Gene-Rations

Roberto Defez

Abstract Today in the world there are about 10 million scientists and research workers and the number continues to increase; meaning that 90% of all scientists who ever existed are alive today. Timothy Ferris (*The Science of Liberty 2010*) links the explosion of scientific research to the development of democracy that is therefore, also linked to the right to vote. Scientific research can be viewed as one of the most sensitive thermometers of the degree of democracy in any country. Many governments have chosen to invest in higher education and scientific research; and scientists might be considered equivalent to the bricks of ancient monuments once erected by pharaohs and emperors. A scientific hypothesis is contrary to a belief, a prejudice, an economic, ideological or personal interest, and feeds on questioning, evolving and updating itself regardless of the sex, religion, or geographical origin of those who produce new verifiable published data. This is how evidence based scientific method can change public's opinion. In an era of decline of twentieth-century ideologies, scientific method is a tool that has immense idealistic potential. If on the one hand, scientific research in Italy suffers from many problems notably by being underfunded combined with a general lack of public trust; then, the "luck" given to scientists to cultivate freedom of thought and choose their research direction comes with enormous responsibility and the need to explain better the array of opportunities to grow and feed future generations, or gene-rations (These concepts have been described in Scoperta, 2018, Codice Editions, by Roberto Defez).

1 Motivations: How I Developed an Interest in Science

FROM THE BEGINNING. Who am I? This was the key question when I was 13 years old and about to enter lyceum. I was raised in a strange and wonderful family that influenced me in many ways. My practical and work-oriented father had a brilliant mind and changed work many times: mostly in construction and finance. By contrast,

R. Defez (✉)
Italian National Academy of Agriculture, via di Niso 4, 80124 Napoli, Italy
e-mail: roberto.defez56@gmail.com

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my mother Laura was more culturally oriented with many social activities and a life-long interest in reading. She was born in Milan and asked her father to offer her a trip to Rome for her 18th birthday, something quite unconventional in Italy in 1951. In Rome she met my father who was working there despite being born in Naples; and they married three years later. That explains why my older brother and myself were born in Rome. This means that we felt at home in any place in Italy, even though the barriers between different areas of the country were and are still deep and real. In addition, both my parents' families originated from elsewhere. My mother's family moved to Milan from the Adriatic coast, while my father's family was quite peculiar. My grandfather was born in Izmir, Turkey from a Jewish family who fled from Zaragoza some 5 centuries ago to avoid the Spanish Inquisition. My surname suggests that my ancestors were originally from Fez in Morocco and later immigrated to Spain. Despite living in Turkey since the late XV century, the language spoken in the family and the only language spoken by female members was Castilian (ancient Spanish). Five centuries without learning Turkish! Being raised at home by aunts, Castilian was the first language my father learned when his father escaped the fire in Izmir in 1919 to sell carpets in Naples, where he met my grand-mother, a Jewish lady born in Alba, close to Turin, before moving south to work in Naples. They settled in Naples and raised 4 children during fascism. When racial law came into force in 1938, the 4 children were expelled from school and had to study moving from house to house to visit their Jewish teacher that had been banned from both schools and universities. Even when World War II began they continued studying, and I like to think I inherited this fury against those who tried to repress my studying. In July 1943 my father's family was notified by the Order of the Prefecture to be sent to a concentration camp. They left their house early in the morning after a whole night of Allied bombing to walk down Vomero Hill to the Naples Prefecture to learn that the Prefecture had been destroyed by a bomb; and thus they could return home. I was probably born only because of a single bomb dropped on the Naples Prefecture on July 23, 1943. Two months later my father Leo and his older brother (Alberto) took part in the liberation of Naples from German Nazis: "The four days of Naples". Naples was the first big European city self-liberated from the fascist dictatorship. Soon after they voluntarily joined the resistance to liberate the whole of Italy from fascists and Nazis in April 1945. My uncle Alberto described all this in a few books and in an interview with the Steven Spielberg Foundation (https://vhaonline.usc.edu/ Search and then digit: Defez). I can assert that my deep Italian roots, as well as my repulsion to any invading army (we have today a dramatic example in Europe), my aversion to those who prevent fundamental freedoms and my belief that we are all part of the same human species are clearly derived from my family's history (Fig. 1).

There are two main lyceums in Italy: Scientific and Classic. The Classic is based on the study of Latin and Greek, which I avoided at the time, although now I'm reading classics such as the Ovidio Metamorphosis. I was in love with numbers and living organisms so I choose the Scientific Lyceum at 13 years old. It was October 1969 and the 68 age arrived in Italy a year later during fall 1969.

