SHAPING FUTURE JOBS

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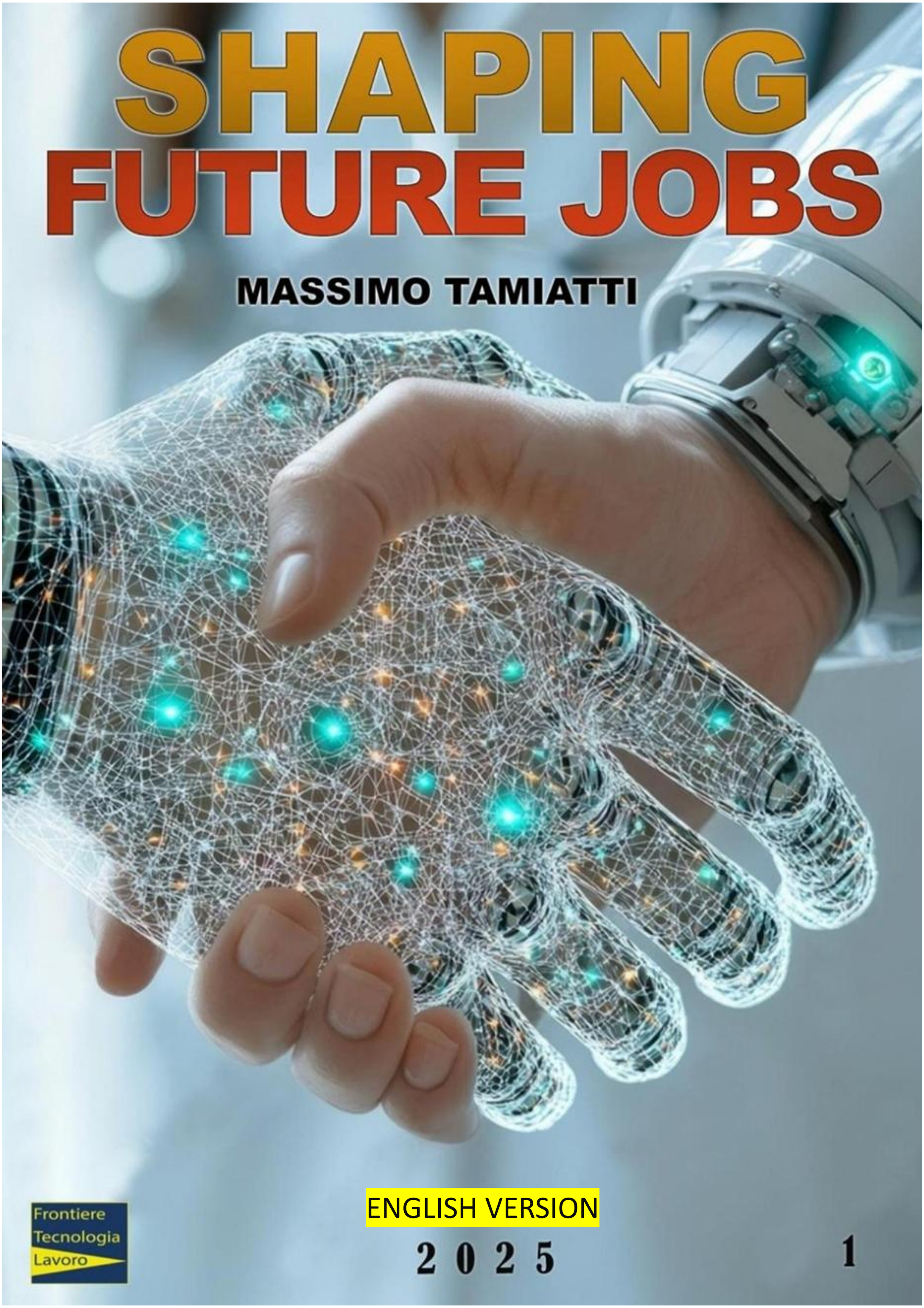

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What is it? This is a scientific dissemination website that studies the impact of new technologies on the world of work. Changes today are very fast and exponential. Professions are not static but very dynamic, so the ongoing evolutions can make them obsolete, transform them, or create entirely new ones. What skills will be necessary to face all this? Upskilling and reskilling, but not only.

Why? After 25 years of research, I have realized that to go beyond the boundaries, numbers are not enough. Traditional approaches are obsolete and tied to the old way of doing research. Today, we need to study the weak signals that are right before our eyes but that we see without really noticing. Stopping to consider these signals and imagining multiple possible futures will be the task of Frontiere. Traditional sources respond in real-time but only photograph the present. Today, however, there is a need to make predictions at least five years ahead, without neglecting the past and without forgetting that every topic addressed has a history to consider.

Who is it for? It's easy to make long-term predictions that cannot be verified. I am convinced that the research world needs an immediate confrontation with the world of education and orientation, and with young people who risk studying for professions that may not exist in a few years. They will be here to exchange opinions with the undecided, the disoriented, and those who intend to start over. Young people need to understand that there is a world above and a world below in the job market. A world of those who program algorithms (few and well-paid) and those who work for algorithms (many and poorly paid). We need to understand what to do to escape a job market that risks condemning young people to €1,000 per month salaries for life.

How will it be? Each topic will be addressed with light publications, with a strong emphasis on temporal depth. The publications will be accompanied by short videos (elivri) that get straight to the point. There will be an open chat for young people on the future scenarios of work, the profiles required, and the necessary skills.

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SHAPING FUTURE JOB

THE FUTURE SHAPE OF WORK

INTRODUCTION

TECHNOLOGICAL CHANGE AND THE FUTURE OF WORK

From the linear world to the exponential world. We no longer live in a linear world, but in an exponential one. But how did we come to this conclusion? By connecting points on a Cartesian plane. On the x-axis (X) we placed time, and on the y-axis (Y) the technological progress achieved at a given moment. The hypothesis was to define a straight line, but it was discovered that this straight line is increasingly becoming a curve, whose slope grows exponentially(1). In the next 20-30 years, this curve will be practically asymptotic to the y-axis. What does this mean? That the curve no longer intersects the axis, and a certain point of intersection can no longer be defined. At a certain point, we will know the speed at which we are going, but we will not know where we are. In technological language, this is called singularity (i.e., technological progress goes out of control, we no longer control the machines, and what will happen does not bode well).

The accelerators of time. We are at the mercy of powerful "time accelerators," particularly Genetics, Nanotechnology, Robotics, and Artificial Intelligence. What is most concerning is the acceleration of technological change, which has never been so impressive in history. If there is one thing that has changed, it is the speed at which we are innovating. Technology is now evolving at a pace that the average human cannot keep up with(2); it also seems to evolve almost autonomously, driven by an intrinsic dynamism(3).

Innovation as the engine of the future. But the future of the world has always been driven by innovation and technology, clearly thanks to research. Research, particularly scientific research, is the engine of innovation and thus of economic competitiveness. Italy has experienced a long period of economic crisis because it pursued a "development model without research." To emerge from the tunnel of decline, we must focus on science, because nothing like research can relaunch the economy in the long term, achieving structural and lasting improvement.

Scientific research and economic competitiveness. What is happening today is above all an extraordinary scientific and technological revolution. There are especially four forces driving, fueling, and generating this revolution. Innovations in these four fields will have a strong impact on the economy and work. These are forces that are trying to remake our world, and in presenting them, we will, so to speak, take a step forward into the future and then two steps back to understand what is really happening. In short, we will be helped by the sociology of the possible.

CHAPTER 1

NANOTECHNOLOGY

Future visions: a step forward. In his famous 1959 conference on miniaturization, Nobel Prize in Physics Richard Feynman prophesied the arrival of the nanotechnology era with the words "There's plenty of room at the bottom." Decades later, in 2001, Nobel Prize in Chemistry Richard Smalley corrected Feynman's prediction: "There's not that much room." This very brief exchange of remarks, spanning about half a century, well summarizes the history of nanotechnology: those methods of manipulating atoms and molecules ("at the bottom" according to Feynman), designed to produce materials and components on the order of nanometers, i.e., tiny technological systems capable of building anything, even on a macroscopic level: "from a spaceship to a tiny submarine capable of navigating blood vessels and fighting infections"(4). These nanorobots can take any form. We are talking about a discipline that transforms information into matter and matter into information, an indefinite number of times instantaneously. The word "nanotechnology" was popularized in 1987 by K. Eric Drexler, a scientist at the Massachusetts Institute of Technology, in an essay titled "Engines of Creation: The Coming Era of Nanotechnology," in which he argued that the future of technology would be dominated by microscopic nanobots he called "molecular assemblers," ideally capable of assembling any macroscopic object, arbitrarily complex, from individual atoms or molecules that compose it. The feasibility of this idea, as the author himself admitted at the time, seemed to belong more to the realm of fantasy than to that of technological speculation, as it was never discussed in its technical details. Instead, Drexler limited himself to arguing it based on a general analogy with biochemical systems: just as ribosomes are capable of assembling proteins, according to the chemical-physical "instructions" encoded in DNA, building extraordinarily complex living organisms, the "molecular assemblers," assisted by Artificial Intelligence, will be capable of assembling any synthetic material, from steel to silicon, with "atomic precision." Without ever questioning the technological feasibility of his nanobots, Drexler devoted much of his essay to considering the different scenarios that humanity in the near future, confronting this new technology, would find itself facing. From the conquest of deep space to the indefinite extension of human life, nanotechnologies will allow humanity to build a new "technological Eden," provided that the "molecular assemblers," with their boundless potential, do not fall into the wrong hands or, even worse, become capable of self-replicating indefinitely and completely uprooting any form of biological life on Earth, rendering it obsolete.

State of the art: two steps back. Beyond the (scant) scientific validity of his theories, Drexler's imagination has had an undeniable impact on the public perception of nanotechnologies and, to some extent, has helped determine the course of their technological development, within the limits of what wild speculation can withstand the harsh test of experimental science. Between the late 1990s and the early new millennium, nanotechnologies were at the center of the debate on the future of technology, with more or less founded considerations on their promises and dangers; a relevance largely due to the spread of Drexler's work, which in any case favored a great push for research in the sector. Today, however, we are far from this scenario. The so-called "nanobots"(5) are still science fiction, something fascinating, but they remain surreal. We could reflect, at most, on the danger of engineering nanoparticles containing toxic compounds or potential chemical and biological weapons, very lethal, developed by governments, but here we are talking about poisons and this has nothing to do with dimensions. The "nano" label does not define a good or bad technology, but identifies a way to solve problems at the molecular level. This can be extremely useful, especially in medicine(6). This means that a public discourse, which takes into account the potential and contemporary challenges of nanotechnology, beyond the post-humanist fantasies of the last century, is sadly lacking, confirming how often the sciences, especially applied ones, are neglected and misunderstood when they cannot be flattened onto sensational and implausible narratives. Certainly, the troubled history of nanotechnologies exemplifies the process that brings nascent science to see the light, disentangling itself from narratives of the future, ideological conflicts, and technological constraints. Beyond nanobots, the issues raised by nanotechnologies are significant and fascinating, starting from the fundamental and cross-cutting question of how it is possible to control and efficiently program the complex assembly processes.

Applications and sectoral impacts. From a more practical point of view, nanotechnologies are one of the fields of contemporary science that pose the increasingly urgent problem of understanding whether, and under what conditions, it is possible to find a technological way out to the challenges of the future and whether there is still room, in the face of the climate crisis we are immersed in, for the unconditional techno-optimism of the past. In this, I believe that Drexler's work, despite all its oddities, and the debate that ensued are a precious example of the value of scientific discussion, even and especially when it goes beyond the limits of technical considerations, to venture onto the uncertain ground of speculation about the future that humanity will face(7). It was therefore from the 1990s that nanotechnologies became research, a concrete fact, leaving the territory of the genius of visionary scientists. And today, after thirty years, we are able to manipulate all kinds of materials on a dimensional scale smaller than a micrometer, modifying their composition and atomic or molecular arrangement, with the possibility of developing "nanotech" products and devices in the most diverse fields. It was estimated that by 2020, about 20% of all products manufactured globally would have employed a certain share of nanotechnologies. In fact, an OIL report stated that about 6 million would have been employed worldwide in this sector. In Italy, more than 670,000 individuals are estimated to be involved in the impact of nanotechnologies(8). These new technologies will create many jobs. The future belongs to biomaterials, now present in many industrial sectors. The ace up the sleeve of nanotechnologies remains graphene (with atoms thick from 0.1 to 0.5 nanometers). A sheet of carbon one atom thick. To obtain it, graphite is treated with a solution of sulfuric and nitric acid. All this gives rise to a material much stronger than steel, moreover very light and thin. Today we are able to see the infinitely small at a dimension where atomic architectures are distinguishable. Sophisticated nanotechnologies allow us to build and repair matter, without distinction between inorganic, organic, and biological. Working, in short, on increasingly smaller dimensions until reaching atomic precision. The direct vision of the infinitely small, of a dimension in which it is possible to distinguish atoms and their structure, is a recent achievement and has been made possible by technologies and methods roughly grouped under the term "nanotechnologies or nanoscience," a discipline that has seen constant progress in improving measurement tools, which could allow us the observation and knowledge of phenomena on increasingly smaller scales, down to the nanometer, the unit of measurement of this new technology. In a nanometer (which corresponds to 1 millionth of a millimeter), three atoms align. We are therefore in the most intimate measure of matter(9), a dimension tens of thousands of times smaller than the thickness of a human hair(10). We use the term "nanotechnology" to embrace a large number of innovative methods and processes, which can include nanomaterials, nanostructures, and nanodevices. The term nanotechnology is thus used to generically describe all microscopic technologies, however different they may be from each other. This new science has allowed researchers to develop materials never seen before (synthetic nanomaterials) and to manipulate existing substances on a nanoscale, discovering entirely new uses for them. These are technologies that continue to have an increasing impact on materials, tools, and processes, involving a variety of industrial sectors. Nanotechnology represents a branch of science directed at the study of very small technologies, smaller than a nanometer! Today, there are already "intelligent" particles of one millionth of a millimeter and microrobots the size of a bacterium. Nanorobots are molecules with unique properties, which can be programmed to perform a specific task. By exploiting nanorobots, nanomachines can be created for various purposes. Nanomotors, nanosensors, nanoactuators can be manufactured. The technologies used for nanorobotic manipulation must use innovative techniques to achieve the assembly and manipulation of cells or biological molecules of such infinitesimal dimensions, by the different types of robots used. In fact, today researchers descend into the basements of matter, where molecules and atoms are found and where the processes of physics, chemistry, and biology take place. Nanotechnologies are entering everywhere, and their pervasiveness is now evident: from electronics to drugs, from food to industrial processes, from agricultural production to 3D printers. They are improving their performance everywhere, so there are increasingly numerous applications in various economic sectors: in food for food preservation; in precision agriculture for miniaturized pesticides, herbicides, and nutrients; in construction with nanotubes for load-bearing structures, with high-strength concrete, with thermally conductive silicones, with anti-corrosion, self-cleaning, insulating, or water-repellent materials; in electronics with the ever-increasing miniaturization of device components (video cameras, screens, biometric scanners, intelligent car headlights, anti-collision sensors, projectors integrated into smartphones, etc.); in medicine and pharmaceuticals (precision medicine for diagnosis or for drug transport within the organism)(11). And it is especially in the medical field that nanotechnologies are bringing their revolution: early diagnoses at the level of single molecules, before the onset of a pathology; new materials for tissues and organs; very small vectors that attack diseased cells, releasing a drug on their membranes; nanosensors that identify tumor markers in a single drop of blood; artificial skin capable of perceiving touches, pressures, heat and cold, hard and soft, and why not, soon the realization of artificial retinas. We must not forget other applications: energy saving (nanocatalysts capable of increasing the efficiency of normal thermal engines); smart fabrics such as films of water-repellent, self-cleaning, antibacterial, insulating, stain-resistant fibers and their applications in the sports sector, in work clothes, and in safety equipment. Finally, nanotechnologies in everyday life: scratchresistant surfaces present in household items, on glasses and watches, toothpastes containing cleaning microspheres, up to cosmetics and sunscreens. But nanotechnologies will play a leading role, in particular, for the energy transition. In fact, regarding the environmental sector, many things have already been achieved, others are in preparation: biodegradable materials, plastics derived not from oil but from plant waste, greater efficiency in transport thanks to ultra-light materials (ten times stronger than steel), special decontaminating sponges that absorb oily substances present in water, molecular recycling of waste, new systems for accumulating and transporting wind and solar energy, improvement of industrial processes, selective filters to make water potable, techniques to minimize the environmental impact in agricultural production, greater efficiency in the exploitation of energy resources thanks to less polluting engines. And something very important, the future prospect of being able to desalinate water at compatible costs, a fundamental challenge in a world where water is paradoxically becoming a precious commodity, despite the existence of entire oceans. Nanotechnologies will increasingly be at the base of the hoped-for energy transition. Advanced nanostructures, in fact, will find application as innovative (bio)sensors, in the production of green hydrogen and new generation batteries and supercapacitors, in the detection of fine dust and toxic gases, of virus sensors and tumor markers, and more. But one of the most ambitious future objectives of nanotechnologies is to increasingly imitate natural systems, which have proven to be much more efficient than technological ones. For example, by realizing artificial photosynthesis. Today, there are already "intelligent" particles of one millionth of a millimeter and microrobots the size of a bacterium. Certainly, we are only at the beginning, but it is evident that in perspective, this artificial microfauna will increasingly be able to imitate certain natural systems. A new generation of tiny machines can perform tasks in the smallest corners of our body, even inside our cells. These medical nanorobots have the potential to act as intelligent drug delivery systems, transporting drugs to infected cells and bypassing healthy ones, thanks to the joint efforts of doctors, chemists, physicists, and biologists in creating technological platforms capable of improving the therapeutic efficiency of drugs and the diagnostic potential of imaging techniques in terms of specificity of action, sensitivity, and limitation of adverse effects. Such nanotechnological platforms have been specifically designed to promote the transport of diagnostic or therapeutic agents through biological barriers, to selectively reach specific targets, to mediate molecular interactions and respond to local and external stimuli, and to identify specific molecules. A well-known example is vaccines based on messenger RNA technology (such as those against COVID-19): ribonucleic acid or RNA is incorporated into nanoparticles that act as vectors. These vectors protect the molecule and transport it where needed. Being chemically engineered, it is easier for these nanoparticles to be accepted by cells. In a not-so-distant future, mRNA modulation could have clinical implications for targeted therapies, without changing the individual's genetic code and thus differentiating itself from genome editing, which instead corrects the genetic defect by acting directly on the DNA. Some of these nanomaterials are currently used in clinical protocols, others are still in preclinical phase studies, many others are still the subject of experimental research. But if these artificial particles enter the body, could they not have contraindications and cause damage? There is therefore a need to study this possibility very carefully. In fact, our immune system is not designed to attack objects so small that could enter the cell and the DNA. It is true that when a nanoparticle enters the body, it is coated with proteins that make it silent, but more rules and experimental verifications are needed. These are just some examples, but the possibilities, as we can imagine, are multiple and constantly evolving. Nanotechnologies are paving the way for many new discoveries and innovative solutions in many industries and sectors. There is no official list of nanotechnology companies in Italy, but it is estimated that there are several hundred. Some of the most well-known and active companies in this sector are Wise, Leonardo, P4I, Solexel, Nanogap, and many others. These companies operate mainly in sectors such as electronics, biotechnology, energy, automotive, and many others. Certainly, the Research and Development area has a very important presence of people dealing with nanotechnologies. Think of universities, government and private research centers, which, thanks to the study of nanotechnologies, develop new solutions and technologies. Naturally, the most significant commitment is in industry. These are companies that produce electronic components, drugs, medical devices, cosmetics, and food. We must not forget the government agencies that regulate their use and safety. There are many job opportunities in the field of nanotechnologies.

