to the questions below.



Prof. Salah Obayya, Director of the Center for Photonics and Smart Materials

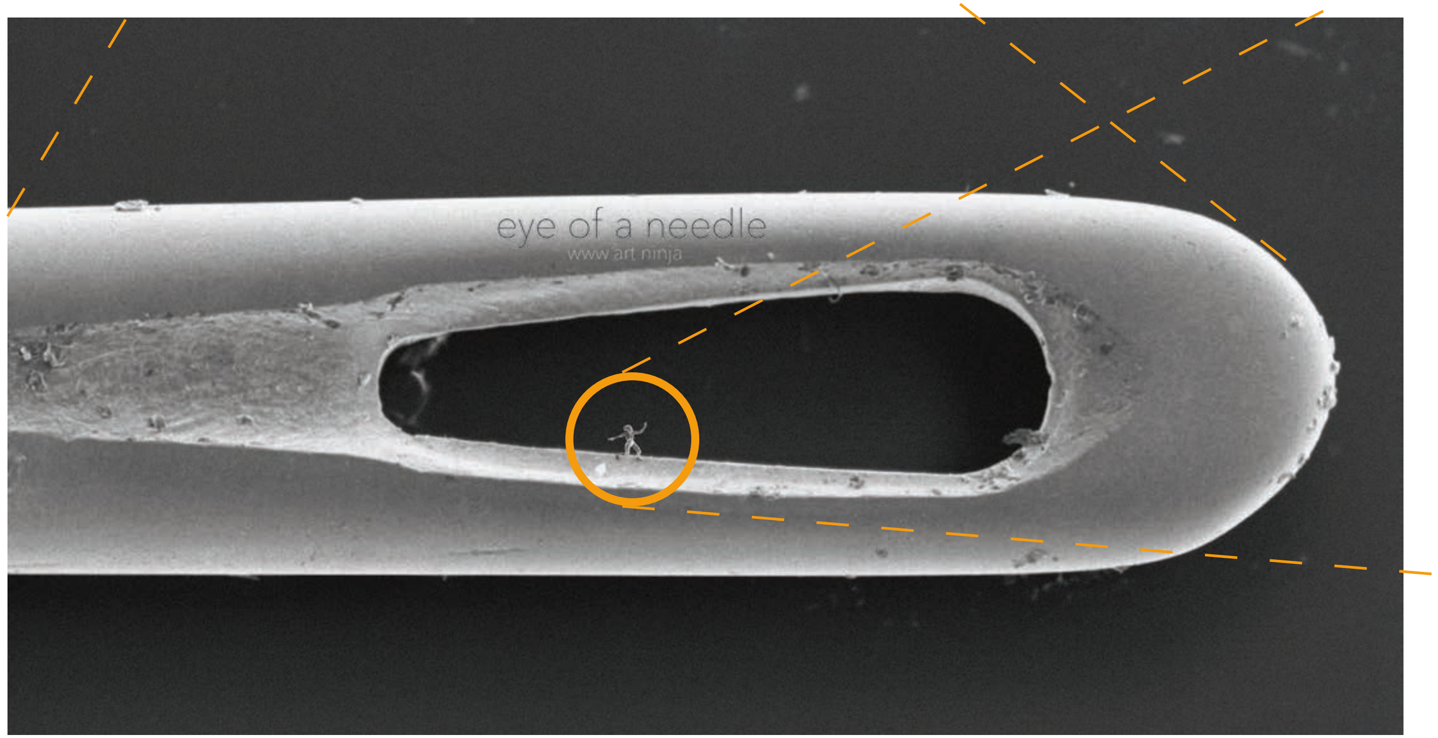


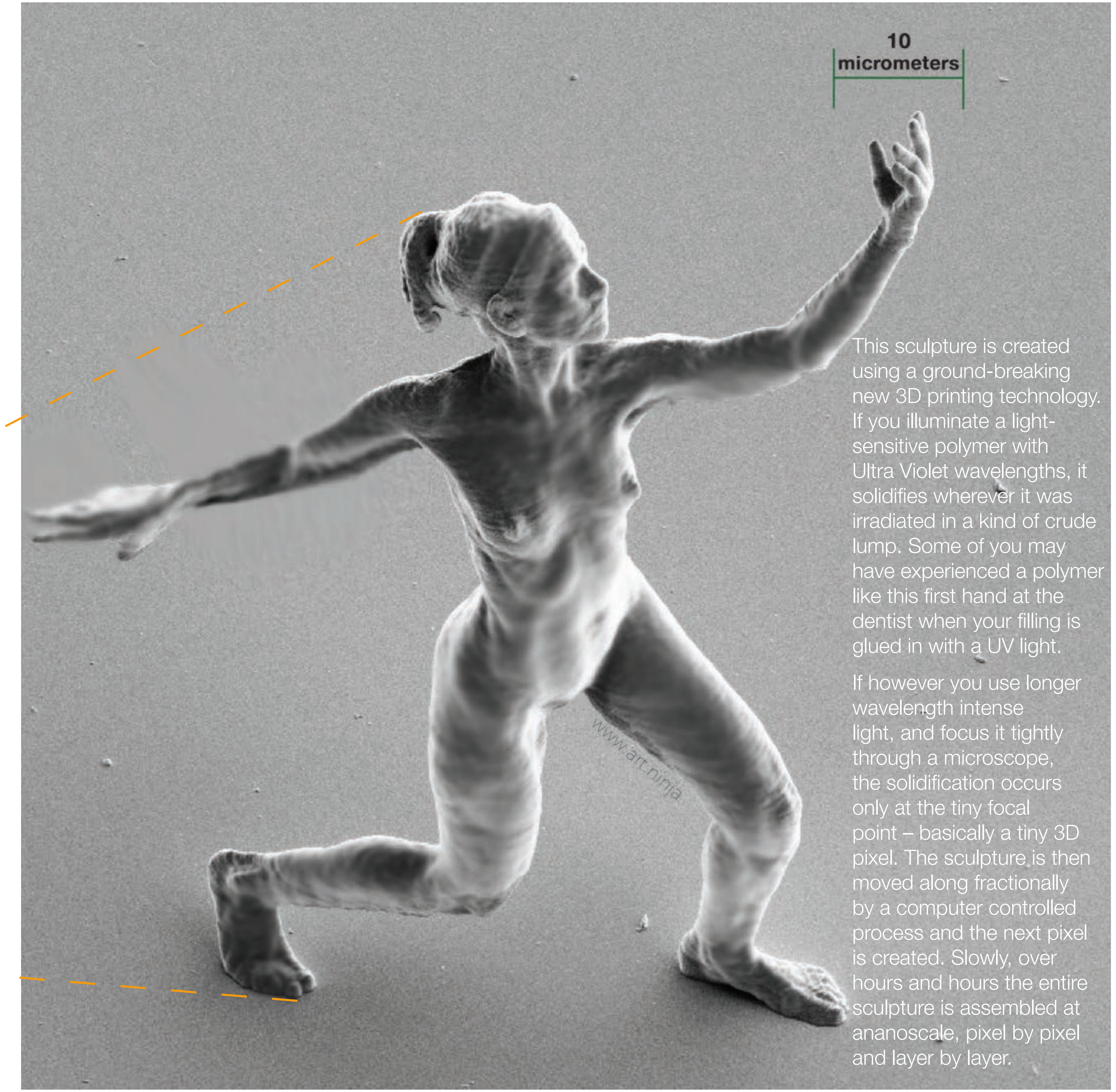
How big is a nanometer ?