On December 12th internal terrorism started in Italy with a bomb that exploded in a bank in Milan to stop workers' strikes and students' demonstrations. Up to the end of

Fig. 1 Alberto Defez in his house giving the interview (https://collections.ushmm.org/search/catalog/vha45146) *Sources* CNR, via P. Castellino 111, 80131, Napoli (Italy)

the 20th century in Naples, politically motivated Italian terrorism and mafia/camorra assassinations killed an average of 100 people each year for decades. Politics was a central issue in my family, because of the war, because of the political choice (left wing) of my father's family and because school and society were faced with political debates and fights. However, I have always refused to be a political representative. I felt unable to teach anyone on how they should live and think, which road is the right one to take, or how to shape the country's future. Despite being attracted by political debate none of my friends and classmates became politicians. My feeling was that I was not ready to make strategic choices for the society, but I was ready to support someone else's decision by providing them with data, analysis and documentation. I am still doing this today and I have ended up being a consultant for many politicians of opposing parties, helping them to have a more solid scientific basis for their decisions.

At the very beginning I was fond of geology, as I love rocks and crystals, but in the summer of 1974 when I had to decide the Faculty I would attend, I chose Biology. This was a key moment in my life. I had the clear perception that as a biologist it was possible to interact with the life and the development of organisms, instead of only making observations as it would have been in Geology. At that time, I could have chosen many other professional directions that looked more promising for me such as: architecture, engineering, financial activities, etc., but I decided that I wanted to be happy while working, and not to work simply for money, being happy only during weekends and holidays. I decided to follow my passion and started to work with a standard (public) salary, despite being raised by professionals and entrepreneurs. Retrospectively thinking, I was very lucky to have the opportunity to decide my own path.

I was even luckier, because Naples became the place where modern molecular biology was first developed in Italy; and at that time one of the leading places in all of Europe. In 1962, Adriano Buzzati Traverso, the best Italian manager, endowed with a remarkable scientific strategic view, was asked to open in Naples a new research institute that took the name of International Laboratory of Genetics and Biophysics (LIGB). He was joined by brilliant researchers including a few Italians who had been working abroad, frequently as post-doctoral fellows in some Nobel laureate's molecular genetics laboratory. The group leaders were 30–40 years old and their informal style of living, the idea of being inhabitants of the world, and not of a neighborhood, the rejection of hierarchies, or authority based on a position of power were fascinating for a young biologist like myself. The LIGB institute appointed a truly international Scientific Council with half of the members from other countries. I still miss having such a diverse Scientific Council. Scientists such as Jon Beckwith or Sydney Brenner were leading the Council and group leaders had to present their research projects to that prestigious Scientific Council. In Pavia, in 1948 Adriano Buzzati Traverso was awarded the second chair of Genetics in Italy. As soon as he entered the University of Pavia he described the situation of funding, salaries, career prospects and research competitiveness and publications in Italy as "an undernourished fossil". This description is still appropriate today (Fig. 2).

Although I met some of the LIGB scientists before joining the Faculty of Biological Sciences, I was able to fully appreciate their relevance and cultural prestige only when attending their lectures at the University. Franco Guerrini, a full professor and a leader at LIGB, was one of them. He was both clever and merciless, capable of fascinating his audience, and yet would blow up at the deepest contradictions from each responder. He was a sort of midwife capable of nurturing an unlimited passion for scientific research, and, at the same time, of discouraging those who were uncertain about a scientific career: a true and strict mentor. I hope that I have been able to follow his teaching, which will be fully accomplished if I will be able to transfer my knowledge and attitudes to the next generation. On February 15, 1978 I joined a laboratory at LIBG where I was going to work on my Ph.D. thesis and 29 days later Italian terrorists kidnapped the leader of Italy's largest political party. He was killed few months later in May and the basis of democracy then wavered.

2 Work Done: My Personal Scientific Approach

NO AGREEMENT TODAY, NO AGREEMENT TOMORROW. After less than three months in the laboratory I understood that scientific research was my calling. I was working on microbial genetics and after just two months I decided to run a crazy experiment looking for the chromosomal position of a new *E. coli* gene that I had identified by mutagenesis. Since I had selected the precious mutation in a bacterial strain unable to mate with other strains, everybody advised me to try to re-isolate the mutant in a strain capable of conjugation, but I chose another approach. My hypothesis was that the mutation was close to at least one of the 50 known selectable