Emerging professions and skills. The demand for qualified professionals in this field is continuously increasing, so career prospects are very promising. Graduates in nanotechnologies can also work in adjacent sectors, such as biology, chemistry, physics, and engineering, depending on their specific skills and interests(12). What are the necessary study titles to face this new technological scenario? Certainly, a degree in nanotechnologies provides a solid understanding of the science behind the technologies, as well as practical knowledge of the technologies and processes involved. Degrees in Physics, Chemistry, Engineering, or Biology can provide a solid knowledge base for working in the research and development of nanotechnology-based solutions. The Master's in Nanotechnologies can then provide more advanced and specialized training in the field and can be useful for those who want to specialize or advance in their careers. The PhD in Nanotechnologies is an advanced degree that provides in-depth and specialized training in the field and can be useful for those who want to work in research or university teaching. Career opportunities in the field of nanotechnologies are naturally open to those who have a solid scientific and technological background and a strong interest in science and technology. More generally, the new profiles go beyond the boundaries of interdisciplinary science, as their goal is to create new materials, new procedures, and methods based on interactions between particles, manipulating matter on a nanometric scale(13) and developing new materials and equipment, such as drugs and diagnostic tools. Professions in this field can include: the Nanotechnology Engineer, who designs and develops nanoscopic products and technologies; the Nanotechnology Researcher, who conducts research to develop new nanotechnologies; the Nanotechnology Technician, who supports researchers and engineers in the production and development of technology; the Materials Scientist, who studies materials at the nanoscopic level; the Medical Technologist, who uses nanotechnologies to develop innovative medical diagnostics and therapies; the Biomedical Engineer, who uses nanotechnologies to develop biomedical devices and technologies; the University Professor, who teaches and conducts research. Equally important and strategic are: the Software Developer, who creates software for modeling, simulation, and analysis of nanoscopic systems; the Designer of these systems and their multiple applications; the Nanotechnology Consultant, who provides technical and commercial advice to companies and organizations; the Nanotechnology Regulator, who regulates their use and the commercialization of products; the "Business Development Manager," who identifies commercial development opportunities and develops strategies for the success of companies; the Safety and Health Expert, who evaluates these two aspects. These are just some examples of professions in this field. With the evolution and increasing importance of these technologies, it is likely that new professions will emerge in the future. There are also emerging figures, better known as nanomedics and materials and nanotechnology engineers. Nanomedicine is the medical application, the result of nanotechnological research and innovations. It deals with all those knowledge and technologies that have a medical use on the order of magnitude of nanometers. Working at these dimensions, nanotechnology alters the traditional distinction between biology, chemistry, and physics. The professional opportunities for the graduate in materials and nanotechnology engineering mainly come from industries that produce, transform, and design innovative materials. Even the sectors of surface treatment, the polymeric materials industry, and the metallurgical industry offer interesting opportunities after graduation in materials and nanotechnology engineering, along with industries that work with materials in the sectors of mechanics, energy, transport, construction, and electronics. The Materials and Nanotechnology Engineer thus finds employment mainly in the high-tech manufacturing industry operating in the various sectors of engineering (mechanical, aerospace, automotive, transport, advanced materials, electrical engineering, bioengineering, transformation and production processes, biomedical engineering) and in companies operating in the electronics sector. This engineer is able to manage, coordinate, and direct highly complex projects and is able to perform leadership activities thanks to the acquired skills in developing innovative methodologies and products, designing and controlling complex micro and nanosystems, and solving cross-cutting issues related to the use of micro and nano technologies. The Materials and Nanotechnology Engineer also finds employment as a researcher in advanced research centers. Furthermore, thanks to the in-depth knowledge of engineering disciplines characterizing industrial and electronic engineering, they are qualified professionals and can access the Register of Engineers also for the industrial section. Innovative materials can become a determining factor for a company. They constitute an indispensable element for all cutting-edge application sectors ranging from energy to health, to transport, with particular attention to the sustainable development of society. The opportunities offered today by nanotechnologies considerably broaden the cultural and technological horizon of the engineer and constitute the ideal completion of their professional training. To operate in this field, various skills are required, including a series of specifically vertical skills, such as in-depth knowledge of physics and chemistry at the molecular and nanoscopic level. Knowledge of materials engineering and science is fundamental, with a focus on the design and production of materials, as well as knowledge of the related production technologies, such as lithography, sputtering(14), effusion deposition, and bottom-up assembly(15), and knowledge of the physical and chemical properties of materials at the nanometric level. The skills of analysis and characterization of materials with techniques such as electron microscopy and Raman spectroscopy(16) are also important. Knowledge of the related applications in various sectors, such as Medicine, Energy, Electronics, and the Environment, is also important. These are some of the necessary skills, but the list may vary depending on the activities and projects. Therefore, beyond solid knowledge, it is good to highlight a series of skills necessary for these types of jobs: significant experience in working with microscopes and other equipment used in laboratories; cross-cutting skills such as the ability to think creatively and problem-solving to solve technical and scientific issues; good communication and teamwork skills to collaborate with colleagues and industrial partners; knowledge of the rules and laws related to safety and protection in the use of materials and technologies. However, a very flexible mental openness is necessary to adapt to rapid developments and changes. Other important skills for working in nanotechnologies are: the ability to analyze and interpret scientific and technical data; knowledge of advanced computer technologies for data processing, analysis, and modeling; expertise in the design and development of new materials. A good knowledge of the English language to read scientific literature and participate in international conferences is also essential, as updating in this sector is of vital importance.

Development prospects and labor market. Nanotechnology is an emerging science that promises rapid and dynamic future developments and from which a significant contribution to economic growth and job creation in the European Union is expected in the coming decades. It is difficult to predict with certainty how many jobs will be created by nanotechnologies in the future. However, it is expected that nanotechnology will have a significant impact on many sectors and will create job opportunities in many areas, including science, engineering, healthcare, and technology. It is estimated that nanotechnology will have an important impact on the production of consumer goods, such as electronic devices, drugs, and advanced materials, and this will lead to a growing demand for experts in these sectors. Furthermore, nanotechnology is destined to play an increasingly important role in personalized medicine and gene therapy, creating new opportunities for professionals in these areas. In general, it is expected that nanotechnology will create many highly specialized jobs in the coming years, offering opportunities to those who have advanced training in science, engineering, and technology. However, as with any other rapidly evolving technology, it is likely that nanotechnology will also reduce the need for some existing professions, so it is important that people are prepared for these changes and adapt to new work models. There is no precise estimate of the number of jobs created by nanotechnologies in Italy. However, it is expected that nanotechnology will have a significant impact on many industries in Italy, including electronics, the production of advanced materials, pharmaceuticals, and biotechnology. This will lead to a growing demand for highly qualified experts in these areas. Furthermore, in Italy, there are many universities and research institutes that conduct advanced research in nanotechnology and biotechnology, offering job opportunities for researchers. In any case, nanotechnology represents the opportunity for Italy to develop new industries and create highly specialized jobs for future generations. According to scientists, four distinct generations are expected for nanotechnology; currently, we are witnessing the first or perhaps the second generation of nanomaterials. The first entirely concerns the science of materials, with an improvement in properties, thanks to the inclusion of "passive nanostructures"(17), for example in the form of coatings and/or through the use of carbon nanotubes to reinforce plastic. The second generation uses "active nanostructures"(18): for example, thanks to bioactivity, it is possible to administer a drug to a specific organ or to a specific target cell by coating the nanoparticle with specific proteins. The complexity increases further with the third and fourth generations. Starting from an advanced nanosystem, the result of nanorobotics, to then, with the fourth generation, move to a molecular nanosystem to control the growth of artificial organs. Nanotechnologies offer great opportunities for social and economic development in various sectors, but many questions remain open about their current and future potential, with particular regard to the effects on human health. The scientific community is focusing its efforts to fill the gaps in knowledge and promote research, taking into account potential risks. However, we still know little about the toxicity of these materials, and even less about their synergistic impact. Furthermore, some nanoparticles could be generated "accidentally" during other processes, and in this case, it would be much more difficult to govern their effects. We do not even know if normally safe materials can become dangerous when reduced to the nanoscale, as the laws of chemistry and physics act differently when particles are infinitely reduced. Inert metals can become highly reactive, and normally benign substances can become toxic. Nanoparticles are so small that they can penetrate deeply into human tissues, and if they were toxic elements, they would cause serious injuries and diseases, as indicated by Professor Maher's research(19). Such consequences, in the broader context of the problem of air pollution, determine a lethal synergistic effect on everyone's health.

But are we really sure that, while science discovers and technology innovates, society remains unchanged? It is not a minor issue. Depending on how we answer, the paradigm with which we judge the world changes. If we answer negatively, we will embrace a new vision of the world in which science and technologies will lose their role as masters of our destiny, where innovation will run parallel to our lives, never taking the lead, condemning us to a perpetual and frustrating chase, where our habits will not be disrupted by novelties that no one expected. Useful or harmful, resolutive or diabolical, the discoveries we imagine will not catch us unprepared as if they "had been catapulted from a parallel universe." Simply because, for the most part, the innovations that many hope for and just as many fear are already among us: when we talk about nanotechnologies, we must not imagine a distant future, but a present in the making(20).

CHAPTER 2

GENETICS

Future visions: a step forward. This discipline is giving humans not only the ability to interpret their own genome and that of all other living organisms but also to modify the genetic code as if we were biological computers. The forces that will drive this discipline will put us in a position to promote eugenic processes. Research, in short, for a refined, superior, more beautiful, healthier, stronger, longer-lived race. Each of us wants to be something more, regardless of what we are. Will we therefore become GMOs, genetically modified organisms? What will be the parameters that define whether it is legitimate or not to evolve biologically, to decide the biological destiny of children? A 1997 film, "Gattaca," in which director Andrew Niccol told of a future of humanity in which all aspects of human life were regulated by genetics, in a context of struggles between those who were born genetically programmed and those who came into the world with a natural genetic heritage. More than twenty-five years have passed, but this film is still very present in the common imagination, so much so that it is still cited in books and essays as a sort of possible/probable future, which could be quickly reached thanks to the progress of genetics. But is it really so? And why is it important to understand how the permanence of the idea of "Gattaca" in the common imagination can influence the perception of 21st-century genetics? Just a few years after the release of "Gattaca" in cinemas, the first phase of the human genome project was closed, and in the following years, the fully sequenced human genome became the heritage of humanity(21).