A nanometer is one billion time smaller than a meter or one million times smaller than a millimeter. If a nanometer was the height of a person, at that scale an atom would be the size of a tennis ball and a 1 cm coin would be the size of the Earth. Most of the time, researchers in nanophotonics study structures of matter measuring hundreds of nanometers but can even work on dimensions down to few nanometers.

One nanometer, it is the diameter of one hair from this sculpture, standing in the eye of a needle. This artwork has been registered as a Guinness world record (2015) for the smallest sculpture of a human and has the dimensions : 80, 100, 30 micrometers.

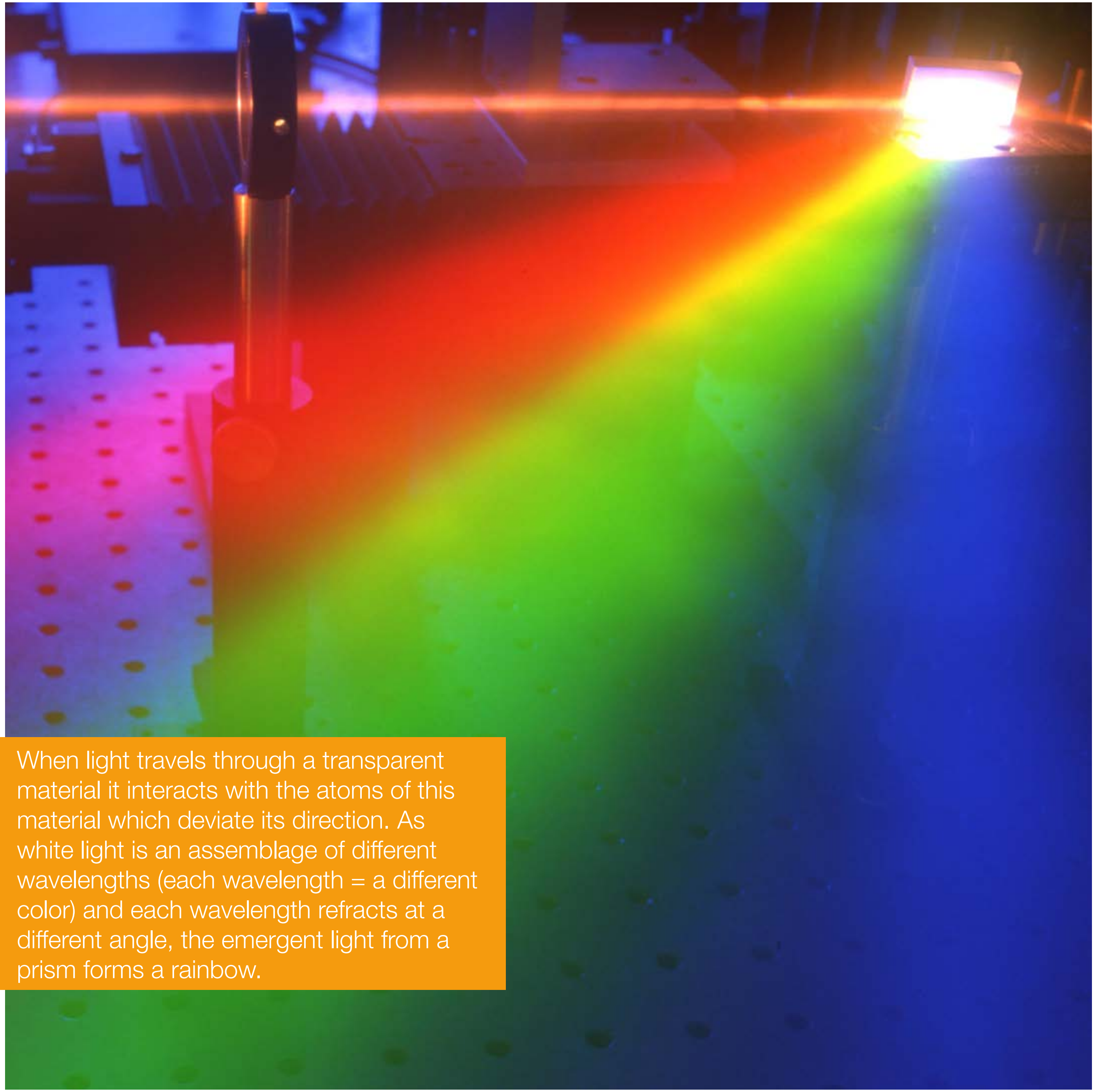
Jonty Hurwitz is a South-African artist. He has worked as a full-time researcher at the University of Cape Town and started producing sculpture in 2009. www.jontyhurwitz.com





This sculpture is created using a ground-breaking new 3D printing technology. If you illuminate a light-sensitive polymer with Ultra Violet wavelengths, it solidifies wherever it was irradiated in a kind of crude lump. Some of you may have experienced a polymer like this first hand at the dentist when your filling is glued in with a UV light.

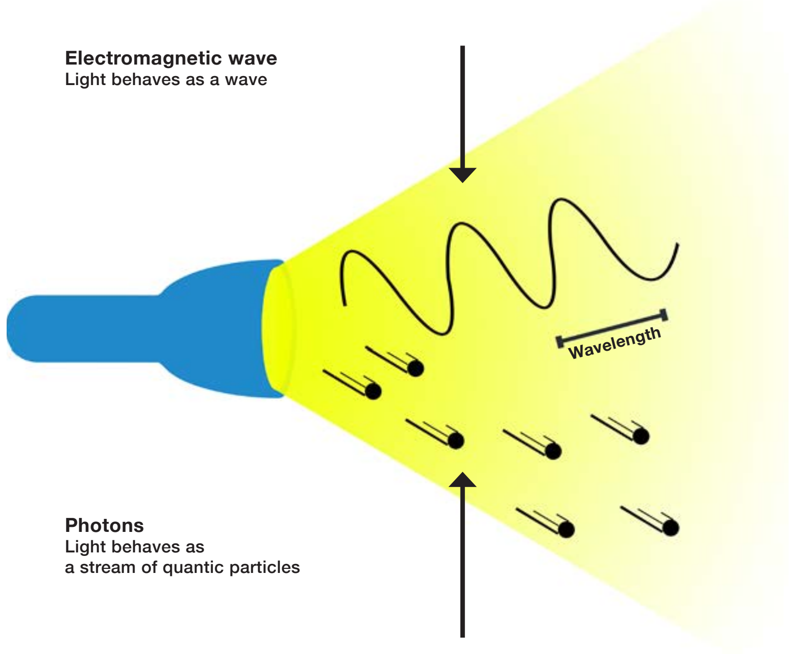
If however you use longer wavelength intense light, and focus it tightly through a microscope, the solidification occurs only at the tiny focal point – basically a tiny 3D pixel. The sculpture is then moved along fractionally by a computer controlled process and the next pixel is created. Slowly, over hours and hours the entire sculpture is assembled at ananoscale, pixel by pixel and layer by layer.