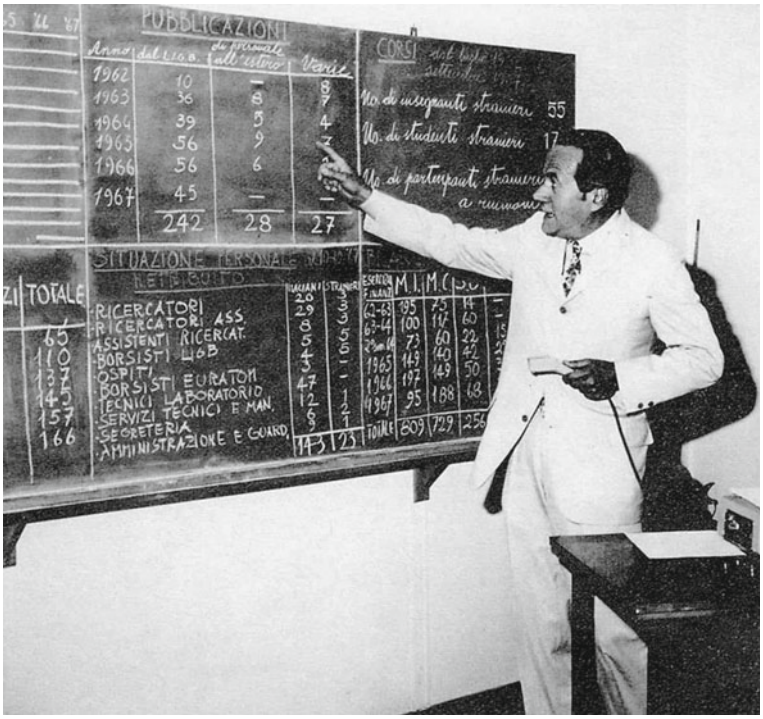

Fig. 2 Adriano Buzzati Traverso at IGB in 1967 (Credit photo to https://www.fondazioneadrianobuzzatitraverso.it/)

genes spread along the chromosome and, assisted by a good amount of luck, I was able to identify the new mutation by co-transduction. I performed that risky co-transduction experiment during the Easter holidays in 1978. This illustrates how I've always placed my research work before any other interest. Coffee, and ice cream in summer, often were my lunch. One year after that I found a fellowship looking for a candidate who was willing to join a research laboratory in France focused on plant-bacteria interactions. I had not yet obtained my Ph.D., could not speak French, and had no experience in this specific research area, but I was ready to leave attracted by this new research experience that, by the way, provided my very first salary. I spent 4 months in Versailles living and working alone for the first time, without knowing, at that time, that plant bacteria interactions would become my main research focus for the next 35 years.

Living in Versailles, fully dedicated to my work, was the best way to understand if scientific research was indeed what I was willing to do for the rest of my life, and it soon became clear to me that I wasn't interested in any other kind of work. I went back to LIGB in the spring of 1980 and then graduated on December 20th at the University of Naples. On that very day we were less than ten graduating students due to a city that was still suffering the consequences of a terrible earthquake that had

Fig. 3 My wife Maria Ciaramella (1958–2018) at the marriage, celebrated in Paris in 2014, of my close friends and scientists at Pasteur Institute: Gordon Langsley and Caroline Demangel

occurred 27 days earlier, causing hundreds of victims and endangering the stability of many buildings including my faculty's. One of the ten students was a very clever lady called Maria Ciaramella whom I married 12 years later (Fig. 3).

Once graduated, I received many offers to work in different laboratories in Italy, but with no or low salary. I was certainly eager to work but I also wanted to be economically independent, and so I decided to leave Italy. My university mentor, Pablo Amati, a lambda specialist who joined LIBG after a post-doc position spent in Matthew Meselson's (a Nobel laureate) laboratory, suggested that I apply for a post-doc position at the Pasteur Institute in Paris, where his phage lambda connections were still very strong. I received a fellowship to join Philippe Brachet's laboratory starting the summer of 1981. The research project was quite distant from my expertise, but I was ready to learn new subjects. That implied not only a lot of reading, but also a strong attitude and dedication to the experimental work. I stayed at the Pasteur Institute three and a half years working very hard, publishing few papers, but each of good quality. This makes me proud even now. In 1981 my first paper reported the results of the Easter 1978 crazy experiment. It was published in Genetics a highly respected although somewhat traditional journal, where Amati and Meselson also published their research. It was my way to acknowledge Amati's mentorship.

> While there, I was also involved in a new project dealing with the effect of the Nerve Growth Factor, produced by neuronal cells, on co-cultivated muscle cells, during their development. This work eventually resulted in the publication of a paper, of which I am very proud, describing how NGF releasing cells are able to establish a cholinergic synapse to maturate. https://doi.org/10.1016/0736-5748(86)90041-9.