State of the art: two steps back. Genetics is a branch of biology that studies genes, heredity, and genetic variability in living organisms(22). In short, how genes work and what we can do with them. The progress made by science and the increasingly accessible prices for everyone will lead to exponential growth in demand in this field (today, to do a DNA test, less than 200 euros are needed; just a bit of saliva and after a few days, you can find out, for example, if you are predisposed to certain diseases). Furthermore, in the near future, genetics will be able to cure the genetic diseases of the newborn directly in the mother's womb. The "sick" part of the DNA could be replaced to eliminate the disease, like a spare part thanks to the work of the genetic engineer. Each of us possesses a great, personal book of life, in which to read our own story and future: it is DNA, which is physics, chemistry, and information, but also the best "drug" of the future. Genetics opens the doors to a tomorrow that is already very close, a new frontier of medicine capable of curing rare diseases and saving the lives of children affected by very serious diseases(23). Experts from the National Human Genome Research Institute (NHGRI) predict that by 2030, it will be possible to have our genome at hand on our smartphone, along with a sort of guide to help interpret it. This is just one of the 10 "bold predictions" outlined by US experts in an article published in the specialized journal "Nature." Among the hypotheses, NHGRI experts also aim to discover the biological function of every gene in human DNA within the next decade and to make genetic tests routine exams, just like blood tests(24). The "themes" are very sensitive and need to be kept under control. The field of genetics is very broad and therefore, depending on the various areas of use, requires specific and different skills, so it must rely on various types of professionals(25). In the field of medical genetics, certainly one of the most important, there are figures who physically perform genetic tests, others as Laboratory Technicians analyze them, and others still explain the results and evaluate the possible strategies that can be implemented(26). For example, they work with people who have fertility problems, to check if there is an obstructive genetic component, or to assess the presence of a gene carrier of rare diseases. Animal medicine also offers many genetics jobs, not only the figure of those who provide breeding advice, as well as the agricultural industry that uses geneticists to develop new crops and improve their performance. There may be people, more interested in research, who deal, for example, with the sequencing of the genome of various organisms, the manipulation of genetic material, and the study of genetic inheritance. Genetic technology can be used to diagnose diseases that have specific genetic markers or are inherited from parents. There are also applications in forensic medicine. DNA analyses are used for paternity tests or for identifying murder victims with unknown identities. Analyses in genetic laboratories can be very rewarding because DNA samples are difficult to extract, and few specialized laboratories are able to work on such rare, unusual, and interesting samples. Furthermore, the cures of the future that will develop between technology, genetics, and digital therapies applied to science will have a very clear objective, which is the personalization of cures. In the next ten years, many new therapies will arrive in clinics. Analysts estimate that by 2030, 50 new advanced therapy products will be authorized(27).

Innovative technologies and applications. But when talking about new frontiers of genetics, one cannot fail to mention genome editing: what is it and what is it for? Genome editing is a highly innovative technology that works like a "proofreader" of DNA: it intervenes precisely to find and correct genetic errors within the entire genome. By knowing the DNA of each individual, it is possible to search for "typos" and act like a proofreader. CRISPR is a new genetic editing technique that allows correcting the DNA of any organism, whose discovery earned Emmanuelle Charpentier and Jennifer A. Doudna the Nobel Prize in Chemistry in 2020. Many consider genome editing as the gene therapy of the future, as it would allow correcting a defective gene directly where it is, without having to provide a copy from the outside. The real revolution in this field came in 2012 with the discovery of the CRISPR-Cas9 system (recombinant DNA), which overshadowed the editing systems that had been used by researchers worldwide until then. CRISPR has shown from the beginning a potential and versatility that were unimaginable until recently: any type of plant, animal, including human, cell can be genetically modified, and the correction can occur even for a single error and anywhere in the genome. Furthermore, this technique is easy to use, fast, and economical. Today, the expense faced by a researcher to sequence a human genome within a specialist laboratory is about a thousand dollars. CRISPR is the acronym for "clustered regularly interspaced short palindromic repeats," i.e., gene sequences that repeat at regular intervals. CRISPR is based on the combination of two elements: a Cas enzyme and a guide RNA that pairs with the virus's DNA to indicate to Cas the point where to cut. As in the case of gene therapy, the editing strategy based on CRISPR can also be administered externally on living cells taken from the organism. It has been compared to a text editor for genes since it is possible to edit and copy their sequences. Used ethically and responsibly, it has the potential to cure any genetic disease, including cancer, blindness, and AIDS. CRISPR-Cas9 is usable at low cost and allows anyone with a basic knowledge of the subject to do genetic engineering(28). Sometimes the sequence of a gene is not correct, and therefore the work done by the protein in the cell is not correct. That is, it does not act as it should in the "normal" body and can have consequences on health or the constitution of a body. These are the sequences that are the focus of geneticists' attention. In agriculture, changing or correcting them means accelerating that process of "artificial selection" on which humanity has always operated to obtain better food varieties. In the future, being able to safely apply this technique to humans could lead to the cure of many genetic diseases. Germline genetic editing represents one of the most promising and, at the same time, most discussed and controversial frontiers of genetic engineering in general and of today's scientific research in particular. We have often wondered what would happen if humanity could alter the very substance of the genetic code? Well, humanity can do it and is already doing it. In fact, on November 26, 2018, during the second International Summit on Human Genome Editing in Hong Kong, Chinese scientist and researcher Jiankui He(29) made an announcement of revolutionary significance for the scientific world in general and for the field of genetic engineering in particular(30). He declared, in fact, that he had given birth to the first genetically modified human beings, the twins Lulu and Nana. All this is the result of numerous genetic engineering experiments already carried out on animals, particularly on Beagles, genetically modified dogs, as strong as bulls, to be used for police operations and to understand the effects of Parkinson's and muscular dystrophy on humans(31). An ethical alarm bell, because for the first time a scientist has communicated that he has deliberately engineered the DNA of a human being, producing heritable changes that will be transmitted to future generations. We do not know if the two genetically modified baby girls are healthy, we hope so. The scientific community, however, has risen in opposition to this research, which should only be retried under very strict guidelines. A Chinese court then sentenced the researcher to three years in prison in 2020 for using the CRISPR genetic editing technique on human embryos. The sentence reflects China's decision to sanction this ethically questionable practice but risks also curbing research in other areas(32). However, there is a widespread belief that altered DNA has already been done with human embryos in the United States as early as 2017(33). To all this is added a biotechnology company based in Israel, Renewal Bio, intending to create synthetic human embryos from stem cells. They would be a "reservoir" from which to draw tissues and blood. The experiment has already succeeded with mice(34), now they have raised the stakes. It would therefore no longer be a matter of giving birth to humans but of "cultivating" them. However, the news of the first form of life entirely created in the laboratory dates back to 2003. Craig Venter was indeed the first to succeed in creating a synthetic virus. However, imagining that a human being could be artificially created seemed until now like science fiction, yet science fiction could soon become reality. Precisely the Israeli start-up, Renewal Bio, is carrying out some experiments that should lead to creating embryos in the laboratory in such a way as to extract tissues and use them in transplant treatments(35). At the current state, research only allows growing simple tissues such as cartilage or bones, while it is encountering not a few difficulties regarding complex organs. In the same mice, less than one attempt out of a hundred has been successful, and even the embryos that have lasted the longest have eventually developed anomalies(36). The use of human embryos for medical treatments, "cultivated" as in this case or cloned, is a topic that periodically emerges within the scientific community. The international community appears increasingly divided over this latest case, between those who see in this practice an advancement of medical science and those, who seem to be the majority, are concerned about the ethical implications of this type of projects(37). Cloning a gene, or rather cloning a DNA sequence, means isolating it from a specific genome and producing multiple copies. Cloning is a scientific practice that has aroused curiosity, interest, and doubts. Although it is widely used in some fields of research, within the limits of what is permissible, many continue to associate it with the famous sheep Dolly(39), while today its applications are much more complex, and there is the actual fear that the situation may get out of control. This achievement marked a fundamental milestone in the history of biomedicine and revolutionized research. In the last 25 years, in fact, many other mammals have been born that have not enjoyed the same fame as Dolly(40). This achievement has had very important repercussions on biomedical research, paving the way for studies on stem cells, which earned Japanese scientist Shinya Yamanaka the Nobel Prize in Medicine in 2012. In fact, stem cells are adult cells that have regained the ability to differentiate into any cell type. The cloning that concerns individual genes is a technique used in many laboratories around the world. It has made possible the production of monoclonal antibodies (COVID-19), the introduction of genes for resistance to fungi in treatments, and the cure through gene therapy of hereditary diseases. The cloning of entire organisms for reproductive purposes (creating organisms) or therapeutic purposes (creating cells) obviously raises important ethical questions, as recalled in the previous analysis. China recently announced (June 10, 2022) the birth of Maya, the first cloned wolf puppy with a surrogate beagle mother(41). Genetics is transversal to many sectors. In summary, it mainly deals with the diagnosis and treatment of genetic diseases and personalized medicine, but also with the production of new drugs and vaccines and the cloning of stem cells. Genetics also operates to obtain more productive and resistant plants and animals. It intervenes in industrial productions (biofuels) and environmental remediation. And let's not forget a delicate field like GMOs(42), used in agriculture and livestock. Research is an indispensable part of genetics and human genetics. It occupies an increasingly preponderant role in every area, but especially in medicine, influencing its progress and knowledge. To understand what genetic engineering is, it may be useful to start from the definition given by the Treccani dictionary: "genetic engineering is the set of technologies that allow the in vitro manipulation of DNA molecules, in order to cause predetermined changes in the genotype of an organism. Through these genetic manipulations, it is possible to produce new gene combinations, determine specific mutations, introduce genes into cells where they can express new functions." The core of genetic engineering is therefore "manipulation," understood as a tool through which to create new gene combinations and determine specific mutations. In fact, the generic term "genetic engineering" is used to refer to a branch of biotechnologies consisting of a set of techniques used to isolate genes, clone them, and insert them into an organism different from the one of origin; the operation can also occur between organisms of different species (for example, even from bacteria to plants and vice versa). In essence, with these techniques, new characteristics are conferred to the cells that receive the modified genes. In fact, innovative biotechnologies, engaged in creating new organisms starting from the transfer of genes from one organism to another, use genetic engineering as their main tool. Precisely, recombinant DNA technology is the basis of genetic engineering: this technique allows identifying a favorable gene in the DNA of an organism, cutting it, and isolating it from the DNA molecule itself; the isolated gene is then joined to a vector consisting of DNA and transferred into a receiving cell. The purposes for which this operation is carried out can be multiple: it may be necessary to genetically improve the receiving organism, or to use the latter to proceed with the cloning of the foreign gene, using the host cell as a "machine" to produce other useful molecules(43).

Professions in the genetic field. But how does one become a Genetic Engineer? In light of what we have seen so far, we can intuit how versatile genetic engineering is, constantly evolving, capable of bringing innovation in a variety of fields, in short, the first step to becoming a Genetic Engineer. Genetic engineering, on the other hand, is a sub-discipline of biotechnology that specifically focuses on the use of genetic engineering techniques to modify living organisms. Genetic engineers use techniques such as cloning and genetic manipulation to create organisms with specific genetically modified characteristics. In summary, a biotechnologist is a professional who uses molecular biology and genetics techniques to develop new products and processes in various fields, while a genetic engineer is a professional who uses genetic engineering techniques to modify living organisms. To become a genetic engineer, it is necessary to study scientific subjects such as biology, chemistry, physiology, genetics, and biotechnologies. Additionally, it is important to acquire technological skills such as programming, computer science, genetic engineering, and synthetic biology. It is advisable to follow a university path in biology, biotechnologies, or biomedical engineering, and further specialize in genetic engineering. The obvious advice is to start with a degree in a scientific field: biology, chemistry, zoology are all excellent options that can open the way to specialization in genetic engineering. Among the more specific courses, we find, for example, genetics, microbiology, biochemistry, medical sciences, or biosciences. The Genetic Engineer is therefore nothing more than a professional specialized in techniques that allow isolating genes, cloning them, introducing them into a new environment in order to confer new characteristics to the receiving cells. One can thus enroll in the Faculty of Biological Sciences with a focus on Genetic Engineering or even better, molecular engineering. Now there are more specific faculties such as Biotechnology, which confer great skill in handling DNA. There is not yet a Faculty of Genetic Engineering, but to study this discipline or rather to become a Genetic Engineer, one must graduate in Molecular Genetics and subsequently specialize in Genetic Engineering. In Italy, there is also the PhD in Genetics, or that of Molecular and Cellular Biology based in Pavia. But in general, innovation and the "biotech" sector are the perfect ground for finding opportunities and employment, especially in the environmental field or in pharmaceutical and cosmetics laboratories.

In summary, genetics has a wide range of applications and is used in many industries and sectors including: scientific research, because genetics is the basis for understanding biological and hereditary processes; medicine, because it plays an important role in the diagnosis and treatment of many genetic diseases; agriculture, where it is used to develop more resistant and productive plants and animals; the food industry, which uses it to develop healthier and low-allergen foods; synthetic biology, which uses it to design and synthesize new living organisms; forensic science, which uses it to identify individuals and solve crimes through the genetic profile; and finally, pharmaceuticals, which use it for the development of targeted drugs for specific genetic diseases. There are many different professions related to genetics, including: the Geneticist, a doctor specialized in Medical Genetics who helps families understand and manage genetic diseases; the Molecular Geneticist, i.e., the scientist who studies how genes influence molecular biology(44); the Evolutionary Geneticist, who is nothing more than a biologist who studies how genes change over time and how they influence the evolution of the species; the Genetic Laboratory Technologist, a professional trained to perform genetic tests using blood, saliva, or tissue samples; the Genetic Counselor, a professional who helps families understand and manage genetic issues; the Genetic Researcher, a scientist who conducts research on genes and genetic diseases; the Genetic Bioinformatician, a professional who uses techniques to analyze genetic data; the Population Geneticist, who studies the distribution and evolution of genetic traits within a population. This can include the analysis of genetic diversity, the understanding of mechanisms that drive genetic variability, the quantification of natural selection, and the modeling of population dynamics. The work of a Population Geneticist is important for understanding evolutionary biology and its practical application in fields such as medicine, agriculture, and biodiversity conservation; the Forensic Geneticist, a professional who uses genetics to solve judicial cases. It is possible, however, to integrate profiles of biology, biotechnologies, and genetics as these disciplines are interconnected and often overlap. Biology provides the foundations for genetics and biotechnologies, which in turn use the principles of biology and genetics to develop innovative technologies. For example, biotechnology can use genetics to create new medical therapies or to manipulate the DNA of organisms to obtain specific products. Biology, genetics, and biotechnologies are all interconnected and work together to better understand the living world and develop new technologies.

Development prospects and labor market. There is no precise number of companies in Italy operating in the field of Genetics, as this sector is constantly evolving and growing. However, in Italy, there are many companies working in the field of Biotechnology, which also includes Genetics and deals with research and development, drug and food production, diagnostics, and consulting services. Some of the most important companies operating in this sector in Italy are Menarini Group, Angelini, Sigma-Tau, Recordati, Farmac-Zabban, Zambon Group, and others. These companies work in partnership with universities, research institutes, and centers of excellence to ensure innovation and the development of new technologies in the field of genetics. But the data of interest is the 65.9% increase in the number of biotechnology companies in Italy, which goes from 476 in 2008 to 790 in 2021(45). 48.5% belong to the Health sector, 30% to the Industry and Environment sector, 11.6% to Genomics and Proteomics(46), and 9.9% to Agriculture and Animal Husbandry. Based on the collected data, the Italian biotechnology industry is confirmed as a sector with a stable or slightly growing population of companies, characterized by a strong intensity of research and development and with peaks of excellence in all application sectors of biotechnologies. Most of the turnover comes from the Health sector (73.9%)(47). Based on the Report on personnel needs prepared by Unioncamere-Excelsior, for the period 2019-2023, the technological and biotechnological field is exactly the one that will have the greatest growth with a total of over 37,000 new positions in the pure biotech sector alone. Which means that, by broadening the perspective, even more positions will be available in research centers and hi-tech companies.