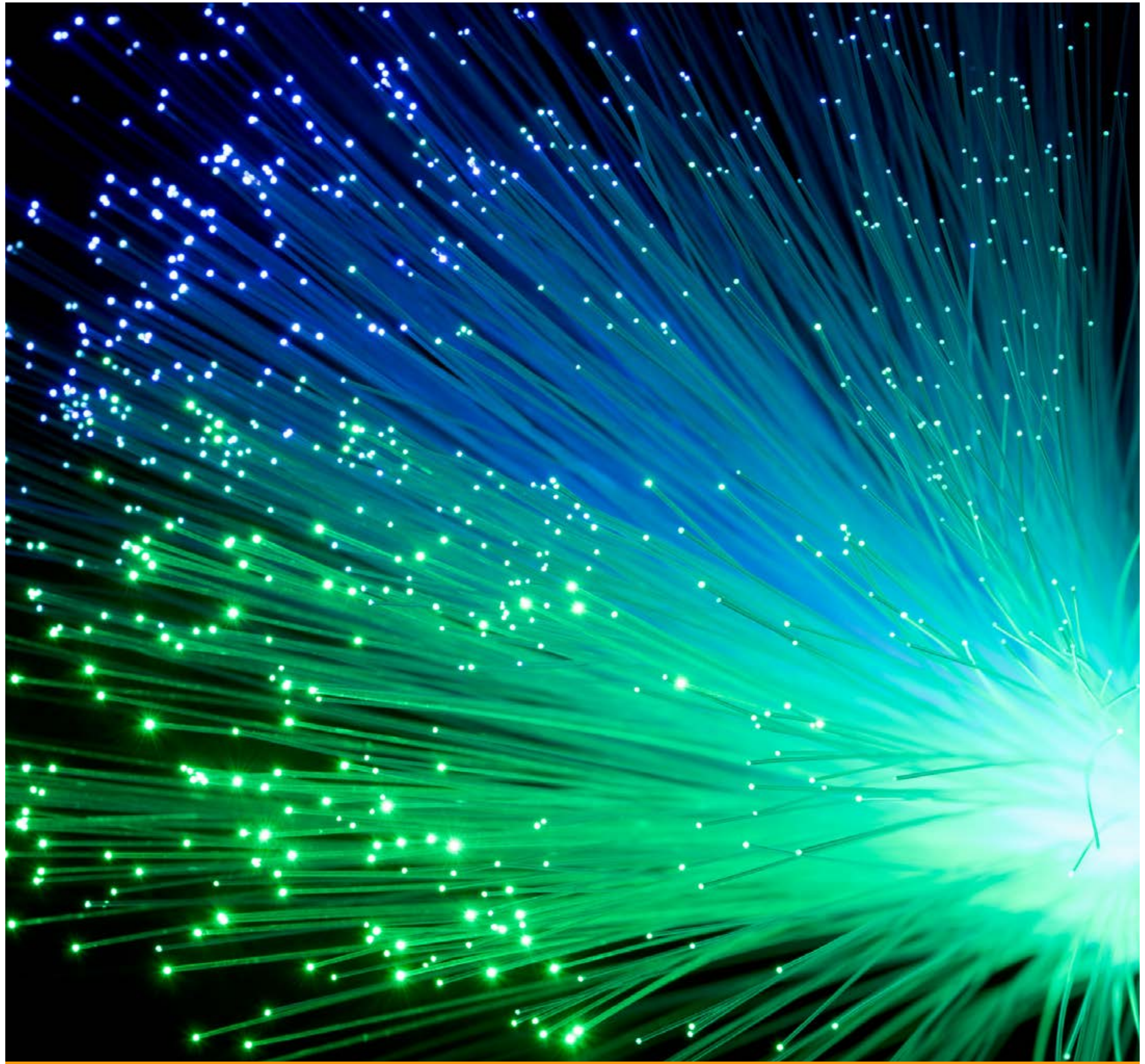


When light travels through a transparent material it interacts with the atoms of this material which deviate its direction. As white light is an assemblage of different wavelengths (each wavelength = a different color) and each wavelength refracts at a different angle, the emergent light from a prism forms a rainbow.

What does light look like on a nanoscale ?