To summarize this period of my career as a take-home message for young scientists, I spent my formative years in two leading institutions LIGB in Naples and the Pasteur Institute in Paris. Both nourished me with new ideas supporting my professional growth with active research groups and intense scientific discussion with group leaders who were not afraid of exploiting and developing novel techniques and challenging pre-existing theories. The rapid turnover of young students and international post-docs was also stimulating and instructive. Once more, the work prevailed on personal life and frequently I had to rush the last experiment in order to take the very last metro back home in Paris. That meant leaving the laboratory around midnight and being happy to find still open those small food shops in Montmartre that were selling hot French fries. Despite a working day that never lasted less than 12 hours, the friendships built in those years were and are still deep and intense. I still spend

my holidays with friends I made 40-years ago in Paris or at LIGB. These are friends and colleagues to whom I reached out to in desperate hope for useful information on anti-cancer immunotherapy for my wife's terminal tumor. An excellent scientific environment is an inexhaustible source of meeting new people and making friends. It can expose you to different ways of life, expertise and opinions.

Normal life and friends in science are the two faces of the same medal. When I was in Paris (1981–84), many events happened. One was the war between Great Britain and Argentina for the claim of the Falkland/Malvinas Islands. My apartment was a little bit larger than a normal "studio" in Paris and I love cooking. Many of my closest friends and colleagues were English and Argentines. Their different views resulted in heated discussions that often took place there, while eating pasta with Neapolitan ragù or a black spaghetti with cuttlefish ink. Cooking and preparing coffee have always been my way of meeting people, discussing and making new friends, while at the same time I came to understand that not all people interested me.

Stimulating scientific environment and open discussion and relationships experienced in those ten years of my training has been a gift for the rest of my life. A meaningful example of the stimulating environment that was absorbable at the Pasteur Institute at those times is that the only other light kept on very late at night was illuminating the laboratory in front of mine, where colleagues were hard working in the effort of isolating the HIV virus.

Also, the experimental group closest to my lab, was run by a microbiologist who had taken over Jacques Monod's old lab. Even François Jacob was still present and active at seminars and conferences. Together with Jean-Pierre Changeux, they routinely gave lectures on the philosophy of science at the College de France. At that time, spurred by the molecular biology revolution, the two addressed several issues like those of evolution, looking for some different interpretation of Lamarkian theory that could somehow be related to the complexity of neurobiology and immunology. The question was: why is the number of antibodies or synapses, far higher than the total number of genes that might code for that character in any living organism? Thus, science was discussed and embraced for its contribution to a deeper knowledge toward a new awareness and cultural progress, not just for its technical applications or for simple paper publications. They professed a science that is capable of supporting progress while reducing the space for religion and unsubstantiated fears, and a science that supports the scientific method of Galileo as an instrument to establish the basis of a discussion or of a political decision. This was a lesson that was to become the foundation for the public and social challenges I have faced as a scientist standing on the side of the non-negotiable rules of scientific method based on documented evidence, published and commented on by the rest of the scientific community; based on the reproducibility of experiments; on the transparency of data removed by any conflicts of interest: a scientific method that can be left unheard or marginalized, but on which no mediation, bartering, or negotiation can happen.

3 Science Today and Tomorrow

ANOTHER BRICK IN THE WALL. After almost 4 years in France, I wanted to return to Italy where I was offered the opportunity of a tenured staff position as a CNR researcher. Evaluating the potential of the place and the country, I chose to join a group that was doing research in the field of soil bacterial nitrogen-fixing symbiosis with leguminous plants: the same subject I was working on in Versailles when I was a student. I had the feeling that continuing with studies that I had performed at the Pasteur Institute on cell biology, NGF and neurobiology it would have turned out in a big failure because of the uncertainty of the funding, the disorganization of the facilities and the chronic delays caused by an overwhelming, penalizing bureaucracy. I have never regretted this specific choice: however, it might have been better to have done a second post-doc in the United States. At CNR, I got a tenured staff position within a group led by a senior scientist who was burdened with daily administrative responsibilities. This facilitated me becoming the leader of a quite large experimental group, working on the front line with the aim of contributing new scientific advancements despite daily endemic and structural difficulties.