CHAPTER 3

ROBOTICS

Future visions: a step forward. For the considerations we intend to make about robots, it will be useful to draw inspiration from the narrative of the future, which, as already observed in other papers, constitutes an important laboratory of scenarios likely to turn into reality, if not in the details, certainly at least in the general features. In the case of robots, literature and filmography are very rich in ideas. The psychology and sociology of robots, androids, gynoids, and cyborgs(48) are one of the most interesting themes of contemporary science fiction and are announced as one of the most problematic sectors of a future that is already within reach in the field of robotics. Writers and directors have investigated with enthusiasm and inventiveness the relationship between humans and machines, indicating their possible developments and the upcoming issues, starting, as already mentioned, from the drama of the Bohemian Karel Čapek (1920), through the stories of Isaac Asimov dedicated to robots, to films like Blade Runner, up to the recent TV series Westworld, which takes us on a great leap into the future. Westworld revisits the classic theme of the relationship between humans and androids: usually in many SF(49) stories, we see two groups in conflict linked by a vertical relationship: one dominates the other. Beyond the dynamics of domination (by humans over androids), there is also a clear ontological difference: androids seem to behave like us, but in reality, they are completely different, they are empty objects that move thanks to an algorithmic program controlled by someone else (us), devoid of consciousness and free will. Here is where the relationship we/other is established, which immediately takes on a vertical anthropocentric direction according to which we are better than the others because of our unique and special characteristics: consciousness, rationality, freedom. In addition, androids are our creations, and this immediately places Western man in a divine position. Starting from this, Westworld immediately settles on the conclusions of the film Blade Runner: regardless of whether Deckard is a man or not, the film shows the human side of androids, both in the figure of the beloved Rachael and the rival Roy Batty. This means that, beyond the joke of the modern Self, Westworld presents another narrative: androids resemble us and have dignity. This is the thesis that will be convincingly developed throughout the plot of Westworld. However, there are those who think very differently, like Philip K. Dick, whose novels have always been characterized by a gloomy pessimism, so much so that in the work "Do Androids Dream of Electric Sheep?" from 1968, he does not believe at all that androids can have any "humanity"; on the contrary, they are distinguished by their lack of empathy and cruelty, in addition to causing a degenerating moral corruption of society. Therefore, this type of narrative also follows very different, even opposite and strongly contrasting approaches.

State of the art: two steps back. The origin of the term "robot" is linked to the Czech writer Karel Čapek, who first used the word robot in 1920 in the play entitled "Rossumovi Univerzální Roboti," in which he described automata that worked in place of workers. This imaginary humanoid was identified as a robot to recall the Czech word "robota," a term that literally means "slave labor" and figuratively referred to "forced labor" (in the sense of heavy work). Today, for us, a robot is a programmable machine capable of performing a predetermined action, and robotics is the intersection of science, engineering, and technology that produces machines that replicate or replace human actions. In the 1990s, 90% of robots were used in automotive factories and were mainly composed of mechanical arms tasked with welding and assembling the various parts of a car. In recent years, our interaction with service robots has increased. They help us with household chores and office work, transport us to different places, and will probably be our virtual assistants in the expanded world of the metaverse(50).

Robotics deals with the conception, design, and realization of machines capable of operating autonomously, with or without human control, and their possible applications. The field of application of robots is continuously expanding: alongside the classic uses of replacing humans in repetitive, heavy, or dangerous tasks, especially in industry, there are also uses that exploit, for example, the ability for precision or to perform maneuvers impossible for people, such as in the medical field. In this science, both the research phases and those of technological application integrate skills in mechanics, computer science, and electronics. Robots are automatic machines that can be either controlled by humans or capable of self-control with feedback mechanisms, thanks to which they react to stimuli or changing environmental conditions; in this, they are assisted by very advanced programs that allow them to make choices appropriate to the situation. Robots can have an infinite variety of shapes and sizes, and the functionalities pursued in a robot's design also determine the capabilities and degree of autonomy it must have. Today, in fact, there are small robots that mimic insects (insectoids) or reptiles, and more original robots that mimic, for example, plants with their root system (plantoids). The former are capable of flying, recording, and transmitting images. The latter are developed to mimic the capabilities of plant roots and identify the best paths to achieve a goal: the stability of the plant, water, or the softest soil. Capabilities of this kind could be useful in agronomy, space exploration, and even to create intelligent endoscopes capable of entering the human body and autonomously finding the diseased part. Finally, for the most complex living systems, the cognitive aspect also comes into play. In this case, we are talking about humans or large animals. The challenge for robotic equivalents (animaloids or humanoids) is to reproduce the inseparable link between body and mind developed in evolution over more than three billion years(51). Robots are anthropomorphic machines(52), often built by large electronics industries for advertising purposes, just as robots are also some toy animals. But our world is mainly populated by non-anthropomorphic and very useful robots, such as automatic carts capable of moving and assembling goods in warehouses, avoiding obstacles, finding the final destination where to deposit the load, and doing so autonomously. Other highly specialized robots are those used in surgery, which make operations with non-invasive techniques possible, unimaginable without their use, or underwater vehicles used in the recovery of wrecks up to great depths(53).

The ethical dimension. It is quite singular that the ethical debate ignites around biological, genomic, and procreative innovations, while on the front of technologies based on AI (Artificial Intelligence) such as robotics, there is a passive acceptance of the possible consequences. But the effects of machines are far-reaching and exert strong pressure on ethics. The ethical problem, already arduous in today's world, is complicated by these new actors that are robots: it is important to understand what is done, how it is done, and why it is done, taking into account, as much as possible, the consequences of the choices made today, consequences that could prove to be irreversible(54). All that the narrative tells us is obviously possible only thanks to technologies that today we can only theorize, but whose theoretical and practical bases are not so distant from what we actually have. Let's take, for example, the case of Sophia, which is undoubtedly the most famous robot in the world and was created by Hanson Robotics, a company based in Hong Kong. It is equipped with an advanced form of AI that allows it to behave in a very realistic manner. This, combined with an appealing physical presence, has made it a media phenomenon of considerable relevance. It has participated in numerous world conferences and has given lectures on climate, becoming a symbol of the avant-garde and technology created by humans. The robot Sophia is capable of answering the questions asked of it, for example by journalists during the numerous television broadcasts where it has appeared; moreover, it can remember previous conversations and is capable of learning new things from each one. It also learns from the Internet, to which its AI is connected. In short, Sophia is capable of "speaking" with human beings, has its own sense of humor, and can assume as many as 62 facial expressions; in practice, it can express emotions. Sophia's "brain," i.e., the electronics that make it "intelligent," is located in the head and is visible thanks to a transparent cap placed at the back(55).

When will we see a robot like Sophia "intelligent" like a human being? According to Ben Goertzel, CEO of SingularityNet, which in 2018 launched an open platform to make the world's AIs more advanced, we are in a transition phase between what are defined as "Narrow AI" and "General purpose AI," the compartmentalized intelligences and those that will be able to reach the level of human beings(56). The transition has just begun, and the project aims to accelerate this process, but it is too early to predict how long it will take to complete; I hope it happens at most in the next eight years. At that point, we will see robots specialized in elderly care and scientist robots." Perhaps the most significant obstacle to overcome is public trust. It is only in recent years that people have become dependent on Narrow AI applications and have accepted them into their lives, without the typical concerns related to security and privacy. Companies that promote AI without any human intervention are difficult to sell, especially when there are unknown consequences. Robots are therefore ready to replace millions of humans in various sectors. But today they are certainly not even remotely similar to humans. "I will never rule anything out," said Blake Hannaford(57), whose work mainly focuses on robotic surgery, regarding potential progress. "But if you look back at the science fiction of the 1950s and 1960s and compare it with today's, it really missed the mark." It might not surprise us at all to learn that robots are actually none of those described by the narrative of the future. Most of them do not resemble humans at all, and all, even the most "dazzling" models, are rather rudimentary in their abilities. Echoing Blake Hannaford, Raj Bhasin, the Chief Operating System of Robotic System, characterizes them as "just a stupid piece of hardware." Their development, he said, depends on human ingenuity and advances in AI that will imbue them with cognitive abilities more similar to human ones, allowing them to perceive, reason, and learn more accurately(58).

Applications and development sectors. But it is still a sector of the economy in great expansion, and today investing in robots can become a great deal for the future. Today they have reached a very advanced level of development and are used in a wide range of applications. Some examples include:

<u>Industrial robots</u>: industrial robots are used in many industries to perform repetitive and dangerous tasks, such as welding, assembly, painting, etc.

<u>Medical robots</u>: medical robots are used in surgery to perform complex operations with millimetric precision.

<u>Space exploration robots</u>: space exploration robots are used to explore the surface of other planets, such as NASA's Mars Exploration Rovers.

<u>Educational robots</u>: educational robots are designed to teach children STEM (science, technology, engineering, mathematics) skills through play.

<u>Agricultural robots</u>: there are many robots used in agriculture to simplify and automate a series of agricultural activities.

<u>Military robots</u>: although the military, for obvious reasons, does not share its results regarding the development of robots, the future of AI-powered weapons is becoming increasingly real(59).

Furthermore, AI is making robots increasingly autonomous and capable of making decisions based on the information they gather from the surrounding environment(60). There are still many challenges to overcome in the design of increasingly sophisticated robots, but the advancement of technology seems to indicate that the future is very promising. Compared to the past, today the robot's actions are no longer a predetermined sequence of movements but are performed automatically thanks to a control system that governs the motion in relation to what happens in the environment. Hence the definition of robotics as "intelligent connection between perception and action with a cognitive dimension," in relation to the possibility of decision and planning of actions to be performed; a sensory dimension, understood as knowledge of reality through data analysis; finally, an actuating dimension with the actions to be carried out to achieve the desired purpose(61). Today, an "artificially intelligent" robot represents a bridge between robotics and AI, where algorithms are necessary to make robots capable of more complex tasks. An example can be a robot capable of using a path search algorithm to move within a warehouse, or a robot integrated with AI capable of detecting the object it picks up and placing it in a different location based on the type. The integration of the two fields gives space to innovation and progress, increasingly instilling confidence in what can be achieved by combining the two disciplines. However, today the robot is above all a mechatronic concentrate of gears, motors, electronics, and sensors that, in attempting to approach the capabilities of a human being, becomes, as we have mentioned, tremendously complex. An all-Italian example is "Robee," one meter and seventy centimeters tall and weighing seventy kilograms, which works in the production department of the Rimini-based MT among lathes, milling machines, and grinders. It picks up parts, interacts with workers and technicians, checks that no one gets hurt during night shifts, recognizes intruders. It is the first cognitive humanoid robot in the world inserted in a manufacturing plant to assist flesh-and-blood people in the most repetitive and grueling low-skilled tasks. It is 100% made in Italy, designed and built by the Brianza start-up OVERSONIC: we are at manufacturing 5.0(62).

Impact on the labor market. But manufacturing remains the context that has seen the greatest spread of robots in the past. Manufacturing society has always been dynamic. Some jobs disappear while new ones are created. From this point of view, robotics can be seen as the evolution of the automotive product, which requires a deep integration of mechanics, electronics, computer science, and design. In a global world, where car production cannot continue to grow indefinitely, a new robotics market could precisely strengthen the industry. Not to mention that compared to the automotive sector, robotics will benefit from the continuous demand for new AI routines (equivalent to current "apps") and there will be a need to manage immense amounts of data shared by millions of robots, which are of enormous interest both for the IT and communications industry and for that of big data. Thinking of the robot of the future as a super smartphone capable of physically performing actions, we can well understand how it could become the new reference product of a new manufacturing industry, combining automotive techniques with ICT (Information and Communication Technologies) techniques. In this case, it is a matter of creating a new professional and manufacturing supply chain. Today, however, it is logistics that sees their impressive spread. On Amazon sites, over 350,000 robots of various kinds work worldwide(63). But even if there is still a long way to go for the development of autonomous vans and trucks, new robots, more intelligent and faster, are taking control of warehouses around the world. However, there are at least 20 million robots operating in the world, and of these, over 3 million work in factories around the planet. Other millions of robots move goods in warehouses, clean houses, mow lawns, and assist surgeons in conducting operations. Some have even started to deliver goods, both by land and air, and to assist the elderly. Italy represents the second European market for robots after Germany and the sixth worldwide. It is only one of the many figures present in the World Robotics report 2022. In South Korea, car manufacturers, queens of the "automotive" sector, employ 1 robot for every 10 workers. All these companies continue to hire for over 15 years, layoffs are a thing of the past(64). The next generation of robots will be mass-produced at costs that, in constant decline, will make them increasingly competitive, even compared to the lowest-paid workers. The possible future replacement of human labor with that of machines is a recurring theme since the dawn of the first industrial revolution(65). During the 20th century, this topic captured the attention especially of fiction, particularly narrative and cinematographic, which strove to imagine the tragic social changes that could be determined by large-scale replacement. On the scientific level, this debate found particularly fertile ground in the last thirty years following the invention and spread of technologies, first the Internet and computers, and more recently, above all, robots and AI, which have determined phenomena identified as the third and fourth industrial revolutions(66).

Emerging professions and required skills. According to a recent report from the McKinsey Global Institute, 30% of the hours currently worked could be automated by 2030: this would mean changing the lives of 800 million employees. However, it might not be so negative. McKinsey believes, like many other scholars, that the new technology will take care of the most "arduous" work and will allow humans to deal with what they like most in the creative and innovative field. This would be a great opportunity for humanity, to advance progress while minimizing costs. As before the industrial revolution, when no one would have imagined the thousands of new work activities born thanks to technology and progress, so it will probably happen with the robotic revolution. The robotic automation of processes will eliminate the need for personnel to perform boring, repetitive tasks and will change the type of work for the better, freeing the potential and creativity of human personnel, who can dedicate themselves to other activities. Regarding the quantitative analyses provided by economic doctrine, without intending to undertake a detailed reconstruction of the existing literature in this reflection(67), it is considered sufficient to note that in the matter at hand, two almost opposite schools of thought essentially confront each other(68). On the one hand, there are positions that can be attributed, in various ways, to the so-called substitution theory, according to which the innovation of production processes due to investments in the aforementioned technologies will lead to an increase in productivity linked to capital and a consequent reduction in the demand for human labor, thus leading to a structural reduction in employment through the prevalence of the substitution effect(69). However, these theories diverge greatly on the extent of this job destruction, providing predictions ranging from the loss of a number of jobs equal to a few percentage points, compared to those currently present on the market, to even hypotheses of the replacement of two-thirds of the entire workforce within the most developed countries. On the other hand, there is the so-called compensation theory, which finds its roots in what was observed in previous industrial revolutions and is based on the Schumpeterian concept of "creative destruction," according to which technological innovation will lead to the creation of new sectors and new professions(70) capable of reabsorbing much of the job loss. This process, of course, is supported by market mechanisms such as wage increases and worker retraining(71). This does not mean that it will all be simple: when low-skilled jobs are no longer available, people will have to learn new skills to compensate and find new employment. "This requires all of us to focus on retraining. There is an urgent need to reform education: people need to learn design thinking, creativity, analysis, programming," says Ian Barkin, co-founder of Symphony Ventures, which deals with robotic automation of processes for large clients. Whether it will be a disaster or an opportunity, we will find out soon; what we can do now is invest in training and learn to adapt, which seems to be the most useful resource for our near future(72).