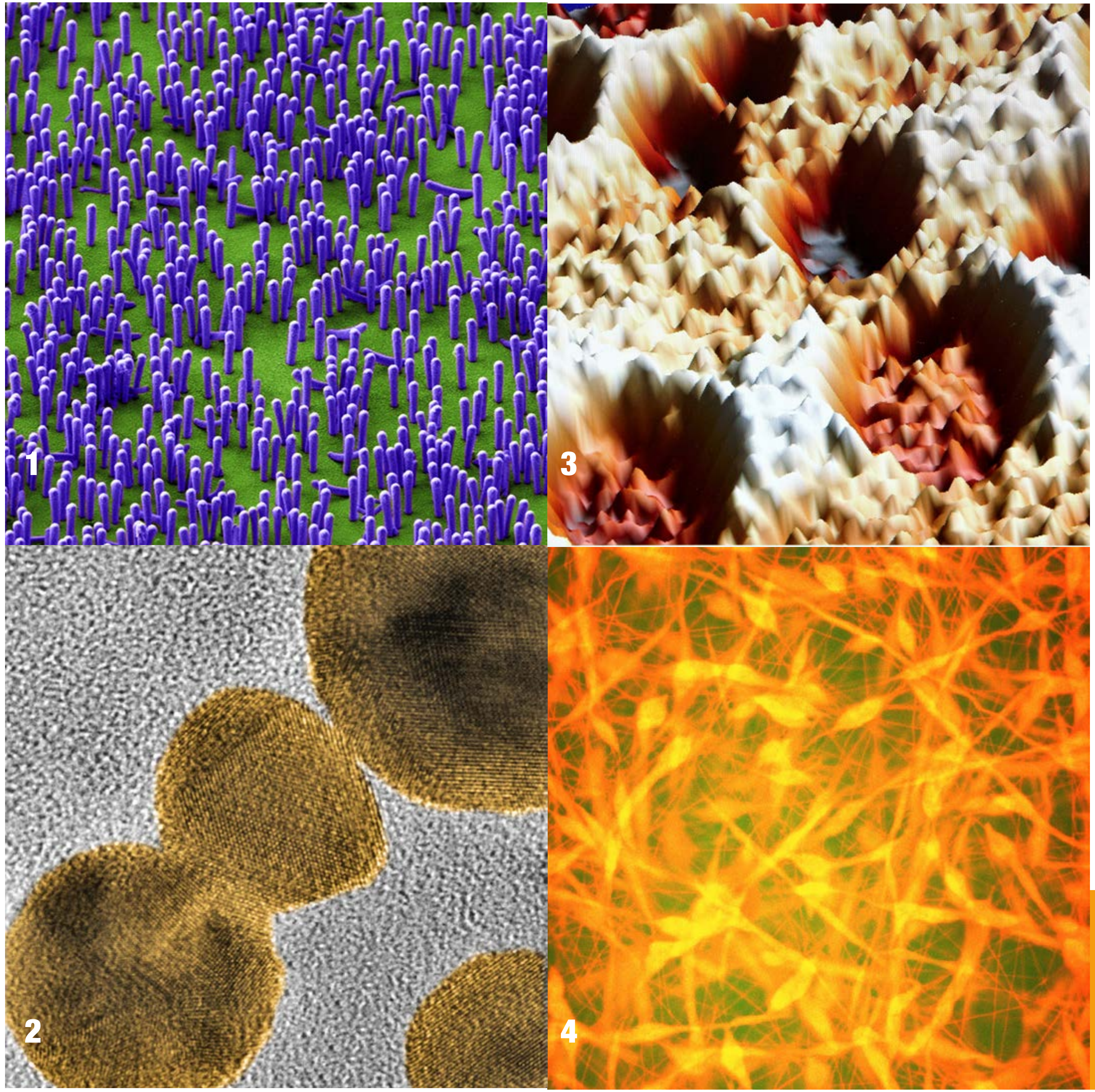
Light has a dual nature. First, it acts like an electromagnetic wave. For visible light, the length of one wave cycle (the wavelength) is between 400 and 700 nanometers. Given that the speed of light is roughly 300,000 km/s, this wavelength range corresponds to a range of number of cycles per second, or frequency. Our eyes can perceive separate frequencies as different colors. In photonics, researchers examine the interaction between visible and invisible light waves and matter, based on Maxwell's equations for electromagnetism. They also take into account the rules of light reflection and refraction upon passing through media interface. However, as researchers investigate other special situations, they find light acting differently, like a stream of particles, or photons. They are quantum particles which means that, as microscopic objects, they don't behave according to the rules that we are used to in the macroscopic (normal size) world we are familiar with. There are always uncertainties in this small-scale world. Peculiar behaviors (like the possibility of being at many different places at the same time.) permit the manipulation of light in different ways to how light is manipulated on a bigger scale. Benefits can include, for example, more efficient transformation of light energy to electricity in nano solar cells.




Optic fibers are made of some materials that refract permanently the light to their core. In this way, the light zig zags along the fiber without escaping.

Why are we using photons for communication ?

Nowadays we use a lot optical fiber cables to transport our information. But why would photons be more efficient than electricity to do so ? Single photons are able to travel so far and so fast because they interact less with their environment than electrons. In fact, they are massless, chargeless, and thereby isolated particles. As a result, and differently from the electrons that constitute electricity, photons can, in principle, move, and transport information, over trip lengths of millions of years. That’s why many nanophotonics applications are concerned with telecommunications.



How to see the interaction between light and matter at that scale ?

There is no way to observe this phenomenon with your own eyes and even with a classical microscope you couldn't see the action at that scale. So, researchers need to use different tools in order to understand what's happening when photon encounters matter. First, they create devices at a nanoscale. This devices can have different shapes and are made of different materials, for exemple silicon or polymer. So the light will interact differently with each of them. To look at the structure of this devices, which are invisible to the eyes, researchers can use different kind of microscope (see illustration)

But even with these microscopes, the researchers still won't be able to directly see what's happening between light and matter. So, they will measure the consequences of this interaction with several tools : single photon detectors, photons counters, spectrometers (measuring level of energy of photons), voltemer (level of electricity produced…)... And it is also possible in some case, to see where the light concentrates on the nanodevice thanks to Fluorescence confocal microscopy. That's with all these measures that they will be able to guess what is happening at this nanoscale.

However, nanodevices are very costly. So before making these kind of experiments, researchers are usually making simulations based on computer modelization. If the observed scale is less than the light waves dimensions, the simulation would be based on Schrodinger equations that describe nano behaviour in order to predict the position or the interaction of the photon, photon energy, the light absorbed or transmitted and the corresponding effects.

1/ Scanning electron microscope (SEM) to see the surface

2/ Transmission electron microscope (TEM) to see inside the device

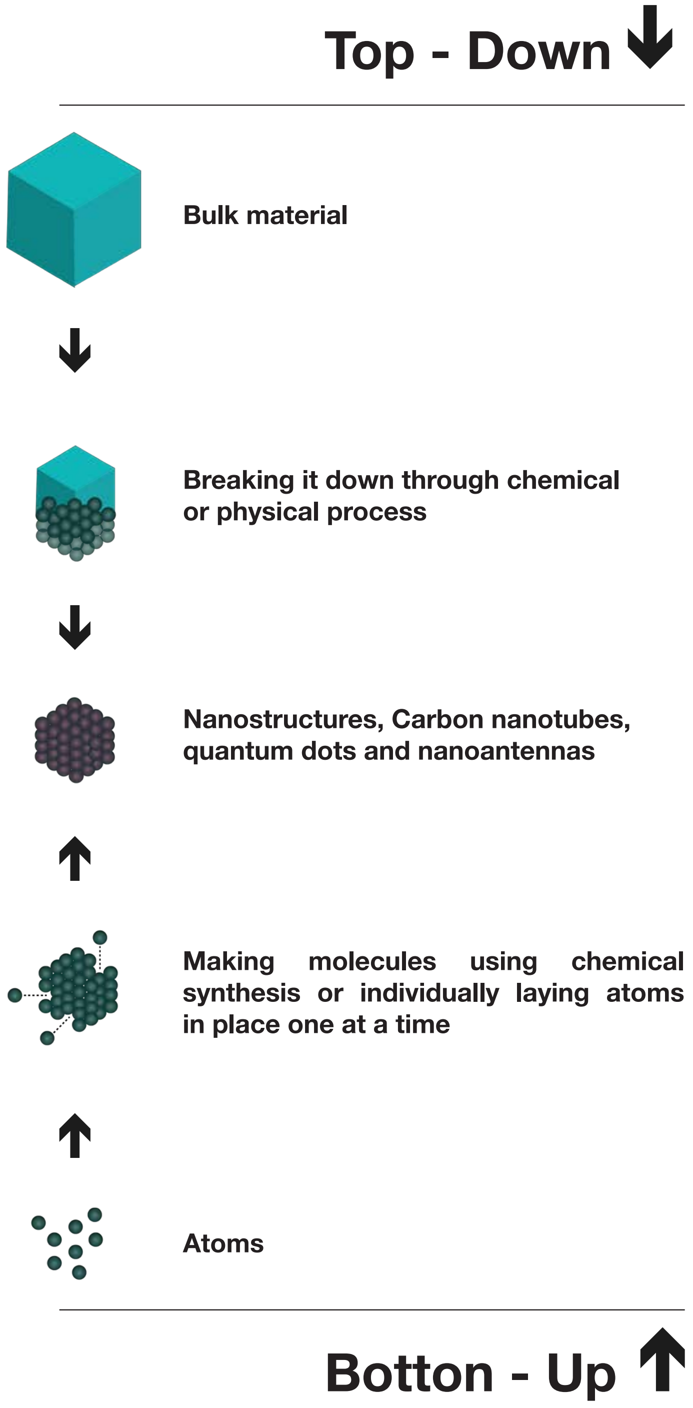
3/ Atomic force microscope to observe the roughness of a nanodevice. Even if the device seems smooth, on a nanoscale you can detect any bumps or holes.