In 1996, after few years of employment, a grant in Biotechnology disclosed new strategies, collaborations and opportunities. The work was to test the effects on biological nitrogen fixation of genes involved in regulation of different phytohormone biosynthesis by expressing each of them in the bacterial strain I had used to infect legumes. The strain was capable of fixing atmospheric nitrogen and convert it into ammonium or glutamic acid, and the assay was conducted with a gas chromatograph that measured how much ethylene (a double bond molecule) was produced by the bacteria colonizing the roots of the legume once they were provided with acetylene (a triple bond molecule, like di-nitrogen). Our hypothesis was that some hormone could enhance the gas triple bond breaking process by initiating the conversion to a reduced state. We found that promoting the expression of the main auxin (IAA, indole-3 acetic acid) had a remarkable effect on upregulating nitrogen fixation. A peak twice as high as any other construct harboring genes leading to the production of other phytohormones was repeatedly recorded. Moreover, plants looked much healthier. The plants were taller and the root nodules where the bacteria had settled on the roots were two or three times larger. Finally, the plant had more pods and seeds. That project is still ongoing and will have a long life, surpassing even my retirement. At that time professional photographers were used to produce the images to be published and I sent the plants by courier to my photographer without telling him which were the plants transfected with the two genes for the biosynthesis of auxins and those infected by the wild strain of the nitrogen fixing bacterium. The effect was so striking that even the photographer was able to tell them apart. Auxins were known to be involved in many aspects of plant growth and development such as root development and cell elongation, but nobody had considered the effects on nitrogen fixation. Recently, we have even shown a direct effect of IAA in binding DNA, altering its super-helical structure and preventing the relaxation of the negative supercoiling.

Improving the efficiency of nitrogen fixation with the view of transferring this possibility to plants other than legumes seemed to us a great breakthrough. Thus, before publishing the article, we decided to patent the method (from my side, by having my research institution as patent holder). It was 1998, and the feeling in the society toward biotechnological applications was frequently distrust. The Mad Cow outbreak (although opposite to the use of biotechnologies) diffused fears about the possible scientific applications to food or feed production. Unfortunately, it was the wrong time. In fact, it was in 1999 that the Seattle G7 international conference took place and biotechnology came out as a new form of pollution on the planet, responsible of all sort of disasters like environmental destruction, risk to human health, threat to traditions, cuisine, ecosystem and many other possible political or social damage. In that frame, scientists had become irresponsible people who by playing God, wanted to change Nature (with a capital N), also by producing Frankenstein's food. From that moment, a misguided and deceitful environmental lobby started to show researchers working on plant improvement with gas suits and masks, as if the plants were producing radioactive compounds. In line, the fruits would be represented pierced by a syringe to communicate that the public had been duped, and the scientists involved insulted as being hired by multinational companies that were poisoning the planet (Fig. 4).

With the other two colleagues who had conducted the experiment to increase nitrogen fixation, we decided to react when, in July 2000, a Green Minister of Agriculture (a striking contradiction given that cultivating is the opposite of leaving ecosystems intact) decided that it was forbidden to do research if biotechnologies were used. Even worse, it became necessary to assign to any resulting product the infamous acronym GMOs, conceived to demonize the technology. At first, our reaction was to write, in November 2000, a short appeal to protest against the choice

Fig. 4 Fake images of GMOs that never existed made to scare people before they can reason

of arresting biotechnological-oriented scientific research. That was the start for an enthusiastic endorsement that came from the most different kind of scientist, doctors, physicists, pharmacologists, etc.; and was somewhat unexpected. It was clear that the scientific community was exhausted by continuous financial deprivation and lack of consideration. A small group of journalists and professors who were experts in communication between science and society helped us to publish the appeal on the inside pages of the Sunday cultural insert of an economics newspaper. It was like getting off a cart pulled by an elderly horse and driving a formula 1 racing car. The issue of the marginalization of the scientific research was an ancient workhorse of the country's political left-wing parties, but this time the scientists (largely left-wing) protested against the obscurantist choices of a left-wing government, and the right-wing took advantage of the opportunity. On February 13, 2001 the library of the Chamber of Deputies offered to bring together the Italian scientists who had protested against the choices of the Government. I ended up being the first author of the appeal, also signed by two Italian Nobel laureates. I also coordinated the mailing list of the 1500 Italian scientists who subscribed to the appeal.

The media impact was devastating, not only for politics, but also for ourselves. All the national newspapers had the story as the first news of the day and the main news broadcasts opened the evening editions reporting about the "uprising" of the scientists. Later I would have learned that the press is always hungry for absolute novelties and that our fate had been decided that that day there was no other appeals or more tragic news to broadcast.