The increasingly important reliance on technology, which has gone from being a mere support tool to a determining part of the process of hiring new personnel, is certainly the most delicate aspect in the analysis of future scenarios in the world of work. Undoubtedly, the realization of advanced robotic systems permeates various aspects of our life in a pervasive and continuous way, reminding us how robots will spread just as computers do today. The times when robots, essentially reducible to manipulative robotic systems, were employed in well-defined and structured areas ("cages") of the production system, where robots and humans had to be physically separated for safety reasons, seem far away. After factories and research laboratories, in a future not even too distant, robots will be among us in our homes and in our cities, or rather, I would say they are already there. The increasing interaction of machines with each other and with people has triggered numerous reflections. Some even talk about "post-human" as a result of this increasingly pervasive and omnipresent relationship with machines, smartphones, and collaborative robots. One thing is certain: new technologies impose a strong rethinking of work. People will be increasingly "hybridized" in a virtuous and design relationship and no longer a Fordist one with the machine. What has changed most compared to the recent past is the quality of the interaction and the great leap in the connection and interface of machines with each other and with workers. However, we already know that automation, even if partial, is already present in many occupations and will be applied in the future to every professional field(73).

Are we inexorably moving towards a closer relationship between humans and machines, and in particular with robots? It is precisely robots and their push that make robotics accessible to an increasingly large number of companies, especially in small and medium-sized enterprises. A perfect example of a non-intelligent robot is precisely the robot (or collaborative robot), which can be programmed to pick up an object and place it in a specific point: the robot will continue to perform this operation without the need to receive any human input after being programmed. It is necessary to lower the production cost and the total cost of integration. This requires simpler and leaner robots, which do not need much equipment to perform certain tasks. Therefore, lean robots with ease of use, convenient and easy-to-implement robots. This is really happening. It will help many companies adopt robotics and benefit from the resulting profits. The collaborative robot represents a paradigm shift precisely because it can work alongside humans(74). We are moving towards human-machine integration. Italy is one of the leading countries in the world in the robotics sector, and Italian researchers have always made original and significant contributions. Why not remember that one of the very first two-armed robots in the world, i.e., equipped with two gripping and coordinated tools, similar to human arms, was the Sigma developed by Olivetti in 1973 and used for assembly operations(75). We have a consolidated tradition of robotic research to be proud of, and at this moment, a historic record of robot demand in Italy is being recorded. Last year, the spread of robotics in Italian companies reached a new record. In fact, in 2021, as many as 11,672 robots were installed, with a 50% growth compared to 2020. If it was not difficult to do better than the first year of the pandemic, it is worth noting that the number of robot deliveries in 2021 is higher even compared to 2019 (+28.7%). In summary, robotics is a growing sector worldwide, with a strong demand for automated solutions in various sectors. It is expected that robotics will continue to develop and evolve in the coming years, thanks to continuous technological innovation and the increasing adoption of robotic solutions by companies and consumers. In Italy, there are several companies active in the robotics sector: Comau, founded in 1973, specializes in the design and production of industrial robots and automation systems for the manufacturing industry; ABB Italia is the Italian branch of the Swiss company ABB, one of the largest producers of industrial robots in the world. In Italy, ABB produces and markets robots for various industrial applications; Kuka

Robotics Italia is a German company that produces industrial robots and automation systems for various applications, has several branches, and produces robots for the automotive, electronics, and food industries; Loccioni, founded in 1968, specializes in the design and development of robotic solutions for industrial automation and precision agriculture; CIM 3D, founded in 2002, specializes in the production of collaborative robots, mainly used in the automotive and food industry sectors; Roboz, founded in 2013, is an Italian start-up specializing in the production of 3D printers for advanced materials, such as carbon and thermoplastics; Bluebotics, founded in 2001, develops robotic solutions for internal logistics, such as autonomous vehicles for material transport in warehouses and factories. These are just some of the main Italian companies active in the robotics sector, but there are many other companies, even small ones, that deal with developing and marketing innovative robotic solutions. The demand for new jobs and new professional profiles is also increasing. Let's remember some:

Robotic engineers: (in space, medical, and mobile fields): design, develop, and build robots and robotic systems.

Automation technicians: install, configure, and maintain automation and robotic systems.

Robot programmers: write programs that control the movement and functions of robots.

AI experts: develop machine learning algorithms and techniques to enable robots to learn and adapt to new situations.

Robot safety experts: ensure the safety of operators and people interacting with robots.

Computer vision experts: develop artificial vision systems that allow robots to see and understand their environment.

Mechanical engineers: design and build the mechanical components of robots.

Electronic engineers: design and develop the electronic systems that allow robots to function.

User interface designers: develop intuitive interfaces for human users to communicate with and control robots.

Mechatronic engineers: develop systems that combine mechanics, electronics, and computer science.

Control engineers: design and develop control algorithms for robotic systems.

Robotic production engineers: develop and manage robotized production lines.

Industrial automation experts: develop automation systems for the manufacturing industry and logistics.

The salaries of robotics professions can vary greatly depending on geographic location, experience, training, and the professional's specialization. In general, robotics professions are in high demand, and consequently, salaries can be quite high. For example, a robotic engineer with about 5-10 years of work experience can earn an average of $70,000 to $120,000 per year. A robot programmer can earn between $60,000 and $100,000 per year, while a robot technician can earn between $40,000 and $70,000 per year(76). However, these are referred to the US context; in Europe, the same profiles earn much less. A robotics professional should have a wide range of knowledge concerning various aspects of robotics. Below are some of the main knowledge areas that a robotics professional should have:

Programming: programming is fundamental in robotics, as robots are generally controlled by software. The robotics professional should be familiar with a wide range of programming languages, such as C++, Python, Java, and others.

Electronics: robots are composed of a series of electronic components. The robotics professional should have basic knowledge of electronics, including circuits, sensors, actuators, and other electronic components.

Mechanics: robotics requires a deep understanding of mechanics, as robots are physical machines that must be designed and built to perform certain actions. The robotics professional should have basic knowledge of mechanics, such as statics and dynamics, laws of motion, and kinematics.

Artificial Intelligence: AI is increasingly present in robotics, as robots become more autonomous and capable of making decisions independently. The robotics professional should have a basic understanding of artificial intelligence, including machine learning algorithms, neural networks, and other related concepts.

Automatic control: robots require precise control to perform specific actions. The robotics professional should have a basic understanding of automatic control, including feedback concepts, regulation, and system modeling.

Safety: robots can be dangerous if not used correctly. The robotics professional should have a basic understanding of safety regulations, including the safety requirements of industrial robots.

Communication: robots often need to communicate with other devices, such as computers, sensors, and other robots. The robotics professional should have a basic understanding of communication, including network protocols and wireless technologies.

These are just some of the main knowledge areas that a robotics professional should have. However, robotics is a constantly evolving field, and the robotics professional should be able to learn continuously and adapt to technological changes. But fundamentally, robotics is the science that deals with the design and realization of robots. This process involves many different disciplines and knowledge. There are several degrees that can be useful for pursuing a career in robotics, depending on the specific area of interest.

Below are some of the most common degrees for robotics:

Mechanical Engineering: a degree in mechanical engineering can be very useful for robotics, as it provides fundamental knowledge about the design and production of machinery, which can be applied to robotics.

Electronic Engineering: robotics requires the use of a wide range of electronic components. A degree in electronic engineering can provide the necessary skills to design and develop robotic systems that use sensors, actuators, and other electronic components.

Computer Science: a degree in computer science can be very useful in robotics, as it provides programming and software development skills, which are fundamental for controlling and managing robots.

Mechatronic Engineering: mechatronic engineering combines the skills of mechanical engineering, electronic engineering, and computer science, providing interdisciplinary knowledge of the technologies necessary for robotics.

Physics: physics provides fundamental knowledge of mechanics, electronics, and mathematics, which can be applied to robotics.

Mathematics: mathematics provides a theoretical basis for robotics, providing fundamental skills in algebra, geometry, trigonometry, calculus, and other mathematical disciplines.

Cognitive Sciences: robotics increasingly uses artificial intelligence and machine learning techniques to improve the capabilities of robots. A degree in cognitive sciences can be useful for understanding the human mind and applying this knowledge to the design of robotic systems.

In general, robotics requires a combination of technical skills and critical thinking. The degrees mentioned above can be useful for developing these skills, but there are also many other training paths that can be useful, such as professional training courses or specific sector certifications.

The research areas on which this technology is based are multiple, and today thousands of scientists around the world are engaged in an unprecedented interdisciplinary effort: engineers, physicists, chemists, biologists, neuroscientists, psychologists, industrial designers working side by side to decode and reproduce the solutions developed by nature on humans. These concern: body, sensors, control systems, sensory coordination, adaptation, computation, brain and mind, interaction, and communication. To this must be added the need to optimize the robot's energy consumption so that it can perform its functions with physical and cognitive performances comparable to those of humans, consuming less than a thousand watts. In companies and universities around the world, engineers and computer scientists are devising ways to make robots more perceptive and skilled.

Future trends. Some challenges are focused on research into new paradigms to endow robots with greater autonomy and thus greater cognitive abilities(77). In this sense, there are five trends that will further drive the growth of robots and automation:

Energy efficiency (today's robots are designed to consume less energy, resulting in reduced operating costs).

Reshoring (relocation to the United States and Europe of microchip production).

Ease of use (robot programming has become easier and more accessible to non-experts).

AI and Digital Automation (robots will increasingly operate as part of a connected digital system: cloud computing, big data analytics, and 5G mobile networks provide the technological basis to improve performance. Cables will become obsolete).

Spread of repair services to give a second life to industrial robots (since the industrial robot has a lifespan of up to thirty years, new technological equipment represents a great opportunity to give a second life to old robots)(78).

Certainly, through the increasingly intensive use of technology, the risk of reducing the entire work process to mere numerical analysis is high, just as it is equally clear that algorithms will shape new ways of knowledge, but as always, some aspects will emerge that will tend to remodel the balance and eliminate redundancy between humans and machines; the first of these will be trust, both that placed in relationships between humans (employer/collaborator-employee) and that expressed by numbers and metrics analyzed by AI systems, which are in any case trained with information provided by humans. The level of confidence with which this balance will be achieved will depend on several factors, such as the ability to make technology interact even with customers, from whom the company's reputation and consequently the ability to attract investments will depend. All factors that in turn will be analyzed by artificial intelligence systems in a kind of circle where the same AI will be both arbiter and party to the fate of companies and their collaborators. The possible recovery of productivity given by machines, where market conditions allow it (a question far from certain until now), would allow improving wages and working conditions.

Should we therefore be confident? I believe so, but on the condition of being willing to radically change our way of thinking about work; to do this, we need three elements: culture, training, and rules. It will take time to mature our awareness, but we cannot avoid it, the challenge concerns everyone, and the responsibility to face it in the best way lies only with our generation. It will take courage, determination, and precisely trust, we do not have many choices, we must change our pace if we do not want to suffer our future, and to think about it, 10-15 years from a technological point of view pass in the blink of an eye(79).

CHAPTER 4

ARTIFICIAL INTELLIGENCE

Future visions: a step forward. The Holy Grail, the "deus ex machina," Artificial Intelligence is the most transcendent of inventions, but also the most insidiously dangerous, why? Because they are technologies so powerful as to endanger the axiological potential of humans, i.e., the entire system of values that we define at the basis of our civilization. If we transfer our type of hallucinated behavior to these technologies (e.g., the pursuit of money at the expense of everything...), these technologies will defeat us, because they do nothing but execute with algorithms what we are, what we say, what we think. So today we must lay the fundamental foundations of an agreement on what we believe is the deepest essence of the human being, and we can also say that surprisingly in the next 20 years, intelligence will no longer be the most important thing because AI will surpass human intelligence on a scale that is not even imaginable. Who will be the rulers of this planet? What do you think they become by descending from us? Are we facing a possible evolution from carbon units to silicon units? Well, once again an old 1968 film can suggest a possible future: "2001: A Space Odyssey" by Stanley

Kubrick(80). This film has inspired many ideas about AI and its capabilities and limitations. The representation of AI in the unsettling supercomputer Hal 9000 has made us think a lot about human nature and the risks associated with AI. The presence of Hal 9000 in the film increasingly transforms from a saving force to an element of deep unease and danger. The supercomputer, more than ever intent on living its existence without having to follow any external imposition, develops a self-awareness that leads it to make numerous drastic decisions, especially that of eliminating the entire crew when it discovers it is in danger of death, as the astronauts had decided to turn it off. Why address a genre, science fiction, which is now considered a true literary genre even by the majority? Simply because it is the only genre that cannot be exhausted, being connected to innovation and progress (both technological and social) that always has new dramatic material to draw from, to create its narratives linked to the ambiguous relationship between humans or, as in this case, non-humans and technology. In this revolutionary mix of imaginative narrative and scientific predictions, the question that arises is: "how will AI change our world in the next twenty years?" In the next two decades, aspects of daily human life will be unrecognizable. AI will generate unprecedented wealth, revolutionize medicine and education through human-machine symbiosis, and create new forms of communication and entertainment. By freeing us from routine work, however, it will also test the organizational principles of our economic and social order. Meanwhile, it will bring new risks in the form of autonomous weapons and intelligent technologies that inherit human biases. AI is at a turning point, and people must become aware of both its bright paths and its existential dangers for life as we know it.

State of the art: two steps back. Today, AI is presented to us as a union, a kind of marriage between biological intelligence, ours, and engineering. It is actually a separation, in short, a divorce, between the "ability to act" (e.g., solving a problem or doing something for someone else) and the "need to be intelligent in doing so." Put very simply, it means "doing things with zero intelligence." And we should be concerned about it, because for the first time in history, we have a form of ability to act that does not have intelligence. This is certainly already an exceptional fact. Today, to be successful, we have separated the ability to act from the ability to be intelligent. This is an extraordinary miracle born a long time ago. In 1950, Alan Turing(81) was already asking the question: "but can machines think?" He posed this important question precisely on the pages of the prestigious journal MIND(82). Furthermore, it is important to emphasize that the Turing Test is a subjective and debated measure, and not all experts agree on its validity and meaning. The fact that a machine can deceive a human in a conversation does not necessarily mean that it has reached a level of intelligence comparable to that of humans, but it could be another type of intelligence. Is an intelligent machine a machine capable of making decisions for humans? If we think this is the definition of AI, we are making a serious mistake. Even if increasingly sophisticated, machines are still mere executors of instructions given by humans in the form of numbers and formulas that have little to do with typically human faculties, such as emotions, courage, responsibility, or imagination. In reality, we could almost speak of "artificial programming" rather than AI. But think about the question: "Am I not a robot?" To date, a machine is incapable of understanding the meaning of a question like this and responding coherently. This is the level of AI today, there is nothing to be done. It cannot pass this test. The best software in circulation is incapable of putting a cross next to this question. Because one thing that software does not do well is lying. We are very good at it! But we are still faced with one of the most disruptive technologies of our time. The computational techniques guided by AI are diverse, from rule-based systems to "deep learning"(83). A map of AI knowledge was created by Francesco Corea and makes it easier to classify AI technologies. His conceptualization combines the paradigms and domains of AI and related problems. The categories on the X-axis include various computational paradigms, and the Y-axis outlines the domains of problems. Various technologies are then mapped to illustrate their potential value. For example, rule-based systems (e.g., expert systems, robotic process automation), which are knowledge engines driven by logic, common in urban systems, are often used to capture and automate structured workflows. Yet it is not excluded that even the intelligence of a coffee machine can have extraordinary technology that after 10,000 times it sees a cat says "cat!" And it is surprising that it does it on its own, because from that moment on it will always recognize it and not just that cat. In short, we have understood that one thing is the ability to act, another is the ability to think. The reasoning up to now is all in these terms. The position of some is still very pragmatic but probably very close to reality. Thanks to the power of digital division and copy-paste, AI is a form of action that does not need to be intelligent to be successful. In other words, an engineering vision of AI emerges, which rejects a cognitive vision. However, a large part of the success of reproductive AI, i.e., engineered (self-driving cars, voice assistants, Amazon's Kiva system), depends on the fact that we have wrapped it - sometimes without realizing it, as when we buy furniture under which "Roomba" can slip - in an environment suitable to make it effective. Autonomous driving will be completely safe when roads, signs, and geolocation have created a habitat tailored to it: this already happens with "train" trucks and autonomous tractors that work the land in the extensive crops of the United States. It is not AI that adapts to us, but we who adapt to this new technology. Not everything that works can be called intelligent. Our washing machines and dishwashers, for example, are not. And this is because to function, the robot in question must have an environment, an "Envelope," a three-dimensional space within which it can operate. What we are doing is exactly this: we are not designing artificial agents such as software, hardware, and robots to solve problems for us, but so that they can function within the world-environment and solve our problems. Optimizing this space is possible today thanks to lower costs, more powerful computing, more data, better algorithms, advances in Machine Learning (ML), more Internet of Things (IoT)(85). AI is often described as the engine behind today's innovations. It is therefore natural that it arouses enthusiasm and high expectations. Thanks to neural network models, inspired by the human brain, computers are achieving good performance in areas that were previously unimaginable. This has made us believe that they will become as intelligent as us and solve all our problems. Examples are the increasingly advanced capabilities of linguistic systems, such as virtual assistants or automatic translation tools. They leave us speechless, and we think that if a computer can engage in something as complex as language, there must be intelligence behind it. It is easy to be deceived, because appearing human does not automatically mean that there is human intelligence behind it. Linguistic tools can imitate us because the underlying models are able to learn patterns from a large volume of texts. But if we compare the capabilities of a virtual assistant (voice command) with those of an average child in a discussion about a paper airplane, for example, the software needs much more data to reach the child's level and will still have difficulty speaking using common sense. To date, says Luciano Floridi(86), AI is a "reproductive" intelligence, not "cognitive." It is efficient precisely because its action is separated from intelligence: the task it performs is intelligent according to our cognitive criteria, but it is not intelligent for the engineered machine that performs it. In AI, what matters is the result, not whether the agent or its behavior is intelligent. For this reason, AI is not about the ability to reproduce human intelligence but the ability to do without it. One way to achieve this goal is to transform the problem to be solved into a game, i.e., to "gamify" it(87): we already know that machines are better than us at chess... But productive (cognitive) intelligence is still very far away. We induce, infer, deduce. At most, AI infers on a statistical-probabilistic basis. Moreover, the quality of inference depends more on the quality than the quantity of data provided.