4/ Fluorescence confocal microscopy to see where the light concentrates on the nanodevice

Researchers assemble individual atoms together inside a vacuum chamber at high pressure and temperature.

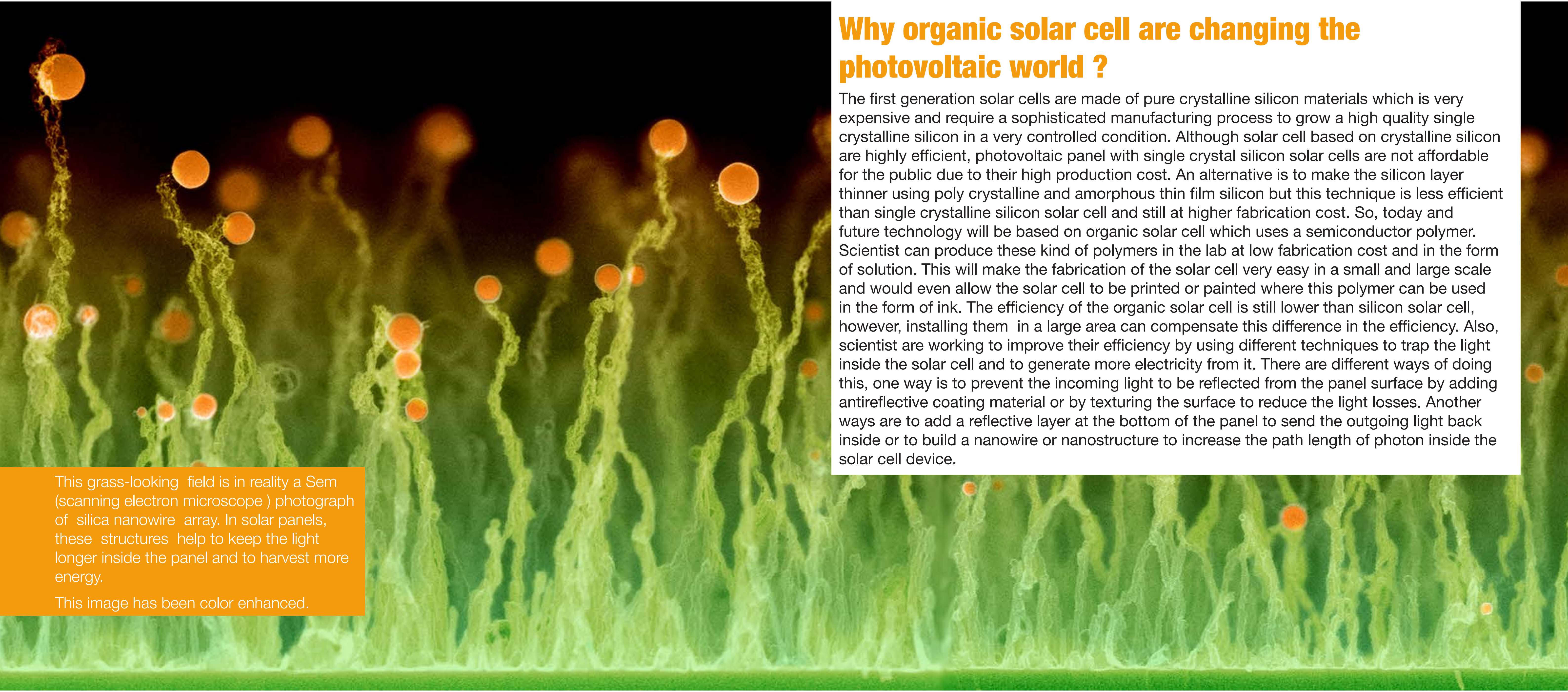
How to create so small device?

There are two methods to synthesize nanodevices: the top-down method and the bottom-up method. The top-down method uses large initial structures which are reduced to the nanoscale. For examples, removing parts from silicon wafers chemically to create nanowires or other nanostructures. The bottom-up method is the opposite approach, where you start with atoms or molecules to build a device. For example, fabrication of amorphous silicon film, where you start by reacting a silane gas in a vacuum chamber at high pressure and temperature. The gas atoms finally deposited and assemble on a glass surface forming an extremely thin silicon film.