Three months later they would vote in the country's political elections and it was already known that the center-right would triumph: our demonstration went fully into the electoral campaign. This is why on that very day (February 13th 2001) delegations of scientists after the session at the Chamber of Italian Parliament, were invited to meetings with the candidate for prime minister of the center-left, of the center-right (who would really later win the elections and become the new Prime Minister), and also with the prime minister in office. Skeptical of these improvised and ephemeral meetings, only useful at giving news of the meeting to the press, I decided not to participate in those institutional meetings. So, instead, after the end of the meeting at the Chamber, we went for lunch with scientific journalists and with the professor of history of medicine with whom we had shared the main choices of appeal. The venue for lunch could not be more symbolic: Piazza Campo di Fiori in Rome, under the statue celebrating the martyrdom of Giordano Bruno, an indomitable heretic (Fig. 5).

The incredible media success was ironically followed by a systematic restriction to carry out research and applications in the field of GMO technologies, supported by a series of laws, shared indiscriminately by all political parties, which turn down the scientific research in the field and caused the lockout of several faculties of biotechnology. This occurred despite the evidence of data saying that many GMO plants are more productive, use less agrochemicals, prevent emissions of greenhouse gasses and are safer that unmodified plants for human consumption and the environment. What was at stake was infinitely more important than the simple application, study or experimentation of GMOs in the field. The question was that of the credibility, transparency and honesty of individual scientists and of the scientific community

Fig. 5 The placemat of the restaurant in Campo dei Fiori in Rome

as a whole. It was a question of fighting against all institutions, including those that provide research funds. This meant that by going against politics we were also penalized for obtaining research funds.

It was a matter of fighting against all the Italian ministries and against all the international misleading environmental organizations that have continued for years to spread lies and fears worthy of the worst medieval obscurantism. The choice I made was to play this game on David's side against a ferocious and invincible Goliath, by intervening in every location and place to speak against falsehoods, contradictions, myopia and the interests of companies and individuals to blame the GMO technology. In those occasions, I repeated several times speaking about my activities, that I never modified plants and I never selected a GM plant (only bacteria), but I realized that the matter was always dragged far beyond my personal activity and interest.

Nevertheless, I stood by my decision of devoting an increasingly important part of my work to science communication, despite all the personal and professional damage that this choice entailed. Up to now I have had about 40 speeches/participations a year, over the last twenty years, on issues relating to innovations in agriculture with contributions ranging from the writing of articles for newspapers to participation in national and regional television broadcasts, from conferences for schools to meetings for science exhibitions and festivals, including eight Italian parliament audits in 15 years, all on strictly scientific issues concerning GMOs, genome editing, or organic and biodynamic agriculture. Also, I have participated in Public Hearings including media emergencies (as well as agronomic) such as the death of 11 million olive trees in Puglia due to the arrival of the quarantined pathogen *Xylella fastidiosa*, or the media war against glyphosate herbicides that hid enormous commercial interests of various players of both agricultural or agri-food chemistry. The war with which Russia is bleeding Ukraine has brought agricultural issues back to the center of the media discussion for imports to the West of wheat, corn, soybeans, sunflower

oil and above all for the banning of Russian and Belarusian fertilizers. Themes that are perfectly in line with the experiments we conduct daily in the laboratory, where we now isolate endophytic bacteria from African wild cereals that provide nitrogen and protect various types of cereals from drought. This is the way the future should be envisioned and planned. **Projects that combine production of food in the context of climate change with the reduction of synthetic fertilizers and the adaptation of plants to changing environmental conditions.** I cannot give any advice to younger scientists as my road has been a highly risky one and some colleagues have been the subjects of personal attacks, physical intimidation to their private residences. Ecoterrorists have also planted bombs inside research institutes. When I hold seminars in some cities I have to notify the local police in order to be protected. Everyone has to deal with these risks and it is not certain that everyone has to act in the same way and expose themselves in person; but at the same time every young scientist has to deal with logic, experimental facts and his personal moral principles. And I have no teachings to give to anyone, but I can listen to the suggestions from others who have faced similar risks and challenges.