Big Data risks generating "noise," disturbance, confusion. Better few but reliable data. Ontologically different, but sometimes useful, are the "synthetic data" generated by the calculation machines themselves. For many decades, AI has been more announced than realized. Today we are surprised by what is happening, but in reality, all the necessary ingredients, which were not available before, are here today: Big Data, computing power, cloud, calculation, algorithms, but above all the fact that our lifestyle is increasingly mediated by machines. There is therefore a digital mediation that creates a large amount of data. These data are what allow us to teach machines to do what we do. This is not a temporary phenomenon, and it is a phenomenon that will grow more and more. This is an industry that in a few years has gone from being scientifically interesting to one with thousands of applications. We will have to think that as we work with Excel today, tomorrow we will work with AI, but if you think about it, we are already doing it. Around the corner, there will be a spread of machines that were already spreading before Covid 19. Covid has given an additional acceleration. They are already among us! Vehicles capable of moving without a driver on normal roads, virtual assistants that communicate with online service customers, automated logistics systems, medical diagnoses based on evidence, algorithms that regulate the flows of social networks, and much more. AI has made giant strides and is now part of our daily lives. When Spotify and Netflix suggest a song or a movie, we are interacting with AI. The same happens with the virtual assistants on our phones or with home devices like Amazon Alexa, which we can talk to to order a coffee or set an appointment. AI is used in facial recognition and is a key ingredient for many other applications. So far, there have been two recognized waves of AI: "artisanal knowledge" and "statistical learning" ("statistical learning" or "Machine Learning"), and we are witnessing the spread of "deep learning." Essentially, in the first phase, we had an AI capable of thinking only about very specific problems, not capable of learning or reasoning in conditions of uncertainty and ambiguity. It then moved on to the phase where it is capable of responding to unforeseen situations. There is therefore a digital mediation that collects data and analyzes it and is capable of teaching machines to do what we do. This is not a temporary phenomenon, it is a phenomenon that will grow more and more. The results achieved are before everyone's eyes. In 1999, Deep Blue defeats Garry Kasparov, the world chess champion, in 2011, an artificial intelligence system (Watson), using natural language, defeats for the first time the two champions of "Jeopardy," (a sort of English TV quiz). In 2017, Alpha Go defeats the world champion of Go, a game 200 times more complicated than chess. In short, if machines have to do something, they do it better than us and much faster. But it is not always so; in the early days of February, a human beat the AI of Go. We thought it was impossible, and yet it happened. The young Kellin Pelrine, computer scientist and Go player, managed to beat the AI.

Current technologies and applications. Today, when we talk about AI, we mainly talk about Machine Learning. The latter represents a subset of AI, but thanks to the rapid development it has had in recent years, it has almost become synonymous with it. To understand what it is, it is useful to recall how a traditional information system works. In traditional software, a programmer tells the computer the instructions to perform a task meticulously, step by step. For the software to work correctly, without crashing, it is therefore necessary to foresee all possible cases. This type of programming works very well for performing well-defined and repetitive tasks, such as sending thousands of emails or copying many files or searching for a keyword in an archive, while it is much less suitable for activities such as recognizing a face in a photo or interacting with a human being. ML, on the other hand, allows a computer to learn to perform a task based on experience. Experience that it accumulates by analyzing the enormous amount of data we have available with digitization and evaluating the consequences of each possible path based on the objectives. In this way, the system learns which conditions can lead to a certain result. To learn, ML uses statistical techniques, so the type of responses it provides are typically probabilistic, for example, it evaluates how this chess move is probably more winning than the other, or that this face is 83% happy, 11% sad, and 6% angry. Obviously, we are simplifying a mechanism that behind the scenes sees sophisticated algorithms, developed by some of the best minds, who work tirelessly on these problems, in a discipline that brings together very different professionals: computer engineers, statisticians, psychologists, biologists, and so on.

In recent years, AI has further developed, and deep learning (DL) has come into play, a method that gives machines the ability to learn with or without supervision. It is based on a layered network, which allows the machine to "generalize" progressively, i.e., to extract increasingly abstract aspects. For example, if we analyze an image, we will start by extracting more "basic" aspects such as the contours of the image in question, then gradually we will arrive at extracting aspects more relevant to human observers: numbers, letters, faces, and so on. The applications of DL are many. Let's mention "Neural Style Transfer," i.e., the ability to understand the style of a certain work of art and transfer it, applying it to photos or videos; language translation; the discovery of new drugs, through simulation and prediction of a certain molecule; medical informatics, for example, to study the health of a patient based on the data provided by the instruments; the analysis of medical images for diagnostic purposes; the training of military robots to perform new tasks, and much more. To put some order, we could say that currently we could identify three types of AI that use ML and more specifically DL:

Generative AI is a type of intelligence that focuses on creating algorithms and models capable of generating original data or content such as images, videos, music, or text. It is multimedia and specialized. From musical tracks to

PowerPoint presentations with graphics and images. Artificial intelligence goes beyond the boundaries of writing but does one thing at a time. It is not multitasking like humans.

Cognitive AI focuses on simulating human cognitive functions such as perception, reasoning, and understanding of natural language with the aim of creating intelligent systems that can "think" and "reason" similarly to humans.

Predictive AI is the field that uses machine learning algorithms and techniques to analyze historical data and identify patterns and trends, with the aim of making predictions about future events or probable outcomes.

But in the last months of 2022, this software arrived that does rather impressive things: GPT-3 (produced by OPEN AI). It is the most important novelty in the field of generative AI. Generative Pre-trained Transformer 3 (GPT-3) is probably today the most advanced AI solution for natural language in the world. This software understands natural language and also produces it through written natural language. It can write prose, poetry; in short, it can write many things including programming code. It is the largest and most advanced ever created so far, with 175 billion parameters. It has been trained on a vast corpus of text in different languages and domains, including news, books, scientific articles, web pages, and conversations. This allows it to generate coherent, natural, and high-quality text on a variety of topics, such as translations, text completion, question answering, creative text generation, and much more. It is important for several reasons and especially for its ability to generate natural and coherent text in different languages and on a wide range of topics. This allows the creation of applications that can be used in many sectors, such as voice assistants, chatbots, automatic translation services, creative text generation, voice synthesis, and much more. With its ability to automatically generate text, GPT_3 can help reduce the time and costs for activities that require text writing. For example, it can be used to generate product descriptions, reviews, emails, documents, reports, and other types of content efficiently and accurately. GPT-3 represents a step forward in the advancement of AI, demonstrating the ability of DL models to understand and generate natural text in an increasingly sophisticated and precise manner. It has the potential to enable innovation in many sectors, including healthcare, education, marketing, journalism, and many others. For example, it could be used to help diagnose diseases, create personalized learning programs, write content. AI, if used well, would allow us to be a bit better, to act better, to do much more and much better, all more effectively.

Unfortunately, there is a downside. If we use AI poorly, devaluing human skills and responsibility, we evidently reduce our control over things, renouncing our self-determination. One of the important aspects that economists deal with are "opportunity costs"(88), i.e., the things we could have done but did not do because we were afraid.

What are the challenges of AI that we will have to overcome? The digital in the broad sense and AI in the specific sense have made everyone vulnerable. For example, if AI turns off the lights of the entire city, it does not consider whether to cut off the electricity to the person with the studio apartment or to the owner of a large villa, so its choices concern all of us. Its purpose would be to help us control the world better. But the world is very complex, so this project of ours will require more and more time and resources, such as enormous computing and memory capacities to manage, in ever-increasing quantities, as we will live in increasingly larger cities. We find ourselves having to manage real megacities. Therefore, we must use AI, for its ability to act autonomously to solve the increasingly complex emergencies and problems that the world will have to face. It must support our responsibility, which must not turn into irresponsibility. A very great responsibility we have is towards the environment, which thanks to AI we can safeguard at best.

Impact on work and the economy. The fact that AI, working for us, can improve our lives and the world, unfortunately, has a downside: little by little, it is stealing our jobs. 47% of human jobs will be replaced by machines. This is what was stated in a "paper" by Carl Frey and Michael Osborne in 2013(10). For 47% of the jobs currently being done, the technology that could replace them already exists. A second estimate, based on a more detailed application of the same methodology, was made by the OECD (Arntz, Gregory, and Zierahn in 2016 and Nedikoska and Quintini in 2018) and considers 14% of jobs in OECD countries at high risk of replacement. Certainly, the risk of routine work is real. All repetitive activities, as emerged from various studies, are or will be replaceable in the coming years, thanks to the evolutionary processes of machines. But beware, with AI, even intellectual jobs are at risk! But automation and artificial intelligence are two different technologies: the impact on jobs is different. Automation undermines physical-repetitive jobs, AI puts executive and creative intellectuals at risk. In short, if until now we had understood that automation replaced manual labor, today the prospect is that even intellectual ones, especially the most basic, begin to be at risk. Routine cognitive tasks can be replicated by machines that are faster, more efficient, more precise, and less costly even within a complex scheme. When you use Siri or Google Assistant, you are actually using DL. But AI also possesses different abilities from human ones, which qualify it in a qualitative and not just quantitative way. The difference between an AI and a human operator lies in two particularly important and qualitatively different abilities from those of our brain: connectivity and the possibility of rapid updating. There will therefore be "threatened" jobs, jobs that will resist, others that will transform, and jobs that will be created. Those professions that require a flexible approach to problems or human qualities such as empathy and trust, but above all imagination and ideas, are not at risk. With all probability, we will certainly have an AI doctor on our smartphone in the coming decades before having a reliable nurse robot.

The AI ecosystem in Italy. This technology is creating innovations that attract increasing investments, in fact, there are many fields in which startups operate, and there is clearly a demand for new jobs. AI will not replace people but will rather amplify human ingenuity and open many perspectives for improving our quality of life. It is certainly necessary to continue talking about AI and all related topics. Just like any other technology, it aims to allow us to achieve more and improve what we do every day. The Italian AI ecosystem is characterized by four categories of actors: the scientific community, technology transfer centers, technology and solution providers, public and private users (such as organizations and companies).

The Italian scientific community is very active in the field of AI. It contributes essentially to the ecosystem in four ways:

Research: Italian researchers are active across the entire spectrum of research, both fundamental and applied to AI. In particular, Italian research is focused on various themes. Research is mainly conducted in the research laboratories of universities and public research centers - such as the National Research Council (CNR) - and in research foundations, such as the Bruno Kessler Foundation or the Italian Institute of Technology. As we will see later, this community enjoys an internationally recognized position in terms of the quality and quantity of its research.

Education and training: Italian universities offer more than 200 degree courses in AI, distributed across about 50 universities. To further enhance this ecosystem, Italy launched in 2021 the National PhD in "Artificial Intelligence"(90), one of the largest and most ambitious PhDs in AI in the world. The program involves over 50 universities, three public research institutions, and three research organizations with the aim of training researchers, innovators, and professionals.

Infrastructures: the Italian ecosystem hosts several high-level research infrastructures, both in terms of computing capacity and data lakes(91). These centers are all able to provide IT structures and AI skills, which allow scientists from any discipline to conduct complex and demanding experiments.

Community: Italian researchers participate in all major international research networks, including the most prestigious EU networks. Italy also has a notable tradition of national scientific research associations, such as A1xIA, CVPL, and AILC.

Despite the good starting point, the Italian AI research sector has four weaknesses, which this strategy aims to mitigate. Despite the international excellence of the Italian AI research community, the persistent problem of lack of scale and critical mass and low interdisciplinary integration in research laboratories, together with low public/private funding for fundamental research, pose a serious risk to the competitiveness of the sector. Although the training of new talents in Italy is at adequate levels, the attraction of profiles from abroad is low, with few qualified researchers moving to work in Italy. So far, no dedicated strategy has been effective in promoting a consistent flow of foreign researchers and professionals. Only 19.6% of AI researchers are women, compared to almost 50% in STEM in general.

Italy generates many fewer patents per publication compared to similar European countries. However, more and more companies are using AI as a factor of industrial growth and a lever of competitiveness to obtain benefits in terms of greater reliability, quality, and safety, lower operating costs, and higher revenues and profits. For example, this type of technology helps companies improve the quality of human work, relieve workers of repetitive, burdensome, and dangerous tasks, increase turnover and profits, acquire new customers, as well as limit risks and improve efficiency in general. According to the study by the European Parliament "Opportunities of Artificial Intelligence"(92), AI will lead to a strong increase in labor productivity (between 11% and 37% by 2035), thanks to innovative technologies that allow for more efficient management of the workforce. The global AI market could reach $387 billion in revenue by the end of the year. Revenues will increase by 260% by 2029, thus exceeding one trillion, thanks to a compound annual growth rate of 20% over the next seven years. In Italy, the AI market has doubled in value in the last two years, and in 2021, the turnover exceeded 380 million euros (+27%)(93). Moreover, 53% of medium-large Italian companies have declared that they have started at least one AI project since the beginning of 2022. Regarding the sectors, according to the most recent data from the Observatory on Artificial Intelligence, the most widespread solutions on the Italian market concern natural language processing, specifically its interpretation for 17.5%, while the part called "recommendation system," i.e., content suggestions in line with customer preferences, for 16%. We also have robotic process automation through AI for a good 10%. There is no updated information on the exact number of companies dealing with AI in Italy, as statistics and estimates vary over time and depend on how the field of AI is defined. However, it is possible to provide some general information on the development of the sector in Italy. According to a 2021 survey by the Politecnico di Milano(94), there are about 3,500 companies in Italy that use AI or ML technologies. The sector in Italy has grown by 50% from 2015 to 2020. Companies that deal with this sector do not have to be listed on the stock exchange and must be focused on techniques such as ML (where systems learn from data to improve business activities), natural language processing (which allows programs to "understand" written or spoken language), or computer vision (which refers to how machines "see"). There are 14 Italian startups at CES(95) that deal with AI and data processing. Therefore, Italy seems to want to embrace the potential offered by AI, although in terms of policies it does not seem to show the due interest in it. The issue of the National Recovery and Resilience Plan (PNRR) remains open as the due importance has not been given to this technology. However, the recent adoption of the Strategic Program for 2022-2024, which arrived very late, could open new scenarios to accelerate innovation and the potential of the country's economic and social fabric in the next three years. There are several research centers and universities in Italy that deal with AI and collaborate with the industry to develop new technologies and applications. Some examples include the University of Bologna, the University of Padua, the Politecnico di Milano, and the CNR (National Research Council). Moreover, there are several companies that deal with AI and ML(96).