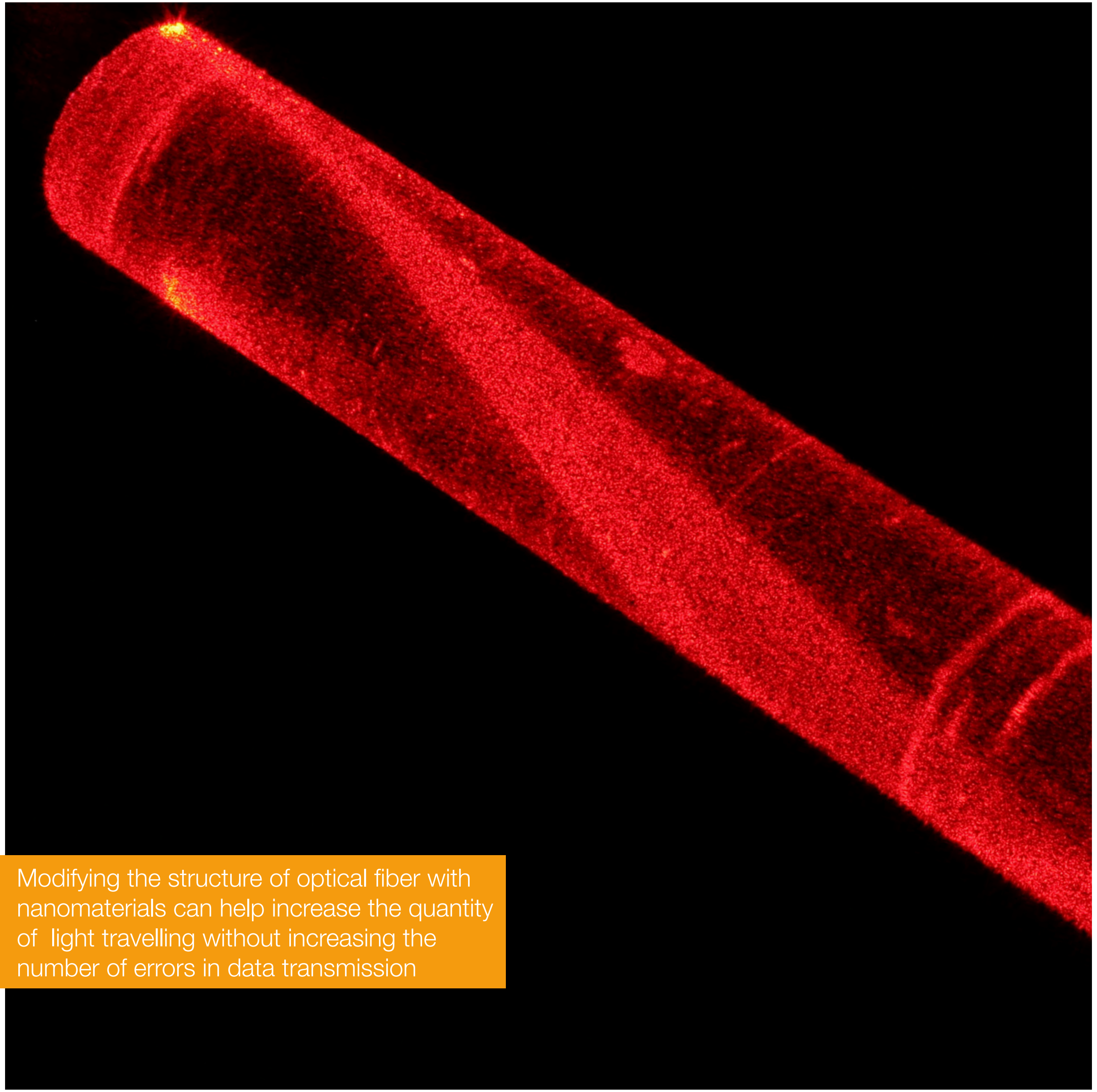
Why organic solar cell are changing the photovoltaic world ?

The first generation solar cells are made of pure crystalline silicon materials which is very expensive and require a sophisticated manufacturing process to grow a high quality single crystalline silicon in a very controlled condition. Although solar cell based on crystalline silicon are highly efficient, photovoltaic panel with single crystal silicon solar cells are not affordable for the public due to their high production cost. An alternative is to make the silicon layer thinner using poly crystalline and amorphous thin film silicon but this technique is less efficient than single crystalline silicon solar cell and still at higher fabrication cost. So, today and future technology will be based on organic solar cell which uses a semiconductor polymer. Scientist can produce these kind of polymers in the lab at low fabrication cost and in the form of solution. This will make the fabrication of the solar cell very easy in a small and large scale and would even allow the solar cell to be printed or painted where this polymer can be used in the form of ink. The efficiency of the organic solar cell is still lower than silicon solar cell, however, installing them in a large area can compensate this difference in the efficiency. Also, scientist are working to improve their efficiency by using different techniques to trap the light inside the solar cell and to generate more electricity from it. There are different ways of doing this, one way is to prevent the incoming light to be reflected from the panel surface by adding antireflective coating material or by texturing the surface to reduce the light losses. Another ways are to add a reflective layer at the bottom of the panel to send the outgoing light back inside or to build a nanowire or nanostructure to increase the path length of photon inside the solar cell device.



This grass-looking field is in reality a Sem (scanning electron microscope) photograph of silica nanowire array. In solar panels, these structures help to keep the light longer inside the panel and to harvest more energy.

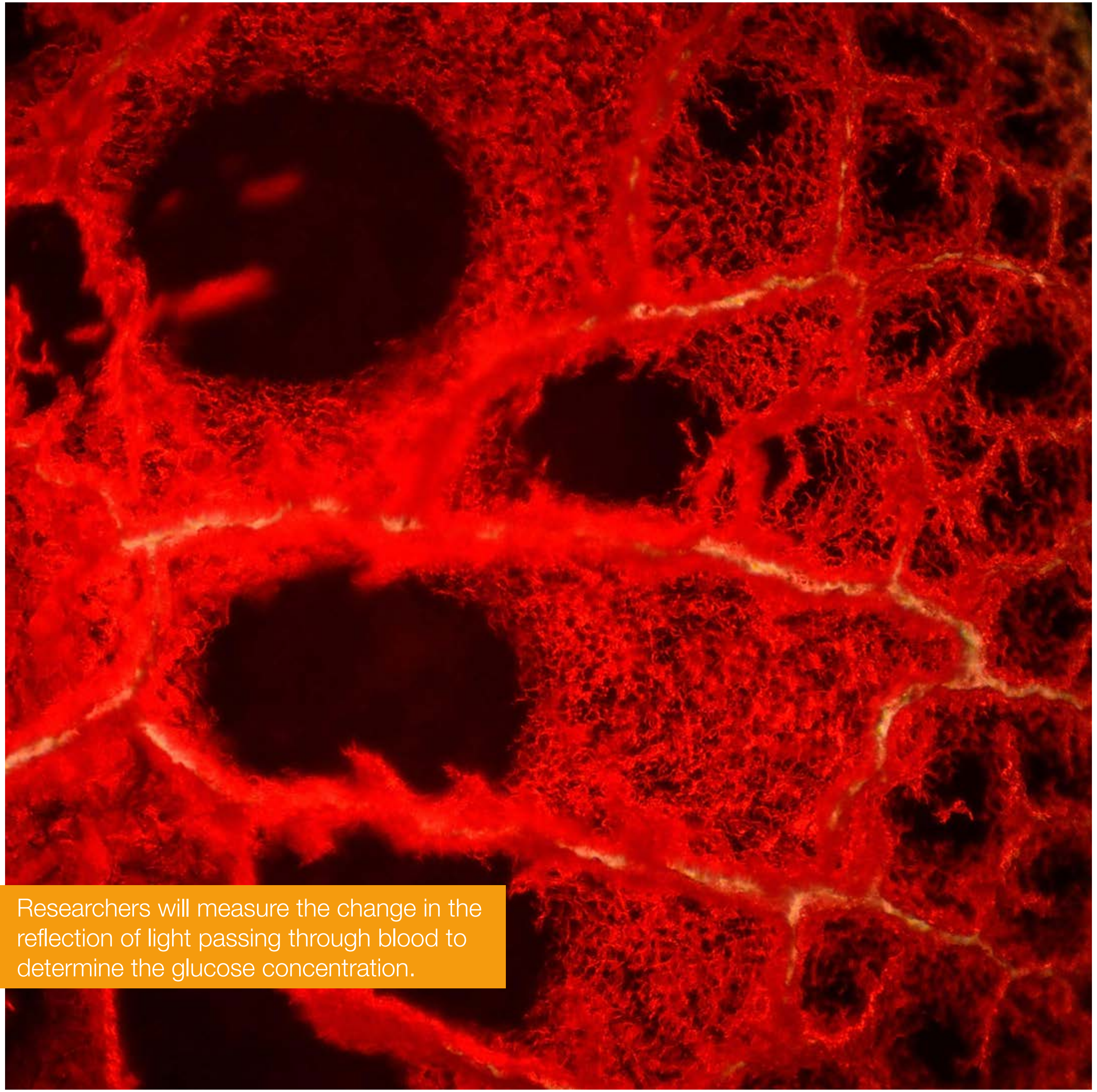
This image has been color enhanced.