4 Advice to the New Generation of Scientists

BROTHERS IN ARMS. To summarize the whole matter I have just discussed, it seems that we have lost the war to support the study and use of GMOs, but at least our honor is safe. In fact, the European Commission offered to each country the ability to prohibit cultivation of GMOs at a national level with the Directive 412/2015 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32015L0412) for reasons that are different from risks for health or the environment. EU thus admits that, despite there is no risk for the environment or health that can justify the denial to cultivate GMOs, social and/or psychological concerns overcome scientific evidences. As of today, 19 EU countries prohibit GMO cultivation for different reasons that go from social objections to landscape unfitness: whatever this means. At the same time, Europe imports and consumes over 30 million tons of GM soybeans per year as food and feed. This soy feeds the entire European livestock and therefore almost all cows, pigs, chickens and even farmed fish, as well as meat, ham, cured meats, milk, yogurt and cheeses, come from animals fed with GMO feed that cannot be grown in Europe. Included the best known, appreciated and exported Italian food products (DOP and IGP). Also, almost all the cotton we wear or handle in contact with our bloodstream, is GM: clear proof that no cotton patch has ever caused allergies or poisoning. Significant is the fact that these improved plants reduce the use of insecticides, promoting environmental benefits, and do not cause damage to health. To further refute the rampant anti-GMO misinformation I opened a blog in 2007 (now closed and transferred to Meta) where data, documents, interviews, documents and scientific articles were made available. Although many journalists have perfectly understood that the anti-GMO message is not based on facts, evidence and scientific articles they cannot fight this battle in place of the scientific community. I named my

blog "salmon", because it swims upstream against the current. The choice of name came years before GM salmon appeared on the market and was used only to highlight the fish's determination to pursue its goal, that is mating and spawning despite all the dangers it would face. The editorial I wrote in 2007 for the www.salmone.org proved years later to be a good omen for the appearance of the new technology of Genome Editing (Fig. 6).

> The "salmon" is a fragile and defenseless animal, but determined as few others. In the most important moment of its life, when it swims up rivers it's exposed to the aggression of hungry and merciless predators who without risking anything try to kill it, while it stubbornly swims upstream to reach its goal. The few who reach the goal will also die, but they do it to give birth to a new generation. The national scientific community, some cultural associations and a network of agricultural entrepreneurs who live off the fruit of their land, gathered under the acronym SAGRI (SAlute, AGRicoltura, RIcerca or Health, Agriculture and Research), must go up against the river of current thinking on GMOs. This in spite of all kinds of predators: almost the entire political class up to the top of Confindustria (the organization of Italian enterprise), large agricultural organizations, large-scale distribution and the environmentalist galaxy singing its catastrophic litanies to the inattentive media. There is objectively no hope of getting through unscathed, but at the same time it's not possible to hand over to our children a country that is so ignorant, so unscientific that it will once again make the fruit of myopic and provincial choices fall on their shoulders.

In my vision, as a scientist who has essentially lost his battle for the acceptance of the old transgenes technology, the CRISPR/Cas9-based method represents the way the new generation of scientist can embrace the challenges and move forward. The GMO burdensome past cannot cut the wings of the new generation's approach, effectively based on genome editing. Even so, my younger colleagues should always be aware that the lethargy caused by such a long lasting prejudicial bias on GMO will still continue for years, no matter if they are safe and respectful of the environment. A misleading "green" approach and the prejudice that scientists are "playing God"

Fig. 6 A bear biting a salmon

makes it even harder to go upstream. A young scientist that wishes to use scientific evidence in the public arena should be aware that she/he might be subject to public mockery (as recently myself http://extranet.greens-efa.eu/public/media/file/1/7922 to which I replied on the n.7 issue 2022 of https://scienceandethics.fondazioneveronesi.it/) and still be solid and confident in the scientific approach.

While waiting for the climate to change, those who edit mutations indistinguishable from spontaneous ones cannot be forced to fight the battle that my generation has valiantly lost. The legacy that I can leave is that it's useless to fight for a technology, for an additional publication, or for a better academic position if there is not an ideal goal to be reached. Pyramids are nothing more than a mass of bricks or stones without the project that holds together the foundations of mathematics, astronomy and engineering technology. I prefer to be a brick of a fascinating and evocative monument. But I have no moral suggestions to give to anyone and everyone has to look within himself/herself for the goal he/she wishes to achieve. Challenges are not always meant to be won. In my case the battle was fought to support the credibility of the entire scientific community. Working on food causes alarm in people instinctively and emotionally. GMOs have spurred these fears deep in people's minds, even though they are even healthier and safer than the plants from which they derive. Perhaps one of the keys to recognize the origins of these ancestral fears can be found in Ovid's Metamorphoses and in that mixing of the bodies of men with animals and of women with plants or rivers: as if some metamorphoses are legitimate while others are not.