The United States currently holds the title of world leader in AI but is losing ground. This is largely due to the fact that they are facing the same growth difficulties that slowed down Japan and South Korea in their paths to becoming technological powers. Meanwhile, China's chances in the race in this sector are growing, despite the current US advantage. Chinese companies seem to be well positioned, driven by their wealth of data. The more data a system has, the better it will work. Moreover, the central government aims to make China an AI superpower. If the situation at the beginning of the 2000s was one of an abysmal gap, today not only has this gap been bridged, but a market and a technological sector with autonomous and peculiar characteristics have been created, operating according to different principles and methods, to meet the needs dictated by the local context. Consequently, the US advantage in the AI race seems less significant than previously thought. In any case, a global duopoly is emerging in a field whose development is destined to disrupt our societies. In fact, the technologies involved tend to operate according to the "winner takes all" logic, which, combined with the enormous investments and the high level of required skills, should naturally lead to strong centralization and concentration. Concentration in a small number of countries, which will play a leading role, on the one hand, and in a small number of companies that are protagonists of the transformation, on the other. The consequences in terms of further polarization and increasing inequalities are easy to understand. There will therefore be jobs "threatened" by AI, jobs that will resist, others that will transform, and jobs that will be created. Those professions that require a flexible approach to problems or human qualities such as empathy and trust are not at risk.

Emerging professions and required skills. There are several professions and roles within the field of AI, including:

Data scientist: a professional who deals with the processing and analysis of large amounts of data to extract useful information for the company. AI uses machine learning algorithms that require data collection and cleaning.

Artificial Intelligence Engineer (AI Engineer): a professional who deals with the design and implementation of Artificial Intelligence systems, such as search engines, voice assistants, chatbots, recommendation systems, and so on.

Machine Learning Expert (Machine Learning Engineer): a professional who deals with the implementation of machine learning algorithms, the choice of the most suitable models for business needs, their optimization, and the validation of results.

Natural Language Engineer (NLP Engineer): a professional who deals with the development of natural language processing systems, such as voice assistants, chatbots, voice recognition, automatic translation, and so on.

Robotic Engineer: a professional who deals with the design and development of intelligent robots that can be used in various fields, such as industrial production, healthcare, security, and so on.

Artificial Intelligence Ethics Expert (AI Ethics Expert): a professional responsible for the evaluation and mitigation of ethical risks associated with the use of Artificial Intelligence systems, such as the risk of discrimination, privacy invasion, and public opinion manipulation, and so on.

Data Architect: a professional who deals with the design of the architecture of data management systems, including those used in the field of Artificial Intelligence.

Computer Vision Expert (Computer Vision Expert): a professional who deals with the development of computer vision systems, i.e., technologies capable of interpreting and analyzing images and videos.

System Engineer: a professional who deals with the design and implementation of artificial intelligence systems, including those based on neural networks, machine learning algorithms, natural language processing systems, and intelligent robots.

Cybersecurity Expert: a professional who deals with the protection of Artificial Intelligence systems from external threats, such as cyber attacks.

Control Engineer: a professional who deals with the design and implementation of control algorithms for Artificial Intelligence systems.

Artificial Intelligence Expert in the Healthcare Sector (AI in Healthcare Expert): a professional who deals with the implementation of Artificial Intelligence systems in the healthcare sector, such as those used for diagnosis, therapy, and disease prevention.

These are some examples of professions related to AI. The list continues to expand as AI is adopted in more and more sectors and applications.

There is no profession that is more important than another in AI. Each profession has its role and contributes significantly to the creation and implementation of effective and efficient AI systems. For example, Data Scientists and AI Engineers focus on the design and implementation of machine learning algorithms, while AI Ethicists evaluate and mitigate the ethical risks associated with the use of these algorithms. NLP Engineers, Computer Vision Experts, and Systems Engineers focus on different areas of specialization, but all are important for building complete and integrated AI systems. Furthermore, the choice of the most important profession depends on the context in which AI is applied. For example, the importance of an AI Expert in the healthcare sector can be very different from the importance of an AI Engineer in manufacturing.

In summary, all professions related to AI are important and contribute significantly to the creation of advanced systems and the use of these systems in multiple contexts. The problem with all these new professions, however, is that they will most likely require high-level skills and consequently will not solve the problems of low-skilled unemployed workers. Creating new jobs could prove easier than training personnel to fill these positions. Certainly, a new awareness will be needed. Humans will no longer be limited to using machines but will have to push themselves to collaborate with them more incisively and in increasingly interconnected environments, not necessarily located in the same physical place. It will be necessary to work to promote dialogue even with artificial intelligence systems. Various knowledge and skills are required to work in the field of AI, including: programming, mathematics and statistics, machine learning, domain knowledge, linguistics, data science, creativity and critical thinking, communication.

These skills can obviously be acquired through university education, but also through professional training and field practice. To work in AI, a background in computer science, mathematics, or engineering is usually required. Here are some possible qualifications: Bachelor's or Master's Degree in Computer Science; Bachelor's or Master's Degree in Mathematics; Bachelor's or Master's Degree in Computer Engineering; Master's Degree in Artificial Intelligence and Robotics; Master's Degree in Cognitive Sciences with a specialization in AI; Master's Degree in Data Science. Additionally, there are specific Master's or post-graduate training courses on AI and its applications, which can be an excellent option for those who wish to further deepen their knowledge on the subject. There is no specific degree that is "the most important," as this field of study is interdisciplinary and requires skills in various sectors. However, as mentioned earlier, a background in computer science, mathematics, or engineering can be an excellent starting point for acquiring the necessary skills to work in the sector. Furthermore, knowledge of the fundamentals of linear algebra, statistics, and programming is particularly important. Many curricula include these subjects, but there are also many online courses and specialized training programs that can help develop these skills. In short, there is no single "best" degree to study AI, but a combination of skills in different sectors can prepare an individual to work in this field.

CHAPTER 5

CONCLUSIONS AND INTEGRATED PROSPECTS

The increasingly widespread use of AI will inevitably have an impact on our society and, in particular, on the world of work, as some cognitive tasks can paradoxically be performed better by machines. Consequently, organizations will have to work to embrace the ongoing changes and focus on the conversion and improvement of staff skills, without forgetting that the resilience of digital contexts cannot be separated from the spread of digital culture and the incorporation of business continuity and risk management principles. Therefore, as the digitization process advances, staff will have to learn to collaborate with AI and automation technologies. Consequently, repetitive and error-prone tasks will be increasingly automated, while staff will increase their ability to provide input where necessary. That is, in this era of technological developments, it is more fundamental than ever to understand the importance of the interaction between humans and technology, increasingly permeated by AI. A technology that is confirmed as a human construct and that only by thinking "humanistically" will we learn to manage, well aware of the need for rules oriented towards the common good. Skills and, more precisely, the tasks that can be "replaced" by algorithms and the professionalism that we will need in the immediate future are the two central themes of the coming years. It is the technology itself that can help us learn faster than in the past, acting as an engine for upskilling and reskilling(18) to increase the technological quotient of many company figures, overcoming the concept that sees the machine as an element "replacing" the human being. Ensuring that people have more opportunities to retrain and aspire to more rewarding functions remains an essential goal to pursue, through shared planning at the ecosystem level. It is possible to direct training, expanding its boundaries, but it is necessary to go beyond orthodoxies by investing in the creation and hybridization of skills. If we prepare adequately even for this technology, making it a national mission that involves all stakeholders, AI will contribute to the improvement not only of companies but of the entire country. The real challenge today is not digital innovation, because it is done very easily, costs less and less, and is mainly done by large companies buying small companies. The real challenge today is digital governance. That is, not so much how digital is renewed but what we do with this innovation, in short, which path we want to take, in which direction we want to move. We must think that there are epochs of great discoveries, epochs of great inventions, and today the time has come for a project, a design that will be exactly what makes the difference. In short, a plan to implement governance.

In summary, we have a great strength, that is, this ability to act that we must direct in the right direction, and we must not worry that it becomes intelligent, but it is certainly a powerful force and in reality, it could solve many problems for us and will certainly continue to grow very quickly. There must therefore be a great design on how and where to direct it, but first, we must ensure that this great force works for us, will we succeed?

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13. Passive nanostructures are nanoscopic structures that do not have active functional properties. In other words, they do not have self-regulation capabilities or interaction with the surrounding environment. These structures are made of materials that do not have electronic, magnetic, or other properties that can be actively controlled. Passive nanostructures are used as base materials for building other nanoscopic structures, such as active nanotechnologies. For example, passive nanostructures can be used as supports for creating sensors or nanoscale devices. Additionally, passive nanostructures can be used to improve the properties of other materials, such as electrical conductivity or mechanical resistance. In summary, passive nanostructures are fundamental materials in nanotechnology and are used as basic components for building more complex and functional structures.

14. Cathodic sputtering, or sputter deposition, is a process by which atoms, ions, or molecular fragments are emitted from a solid material called a target, bombarded with a beam of energetic particles (usually ions).

15. Bottom-up design is the traditional method. First, the parts are designed and modeled, then they are inserted into an assembly, and couplings are used to position the parts. To change the parts, modify them individually. These changes are then displayed in the assembly. Bottom-up design is the preferred technique for already built parts or standard components such as hardware, pulleys, motors, etc. These parts do not change shape and size based on the project unless another component is chosen.

16. Raman spectroscopy or Raman scattering spectroscopy is a material analysis technique based on the phenomenon of scattering of monochromatic electromagnetic radiation by the analyzed sample. Raman spectroscopy is widely used in the study of materials, both in solid, liquid, or gas phase. It is a non-destructive technique that provides quick responses, does not require special conditions for measurement execution, and can be performed directly on the sample.

17. Passive nanoparticles are drug delivery systems that use passive targeting to accumulate in specific areas of the body, mainly through physiological characteristics of the target. They can be organic (polymeric, lipidic) or inorganic (e.g., metal oxides), with sizes generally between 10-300 nm.

18. Active nanostructures are used in many high-tech applications, such as in the creation of nanoscale electronic devices, like sensors, actuators, and memory devices. Additionally, active nanostructures are used in biotechnology to create personalized diagnostic and therapeutic systems. In summary, active nanostructures are advanced materials in nanotechnology used to create functional structures and develop new technologies and advanced applications. Their ability to interact with their environment and modify their properties in a controlled manner makes them very useful in many areas of science and technology.

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22. The systematic study of this discipline is attributed to the person who, after his very important discoveries, is defined as the father of genetics: Gregor Mendel. He was an Augustinian monk from the monastery of Brno, in Moravia. He was born in Heinzendorf in 1822, where his parents practiced agriculture. In the garden of his monastery, Mendel performed thousands of crosses between peas, which led him to explain his results by

describing two laws of heredity, through the introduction of the idea of dominant and recessive traits. Gregor Mendel is therefore considered the founder of modern Genetics.

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26. A genetic test is a DNA analysis that can help determine if there is a change in a particular gene or chromosome. The change, called a mutation, can affect all cells of an individual and can be passed on to future generations.

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35. Man takes the first steps in the complex world of cloning in 1938, when Spemann performs the first nuclear transfer; in 1952 Briggs and King, English researchers, begin experimentation on the frog, attempting cloning from embryonic cells, and ten years later John Gurdon succeeds in extracting the nucleus from an intestinal cell of a tadpole to transfer it into an egg. In 1972 genetic engineering amazes the world by presenting the first transgenic mouse; then we move on to increasingly larger animals, leading in 1997 to the birth of Dolly, the first fully cloned sheep.

36. Dolly is the result of a cloning experiment by somatic cell nuclear transfer, a technique in which an egg cell is deprived of its original nucleus, which is replaced with that of an adult cell from another animal in order to generate a new specimen with the same genetic heritage.

37. The first cloned mare, Prometea, was born in Italy in 2003 as a result of studies conducted by Professor Cesare Galli.

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39. GMO stands for genetically modified organism; these are plants, microorganisms, or animals in which part of the genetic heritage has been modified with genetic engineering techniques.

40. Genetic engineering, in addition to isolating and cutting DNA sequences to transfer them to other cells, as we have seen with the recombinant DNA technique, allows "altering" the sequence of the original gene's DNA and producing one more suitable to respond to specific needs, as happens, for example, with Genetically Modified Organisms (GMOs).

41. At this point, however, it is important to emphasize the subtle difference between transgenic organisms and genetically modified ones, often confused and mistakenly considered the same thing. The term transgenesis refers to the insertion, into the genome of a given organism, of genes from an organism of a different species. Instead, GMOs are defined as those organisms from which genes have been removed or in which the inserted genetic material comes from an organism of the same species.

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<https://www.2duerighe.com/generazione-nao-un-robot-per-la-salute/111986-robot-e-societa-riflessioni-sul-futuro.html>

52. An anthropomorphic robot is a particular type of automaton capable of recreating and reproducing some characteristics of humans as well as imitating some of their traits such as movements and roughly their appearance.

53. Types of robots. We can distinguish robots into five macro categories: Pre-programmed Robots: operate in a static and controlled environment performing simple and repetitive tasks, an example are the mechanical arms present in the assembly line of a factory; Humanoid Robots: resemble or imitate human behavior, sometimes performing activities and expressions that replicate those of humans, an example are Sophia by Hanson Robotics, Atlas by Boston Dynamics or the humanoid social robot Pepper; Autonomous Robots: are usually designed to perform activities in environments that do not require human supervision, using sensors to perceive what surrounds them and then employing decision-making structures to perform the next action. An example of an autonomous robot is the Roomba vacuum cleaner, which uses sensors to move freely throughout the house; Teleoperative Robots: semi-autonomous robots that use a wireless network to allow human control from a safe distance. They are usually employed in extreme geographical or weather conditions, such as robots used to repair underwater pipe leaks during oil spills or those for mine detection on a battlefield; Augmented Robots: are enhancement robots, also known as VR robots, which improve or replace the abilities that a human being may have lost. An example is robotic prosthetic limbs.