Modifying the structure of optical fiber with nanomaterials can help increase the quantity of light travelling without increasing the number of errors in data transmission

How to save our resources (and so save the world) thanks to nanophotonics ?

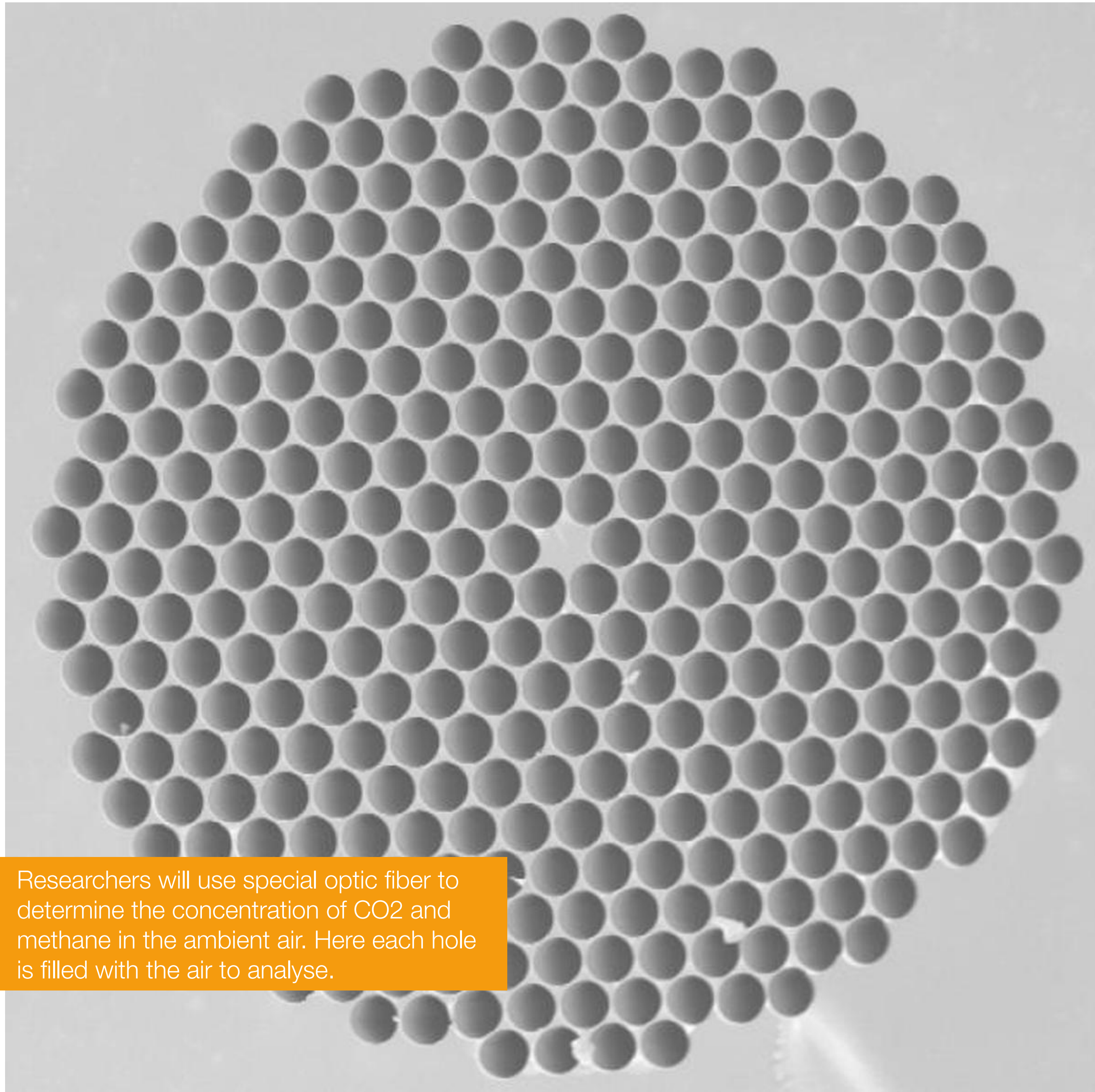
Data transmission could represent up to 51% of energy consumption by 2030. So, it becomes urgent to reduce the energy needed to transmit data. One of the projects in Zewail City is to improve the quality of the light transportation in optical fibers. Upon transmission, the light changes some of its characteristics, for example its polarization, resulting in errors in data received. The higher the rate of data transported, the more the errors take place. Modifying the structure of optical fiber with nanomaterials can help avoid light polarization changing during transmission. Another way to transport high data volumes is to take advantage of the quantum nature of light. In special crystals and optical fibers, researchers are able to generate pairs of photons (thanks to the coherent laser beam) that are mutually correlated, or entangled. This means that the two photons are somehow linked and if one changes one of its three properties (spin polarization, level of energy/time, position), which can happen during the transportation process, the other will change it too. This entanglement permits the encoding of twice as much data as when using single photons, and is called “super dense coding”. This method is still in a research state, but one day it could help reduce the energy consumption needed for data transmission.



Researchers will measure the change in the reflection of light passing through blood to determine the glucose concentration.

