WHAT IS BEHIND A BREAKTHROUGH?

The study and the analysis of the social environment and its effects on the other aspects of human life have been widened and deepened in the last decades and they probably have a historical root in common: the Darwinian theory of evolution that was at the base of Realism, a literary and cultural current that carefully studied the influence of the social environment on man. This concept was also known in philosophy and among the most influential exponents of the XVIII century there is Hegel who considered the conscience as a personal perspective of the world influenced by particular cultural horizons.

Then it is undeniable how our daily experiences such as joy, sadness, difficulties, the ability to adapt or change, the desire to know and discover define leanings and passions which each person develops in the course of his own existence. The same principle, that could be considered universal with good reason, is applied to scientists and their work in equal measure.

Lots of important scientific discoveries would never have been made if some scientists had not lived in a certain way, gradually developing capacities and interests that have enabled them to reach exceptional objectives. In order to understand how the personal life affects work we should start by saying that nothing we live is forgotten, but lots of past experiences unconsciously influence us when it comes to our future life and our personality.

Family and school: it could all start from here

Often, the first component that influences a scientist's life is family. Not for nothing, in fact, have many people, famous in several scientific fields, had parents who were already chemists, physicists or mathematicians. A striking case is without doubt represented by the Curies. Marie Curie was strongly influenced by his father Wladyslaw, scientist and math teacher. Since her early adolescence she had already developed extraordinary capacities of memorization, concentration and knowledge which helped her when she started working and making that kind of discoveries which made her a legend of science. Her daughter Irène had also brilliantly followed in her parents' footsteps and what is more, in the school that she attended, there were her mother Marie who taught physics, Jean Perrin as the chemistry professor and Paul Langevin who did lots of math lectures. These are certainly meaningful experiences that have enormously contributed to Irène's future choices (for example she kept on solving lots of exercises invented by her or sent by her mother while she travelled or she autonomously deepened particular aspects of the school lessons). It does not come as a surprise that with her husband Frédéric Joliot she experimentally demonstrated the existence of a new fundamental particle (the neutron) thanks to the application of radioactive alpha particles which her parents had already studied.

Another spectacular case concerns Vera Cooper who became famous for her pioneering studies on the dark matter and energy in the universe. Since she was a little child, she loved looking up at the stars and with her father Philip's help, when she was only 14 years old, she built an amateur telescope that she used each night until her mother obliged her to go to bed. So, it is understandable how family and in particular parents play a key role in their children's intellectual development.

Teachers also have became mentors for their students as it happened to Katherine Goble Johnson, the main character of the Margot Lee Shetterly's book "Hidden Figures" and the

namesake Theodore Melfi's film, who was deeply inspired by different professors including Angie Turner King, one of the first Afro-American women that received a PhD in mathematics. It can happen that in high school there are teachers who are willing to deepen their lessons and help their students in scientific competitions or projects. One of thousands and thousands cases involves the Brazilian teacher Fabio Bruschi who received the 2016 Inspiring Educator Award by the Google Science Fair's Evaluative Panel for having helped his sixteen-years-old student Maria Vitoria Valoto in the realization of cheap and reusable pills to solve gastric problems linked to the assumption of lactose.

Coincidences and errors: when cleverness is not enough

Fortuity is another principal factor that could be the spark for a scientist's "Eureka". Sometimes things just need to be seen from a different point of view and this happened to many famous people. Ørsted, an important Danish physicist, during a lecture he was giving at the university, approached a magnetic compass to a current-carrying wire. He noticed that in these conditions the needle of the compass started to move: the first experimental observation of electromagnetism was made. A similar case, but far more amazing, is linked to the birth of the microwave oven. Its inventor, Percy Spencer, worked at the Raytheon, a company specialized in the construction of radars and their components. One day, while he was working on an operative radar, he realized that a candy bar he had in the pocket was completely melted. Because of that event, he understood that the microwave beam of the radar was able to warm little objects. So we only have to thank a piece of chocolate for an important appliance we own in the kitchen! Often a phenomenal discovery is just a snag, an uncalculated error that happens during an experiment which, according to the initial predictions, should have given different results. Griffith accidentally conducted a well-known experiment while he was working on a polio vaccine and that opened the way to the discovery of DNA as the molecule which contains the genetic information. Alexander Fleming discovered lysozymes by mistake when he sneezed in a Petri dish. In a similar way, he contaminated another one full of staphylococci with spores by leaving it near an open window: that carelessness led him to the discovery of penicillin .

Other important scientific breakthroughs as the cosmic microwave background, Uranus or X-rays are just the result of fortunate coincidences that describe another factor involved in scientific research: serendipity.

Is it easy to analyze the process behind a breakthrough?

Generally it would be impossible to define a single process that should lead the scientists to sensational and fundamental discoveries. Effectively each life is unique and everyone reacts to external stimuli in a totally different way. Then, when I think about a rational way to explain how we can create geniuses that are bound to change the world, I imagine an everlasting equation with infinite variables whose importance depends on the person we are talking about. Anyway we can certainly determine some common factors among the great scientific minds: passion, dedication and an indefatigable work. If Andrew Wiles had surrendered after that his theory seemed to be confuted, now we would not have had a general proof of the Fermat's Last Theorem. If Edison (who based his observations on Tesla's work) had stopped looking for the best filament to build an efficient light bulb, we would have found ourselves backward in the illumination technology.

In order to stress the effort and the commitment that each scientist puts in his work, I really like remembering this Albert Einstein's citation (he is an absolute genius not only

in physics): *"There is a driving force more powerful than steam, electricity and nuclear power: the will."* If there is determination, no obstacle can resist and it is not rare that many scientists reach an aim after years, maybe decades of study and research.
Let's think about the case of gravitational waves: the projects LIGO and Virgo have observed these oscillations only in 2015 but the 2017 Nobel Prize in Physics Laureates' work started in the '60s. It is banal thinking that results are just around the corner: the beauty of science consists of the research in the unknown and firstly scientists are not totally sure where their observations and deductions are going to drive them.
Truth be told, I do not appreciate that in the course of history mankind only remembers the name of people who made it, who arrived to a discovery at the base of a paradigm shift. The path to it is long and arduous and many other scientists have surely paved the way and contributed to the achievement of the objective (think about the poor Tycho Brahe whose numerous data he derived by innumerable astronomic observations were used by his student Kepler to formalize the three laws of the motion of the planets).
Therefore I take the opportunity to indistinctly thank all the scientists, the real heroes of our society thanks to their work and the sensational discoveries they can make but especially because they are the ones who are able to explore the unknown and to push themselves beyond the limits of knowledge.
Anyway, now, I am just wondering if I will ever sneeze in a Petri dish too…