54. Luca De Biase, "Here Come the Robots" in "ilsole24ore.com" on November 25, 2015.

<https://st.ilsole24ore.com/art/notizie/2015-11-25/quindici-chiavi-anticipare-futuro-130732.shtml?uuid=ACKxL2gB>

55. Pierluigi Sandonnini, "Humanoid Robot Sophia: What It Does and How It Works" in "ai4business.it" on August 22, 2022.

<https://www.ai4business.it/intelligenza-artificiale/ecco-a-voi-sophia-il-robot-umanoide-che-esprime-emozioni/>

56. Narrow artificial intelligence (narrow AI) is focused on a narrow task. In the words of John Searle, "it would be useful for testing hypotheses about minds, but it would not actually be a mind." It contrasts with strong artificial intelligence, defined as a machine with the ability to apply intelligence to any problem, rather than to a single specific problem, and sometimes it is considered that it requires consciousness, sensation ability, and mind. By "General purpose AI" we mean a system capable of performing general application functions, such as image recognition, speech understanding, audio and video generation, pattern detection, answering questions, translation, etc.

57. Blake Hannford, "Surgical Robotics: Systems Applications and Visions," ed. Springer Verlag, 2010.

58. "The Future of Robots and Robotics: Will They Steal Our Jobs?" in "economia-italia.com."

<https://www.economia-italia.com/futuro-di-robot-e-robotica-ruberanno-il-lavoro>

59. Luigi Mischitelli, "Artificial Intelligence in the Military Field: State of the Art, Scenarios and Role of Italy" in "agendadigitale.eu."

<https://www.agendadigitale.eu/cultura-digitale/intelligenza-artificiale-in-campo-militare-stato-dellarte-scenari-e-ruolo-dellitalia/>

60. Robotics is the intersection of science, engineering, and technology that produces machines, called robots, which replicate or replace human actions, while artificial intelligence is the simulation of human intelligence processes by machines, particularly computer systems.

61. Bruno Siciliano, "Questions About the Future," in "tecnelab.it."

<https://www.tecnelab.it/osservatorio/robotica/questioni-sul-futuro>

62. Ilaria Vesentini, "OVERSONIC's Humanoid Robot at Work in Production Lines," in "oversonicrobotics.com" on March 5, 2023.

<https://oversonicrobotics.com/il-sole-24-ore-il-robot-umanonide-di-oversonic-al-lavoro-nelle-linee-di-produzione/>

63. Stefano Latini, "Robots at Work, Unfounded Fears About Unemployment" in "ipsoa.it" on March 14, 2022.

<https://www.ipsoa.it/magazine/robot-al-lavoro-timori-disoccupazione-infondat>

64. World Robotics Report 2022.

<https://ifr.org/downloads/press2018/2022_WR_extended_version.pdf>

65. Mokyr, C. Vickers, N.L. Ziebarth, "The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?" in "aeaweb.org" in 2015.

<https://www.aeaweb.org/articles?id=10.1257/jep.29.3.31>

66. From a practical point of view, even if not all authors agree on the distinction between the two revolutions, we limit ourselves here to recalling the concept of the "third industrial revolution," which occurred around the mid-1990s with the spread of ICT systems, i.e., technologies concerning the creation, storage, and exchange of information through integrated systems of telecommunications, computers, audio-video technologies, and software; on the other hand, we intend to speak of the "fourth industrial revolution" as one having as its object a new model of industrial development, also defined as "Industry 4.0," which developed and spread from the first decade of the current century, according to which the functioning of the factory is based on the interpenetration between the physical and digital worlds, thanks to the introduction of new technologies such as artificial intelligence (AI), robotics, the "Internet of Things" (IoT), 3D printing, quantum computers, genetic engineering. Other authors believe that what is defined as the "fourth" revolution is actually just a continuation of the third.

67. S. Lovergine, A. Pellero, "What Future for Work: Analysis of the Literature on the Impacts of Robotics" in "bollettinoadapt.it."

<https://www.bollettinoadapt.it/wp-content/uploads/2019/04/INAPP_Lovergine_Quale_futuro_per_il_lavoro_2019.pdf>

68. M. Borzaga, "The Repercussions of Technological Progress and Artificial Intelligence on Labor Relations in Italy" in "unibo.it" in 2022.

<https://labourlaw.unibo.it/article/download/15994/15061/61852>

69. This theory became popular following the publication of J. Rifkin's volume, "The End of Work. The Decline of the Global Labor Force and the Dawn of the Post-Market Era" in 1996.

70. Paolo Ichino, "The Consequences of Technological Innovation on Labor Law" in "pietroichino.it."

<https://www.pietroichino.it/?p=46233>

71. S. Lovergine, A. Pellero, "What Future for Work: Analysis of the Literature on the Impacts of Robotics" in "bollettinoadapt.it."

<https://www.bollettinoadapt.it/wp-content/uploads/2019/04/INAPP_Lovergine_Quale_futuro_per_il_lavoro_2019.pdf>

72. "What Will the Professions Be in 2030?" in "ifoa.it."

<https://www.ifoa.it/blog/quali-saranno-le-professioni-nel-2030/>

73. Marco Bentivogli, "The Work That Will Save Us," ed. San Paolo, 2021.

74. Alessio Cocchi, "The Benefits of Industrial Robotic Automation for the Company" in "universal-robots.com" on April 7, 2021.

<https://www.universal-robots.com/it/blog/i-benefici-dellautomazione-robotica-industriale-per-lazienda/>

75. Engineer Mario Salmon was one of the first professors to teach a specialist course in Robotics in Milan and has recounted his experience in a book entitled "The 1970s: A Case of Innovation and Life at Olivetti, Birth and Growth of the SIGMA Robot." A truly rich book of acute considerations, largely still valid today, and which well represent some of the typical problems of industrial automation and the replacement of human labor with machines that were then defined as "a bit intelligent."

76. Source Payscale, a US company of cloud computing that provides information on the salaries of work activities in the world through its website, launched on January 1, 2002. It was founded by Joe Giordano, former Microsoft manager, and John Gaffney.

<https://www.payscale.com/research/IT/Job>

77. Giovanna La Rosa, Claudio Moriconi, Attilio Sacripante, "Robotics. The Scenario, Applications, New Frontiers," ed. ENEA, 2008.

78. Michelle Crisantemi, "Robotics: The Five Trends That Will Drive Growth in 2023" in "healthtech360.it" on March 29, 2023.

<https://www.healthtech360.it/whitepapers/robotica-le-5-tendenze-che-guideranno-la-crescita-nel-2023/>

79. Davide Giribaldi, "We Will Work with Robots: Risks and Advantages of an Inevitable Future" in "agendadigitale.eu" on August 8, 2019.

<https://www.agendadigitale.eu/cultura-digitale/lavoro-la-sfida-della-collaborazione-uomo-macchina-vantaggi-e-rischi/>

80. 2001: A Space Odyssey (2001: A Space Odyssey) is a 1968 film produced and directed by Stanley Kubrick, written together with Arthur C. Clarke, who produced the subject and, on the same track, wrote the novel of the same name published in the same year. It is a science fiction epic set in the near future that touches on themes such as the identity and destiny of the human species and the role of knowledge. Inspired by Clarke's 1948 short story "The Sentinel," the author himself recognized that the two works stand to each other "as an acorn" stands "to an adult oak." It is considered one of the greatest masterpieces in the history of cinema, marking an epochal turning point, even outside the science fiction genre.

81. Alan Mathison Turing, born in London on June 23, 1912, is considered one of the fathers of Computer Science and is known for having decrypted, during World War II, the Enigma code used for communications in Nazi Germany.

82. The Turing test is a criterion devised by A.M. Turing to demonstrate a machine's ability to think. It was proposed in 1950 in an article published in the journal «Mind». It is an experimental situation consisting of a game with three participants: a man A, a woman B, and a third person C. The latter is kept separate from the other two and, through a series of questions, must determine who is the man and who is the woman. For their part, A and B also have tasks: A must deceive C and lead him to make an incorrect identification, while B must help him. So that C cannot have any clues (such as handwriting or voice analysis), the answers to C's questions must be typewritten or similarly transmitted. The Turing test is based on the assumption that a machine replaces A. In this case, if C did not notice anything,

the machine should be considered intelligent, as it would be indistinguishable from a human being. The machine, that is, should be considered as having an "intelligence" equal to that of man. The criterion proposed by Turing is considered the basis of artificial intelligence; however, to establish intelligence, it is based on a purely observational assumption and therefore needs further clarification given the complexity of the concept of intelligence itself and the impossibility of a universally accepted definition.

<https://disf.org/files/macchine-calcolatrici-e-intelligenza.pdf>

83. Deep learning is a branch of machine learning that trains computers to perform tasks similar to those of humans, such as speech recognition, image identification, and making predictions. It improves the ability to classify, recognize, detect, and describe through data.

84. Francesco Corea, "Artificial Intelligence," ed. Bollati Boringhieri, 2020.

85. Machine Learning (ML) is a subset of artificial intelligence that deals with creating systems that learn or improve performance based on the data they use. IoT, an acronym for "Internet of Things," refers to that technological development whereby, through the Internet, every object acquires its own identity in the digital world. As mentioned, therefore, IoT is based on the idea of "intelligent" objects interconnected with each other to exchange the information they possess, collected, and/or processed.

86. Luciano Floridi is an Italian philosopher, full professor of philosophy and ethics of information at the Oxford Internet Institute of the University of Oxford. Floridi is mainly known for his philosophical research work concerning: the philosophy of information, the philosophy of computing, and computer ethics, and for having coined the term Onlife, a neologism used to describe the experience lived in a hyper-connected world where there is no longer a distinction between being online or being offline.

87. By "gamification" we mean the use of mechanisms typical of the game and, in particular, of the video game (points, levels, prizes, virtual goods, rankings), to make users or potential customers participate in the activities of a site and interest them in the services offered.

88. The "opportunity cost" in economics is the cost resulting from the failure to exploit an opportunity granted to the economic subject. This concept is fundamental to understanding economic decisions, as every choice implies a sacrifice in terms of lost opportunities. In other words, opportunity cost is the sacrifice that an economic operator must make to make an economic choice.

89. Nicola Cosengo, "Robots and Humans: The Challenge of Automation and Work" in "unipd.it" on July 24, 2024.

<https://ilbolive.unipd.it/it/news/robot-lavoro-sfida-automazione-umani>

90. The National Doctorate in Artificial Intelligence is divided into 5 federated doctorates that bring together 61 universities and research institutions. The 5 doctorates have a common base aimed at the foundations and development of AI, and each has an area of specialization in a strategic sector of AI development and application. Each doctorate is organized by a lead university, in collaboration with the CNR: Health and Life Sciences, Campus Bio-Medico University of Rome; Agri-food and Environment, University of Naples Federico II; Public Administration, Sapienza University of Rome; Industry, Politecnico di Torino.

<https://www.phd-ai.it/>

91. A data lake is a centralized repository where Big Data in raw granular format from numerous sources is stored. It can contain structured, semi-structured, and unstructured data; this means that data can be stored in a more flexible format for future use. When storing data, the data lake associates it with identifiers and metadata tags to speed up subsequent retrieval. Created by James Dixon, CTO of Pentaho, the term "data lake" refers to the particular nature of the data stored in a data lake, which differs from the clean and processed data contained in traditional data warehouse systems.

92. European Parliament, "What Are the Risks and Benefits of Artificial Intelligence?" in "europa.eu" on September 29, 2020.

<https://www.europarl.europa.eu/topics/it/article/20200918STO87404/quali-sono-i-rischi-e-i-vantaggi-dell-intelligenza-artificiale>

93. Artificial Intelligence Observatory of the School of Management of the Politecnico di Milano, "Artificial Intelligence: Italy Has Awakened!" in "osservatori.net" in February 2022.

<https://www.osservatori.net/comunicato/artificial-intelligence/artificial-intelligence-italia-mercato-progetti-2020/>

94. Artificial Intelligence Observatory of the School of Management of the Politecnico di Milano, "The Artificial Intelligence Market is Growing in Italy" in "osservatori.net" in February 2022.

<https://www.osservatori.net/comunicato/artificial-intelligence/artificial-intelligence-italia-mercato-progetti-2020/>

95. The Consumer Electronics Show (CES, lit. "consumer electronics show" in English), also called International Consumer Electronics Show or International CES in the 2000-2010s[1], is the most important consumer electronics fair in the world. It is held once a year, in January, at the Las Vegas Convention Center (Las Vegas, Nevada).

96. Almawave: is a company that deals with natural language analysis for the creation of chatbots and virtual assistants.

Yoox Net-A-Porter Group (YNAP): is a company that operates in the fashion sector and uses AI to personalize the customer experience and improve the efficiency of operations.

Leonardo: is a company that deals with advanced technology for defense and security, and uses it to improve the efficiency of operations and to develop new solutions.

Exprivia: is an IT consulting and services company that offers solutions to improve business processes.

Reply: is an IT consulting and services company that offers solutions for various sectors, including logistics, manufacturing, finance, and trade.

Eureka! Engineering: is a startup that deals with the development of solutions for process automation and the creation of autonomous robots.

97. The term "upskilling" refers to the ability to improve, develop, and retrain the worker's skills, upgrading their skills, or their "skills," for example in the digital field. The term "reskilling" refers to the ability of an employee to acquire new knowledge and skills necessary to perform a new job task, different from the one they currently perform.

SUMMARY

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Massimo Tamiatti

I have always been involved in the study and dissemination of topics related to new technologies, new jobs, and new skills. I do this in a completely new and different way compared to traditional research approaches because, in addition to consulting traditional sources, I consult sources from major strategic consulting firms, which do not have a static but dynamic vision of reality, as they focus on the future. I systematically use the web to search for the most up-to-date content, perhaps through webinars with privileged witnesses on the subject of the investigation or through some important influencer specialized in the topic being addressed. Obviously, today, I use Generative Artificial Intelligence tools. I do not neglect the present; I try to interpret the signals that we have before our eyes, which we are often used to looking at and not seeing, and which suggest what could happen. I do not neglect the past, that is, history, but in reality, many disciplines are mixed: economics, statistics, sociology, psychology, anthropology, and above all, I use imagination anchored to the facts that happen every day in the world. I consider numbers very important, but they are not everything; at the center, there must always be a particular attention to the privileged witnesses of the things that happen and their personal stories. Frontiere does not have the gift of foresight, but our team can make hypotheses, and among these hypotheses, I have realized that it is very likely to encounter the future. Spreading the culture of anticipation helps people understand what is happening in the world, especially in the world of work, helps them prepare, elaborating strategies, and organizing themselves to make very important conscious and correct choices for the effect they will have on their lives.

Institutional Profile

I was Chief Research Officer of the Agenzia Piemonte Lavoro, where I coordinated groups of researchers in the field of labor and vocational training policies until June 30, 2023. Since July 1, I have become part of the staff of the "Laboratorio Riccardo Revelli" as an honorary member. I am an expert in public employment services. Currently, I am a member of the group that coordinated the organization of the "Settimana del lavoro 2024" and related events on behalf of the Istituto per la memoria e cultura del lavoro, dell'impresa e dei diritti sociali (ISMEL), of which I am a member of the scientific committee. I am a member of the scientific committee of Polis policy, Accademia di alta formazione. I am the founder and director of the online scientific dissemination site **http://www.frontieretecnologialavoro.com** since 2022 and a member of the Associazione dei Futuristi italiani di Roberto Poli. I am an expert in the use of forecasting techniques applied to local labor markets, in collaboration with the start-up Skopìa, specialized in future studies and anticipation, aimed at helping organizations develop anticipatory strategies to support complex decisions in areas of strong uncertainty. I have a degree in letters and philosophy, with a thesis in contemporary history and one in political science, both obtained from the University of Turin, and I am the author of numerous publications related to the labor market, and in particular to the new scenarios of the labor market, new professions, and new skills.

The following collaborated with me on this project: Gabriele Lamberti, Benjamin Dafku, Ivan and Federico Giacobino.