What can nanophotonic sensors do to revolution the life of diabetic people?

The concentration of glucose affects the optical constants of blood and results in a different reflection of the light when it passes through. Researchers are trying to use nanophotonics in order to design highly efficient biomedical sensors able to detect the smallest of changes in glucose concentration based on this optical change in light. These sensors are very sensitive and in the future they could replace the classical way of measuring glucose concentration for diabetic people. They then wouldn't need to prick their skin for blood testing anymore as light can get through the skin.



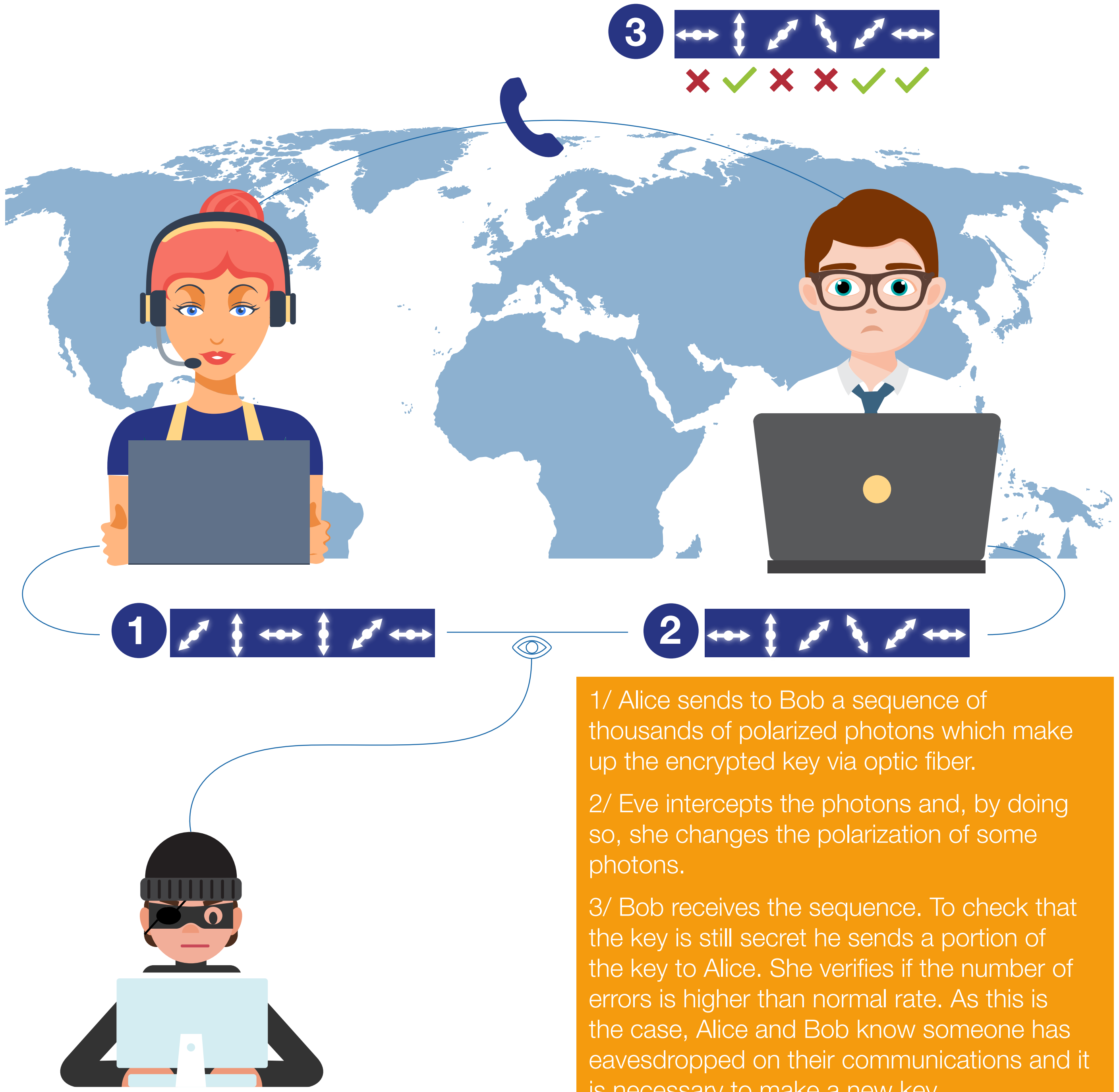
Researchers will use special optic fiber to determine the concentration of CO_2 and methane in the ambient air. Here each hole is filled with the air to analyse.

How nanophotonics could save Egypt's heritage

In Zewail city, researchers are developing, in collaboration with Nottingham University, sensors for the Ghuria complex, ancient British buildings made of calcite stones. This kind of stone is very sensitive to carbon dioxide and gets degraded if its concentration is too high. As CO_2 absorbs near infra red light, its concentration level affects the reflection of light which can be measured by nanosensors. From this information, researchers can detect the CO_2 concentration and estimate the speed of the degradation process. Moreover, the Ghuria area hosts a lot of leather factories which release methane into the atmosphere, a very inflammable gas that can lead to a fire. Nanophotonic sensors can measure the methane concentration. The advantage of using these kind of devices is that researchers can insert them inside a fiber, where air is pumped in to be in contact with the sensor, and then make light (usually laser) run through it to measure its reflection. Their size is 1 micrometer radius so they are invisible and they don't need electric power cables to work, unlike classic electrical sensors. Moreover, the fiber containing them would be very discreet. This would help keep historical places safe without visual disturbance.

Why photons are the most reliable courier?

Photons can play a very important role in protecting classified data. Today, most safe communications are encrypted with some secret coding which needs the correct key to be read. In the middle ages, a king would have initially sent a messenger to his spy with a decoding key. (For example 1=T ; 2=B 3=I and so on.) Then, other messengers would have delivered the encrypted messages. But what if the first messenger had been intercepted by the guards of the enemy, forced to release the decoding key and paid to pretend he delivered the message correctly without anyone knowing about it? Then, the enemy country would be able to read any following intercepted message. To avoid this sort of problem, nowadays, it's safer to use a quantum key delivered by photons because it will always let you know if someone has eavesdropped on it. It is in fact possible to encode a random key in one of the properties of individual photons (like polarization) and send it via optical fiber to the person you wish to send the secret message to, as you can see on the illustration.



1/ Alice sends to Bob a sequence of thousands of polarized photons which make up the encrypted key via optic fiber.

2/ Eve intercepts the photons and, by doing so, she changes the polarization of some photons.

3/ Bob receives the sequence. To check that the key is still secret he sends a portion of the key to Alice. She verifies if the number of errors is higher than normal rate. As this is the case, Alice and Bob know someone has eavesdropped on their communications and it is necessary to make a new key.

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