Calestous Juma in his illuminating book: Innovations and Its Enemies. Why People Resist New Technologies (https://oxford.universitypressscholarship.com/view/10.1093/acprof:oso/9780190467036.001.0001/acprof-9780190467036), notes that Hephaestus has two unique characteristics: he is the only god of Greek mythology to be physically disabled, and the only god scientist capable of making unparalleled technological innovations. Hephaestus is conceived by Hera as a revenge for the betrayals of Zeus, but born ugly is thrown by his mother down from Olympus, thus becoming lame. Thanks to his workshops in the bowels of Mount Olympus (or Etna or any volcano) Achilles' armor and shield, the belt of Aphrodite, the bow and arrows of Eros, the chariot of Helios (Apollo), Pandora's box, in addition to the helmet and sandals by Ermes, are all made. Technological innovations bring envy and distrust. Just think of the feminine counterpart of Vulcan that is the most feared and isolated goddess of all the gods of mythology: the Goddess of Agriculture Demeter. I published the following text on Il Corriere della sera, La Lettura, on July 7th, 2019, page 6:

> The dim of twilight illuminates the Eleusinian plain in Attica. It is September 20, 480 BC. and a cloud of angry dust rises from the fields scorched by the arid summer. But that day the men are distracted and do not pay homage to the goddess of wheat who has granted them a bountiful harvest. The cloud is the result of the wrath of the offended goddess and will hit the Persian ships crossing those waters. Having offended the goddess of wheat will cost the invading army defeat in the naval battle of Salamis and with it the Persian aims to invade Greece will fade. If the world is what we know today, if the cultures of Egyptians, Jews, Greeks and Romans have come down to us, it is above all because our culture is the culture of wheat. Wheat with its symbols, its myths, its legends, technology, genetics and biotechnology where the Egyptians excelled, capable of giving life to fermented foods. The

Six Thousand Years of Bread by EH Jacob (https://www.amazon.com/Six-Thousand-Years-Bread-History/dp/1629145149) narrates these myths and events. These six thousand years are what forged our ancestors and are the foundation of Western civilization. Before we were hunters/gatherers who lived in sparse nomadic groups unable to release the refined potentials of the mind, emotions, fears and human relationships that flourish from common life in groups, communities, villages and then cities.

Only a settled people can set up an oven to bake bread: women are probably the source of the abrupt change of direction of human evolution. They observe that by planting seeds plants are born that if you take care of them will give a new crop. And the myth of wheat merges with the myth of the earth as a pregnant mother. The seed deposited in the womb of the earth will give birth to a new life. March 25 is the feast of the Annunciation to Mary of her conception, but it is also the day when the soil that will host the wheat seeds is plowed. August 15 is the assumption of Mary and also the moment of full ripening of wheat.

Dante compares Lucifer to a mill with three mouths, where he places Judas, Brutus and Cassius. (think of a mill as something like a GMO, as it is unnatural since it harbors the natural forces of wind and water to mill).

Agronomists such as Nazareno Strampelli (the father of hybrid granaries including Cappelli wheat) showed it first and followed by Norman Borlaug (Nobel Peace Prize winner for having quadrupled the yield of wheat in developing countries): without innovation and genetic selection we will not be able to counteract the ongoing climate changes, plant diseases, or defeat the prophecies of Thomas Robert Malthus to feed ten times more people (and better) than in his time (Fig. 7). Without innovation we will only have to rely on the dust cloud of some goddess, hoping she is kind.

The ongoing climate change, the war in the heart of Europe, the desertification of vast areas of the planet and resulting migrations, the extraordinary increase in the world's population and the desire to feed more and better, the conflicts over the use of water, are all factors that today are contributing to the dramatic food crisis. Norman Borlaug stated "If you desire peace, cultivate justice, but at the same time cultivate

Fig. 7 Norman Borlaug (left) shows to the USA vice-President Wallace (center) the problems of Mexican wheat in 1944. On the right, the Mexican Minister for Agriculture, Gomez. Photo credits: the Norman Borlaug Heritage Foundation

the fields to produce more bread; otherwise, there will be no peace" https://www.nobelprize.org/prizes/peace/1970/borlaug/lecture/). Without a vision of the future we will have a little hope of preventing new wars, of feeding enough people and of developing a safer future for the next generations. Without genetics, food will be rationed for the new generations: the "gene-rations".

Roberto Defez Researcher in Molecular Microbiology at the Italian National Research Council. Defez investigates the bacteria-plant interactions to understand the mechanisms leading from microbes phytohormone (auxin) biosynthesis to the increase of nitrogen fixation, plant salt and drought tolerance, to a reduced requirements for phosphate and an increase in plant dry weight and seed production. Work started with Rhizobium-legume symbiosis and now focuses mostly on cereal (rice, wheat) growth supported by endophytes isolated from harsh conditions. A collection of wild IAA (indole-3 acetic acid) producing endophytic strains triggering an increase in nitrogen fixation has been established. Defez is active in the public debate on GMOs, genome editing and organic agriculture. He is member of the Georgofoli Academy.