5 Bettering Humanity through Biology

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Biology is arguably referred to as the "science of the XXIth century". This prestigious title intrinsically contains a huge responsibility. For many centuries, Biology has contributed directly or indirectly to bettering humankind, although its obvious and objective effects have only been made evident since the XIXth century. There are three main domains to which Biology has made significant contributions: Agriculture, Environment and Medicine. Several scientific disciplines connected to Biology have been involved such as Genetics (mendelian and molecular), Cell Biology, Ecology, Microbiology, and what was known for a long time as "Natural History" (today we would include these roughly within Botany and Zoology). Agronomy, a relatively recent science, has made a tremendous impact by providing knowledge on growing plants and animals, and developing new and better crops. One specific moment in time, following WW II, known as the "Green Revolution" benefitted humanity immensely, by combating hunger in countries such as India and Mexico. The "father" of the Green Revolution, Norman Borlaug, was awarded the 1970 Peace Nobel Prize for such achievements. In the XXIth century, biologists and agronomists are working hard to develop new and better crops to feed almost 8 billion people. In the medical field, the contributions are inumerable, from the discovery and development of vaccines (Jenner and Pasteur), to antibiotics (Fleming) and combatting diseases. This has increased the average life expectancy of humans from around 30-40 in the beginning of the XXth century, to a present value of around 75 (depending on the country). These achievements have been recognized by society, through dozens of Nobel Prizes in Medicine. All these successes have been made possible through Biology. In the past 30-40 years, numerous voices have been raised alerting for the environmental degradation of our planet, its land and oceans, its biomes and ecosystems. We have been depleting our planet at an incredible rate. But today, biologists and environmental scientists have the knowledge and tools to better the planet. We know how the ecosystems function and what causes

harm them. There is still time, together with a strong public opinion, to halt the damage. Once again, Biology is a principal actor.

1. Introduction

Throughout the ages, biological science has made tremendous contributions to bettering Humanity. In the IVth century BC, Aristotle was aware of the advantages and contributions that the natural sciences provided, from the purely scientific point of view to the empowerment of politicians (he was firstly advisor do king Philip II of Macedonia, and later teacher and mentor of Alexander the Great).

Naturalists and medical doctors (although at the time it would be hard to distinguish between both) were frequently requested and hired by kings and other rulers, throughout the world, be it Rome or China. Perhaps one of the famous cases would be the Greek-born Galen, who functioned as the imperial doctor of several Roman emperors.

All through Humanity's History, it is clear that rulers at large, and even most countries' populations, were aware of the fantastic contributions that knowledge and practices with a biological background make to better peoples' lives. These can be broadly characterized under Agriculture, Environment and Medicine. It is also interesting to observe the close relationship that these developments and this progress were closely associated with technical improvements, physical or chemical, for example the development of the microscope, or the identification and development of pharmaceutical compounds.

2. Agriculture

Very early on, let's say several thousands of years BC, when human being changed from a hunter-gatherer mode of life to a more sedentary

agricultural entity, it became clear that he was able to domesticate plants and animals and provide a more varied diet to feed his family and tribe, as well as to breed animals for all sorts of activities; all this was very empirical, of course, but it was a beginning. Even around 4000 BC, one is stunned by the magnificent engraving found in present-day Iraq, displaying a pedigree showing the transmission of characteristics through five generations of horses (Fig. 1).

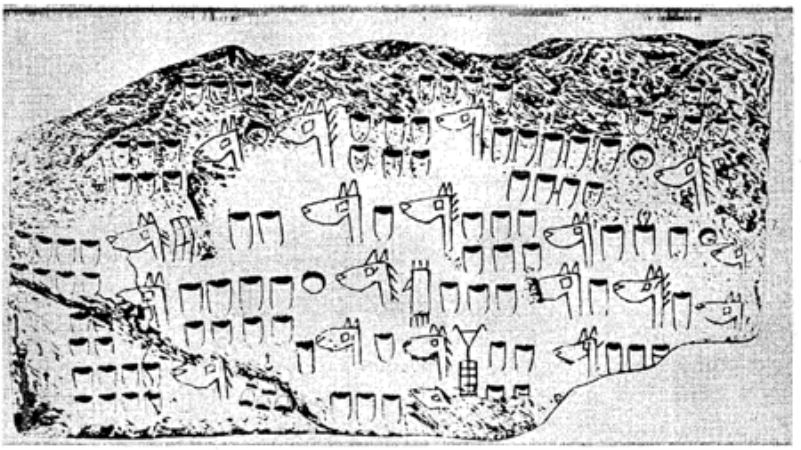

Fig. 1 – W. Amschler – 1935

The domestication of numerous crops took place throughout the Neolithic period, all through ancient Egypt, Greece and Rome. The early civilizations were in fact located in an area known as the "fertile crescent", which we know today is the center of origin of a large number of crop species, namely cereals.

Knowledge of crop as well as medicinal and aromatic plants was greatly expanded in the XVIth century, with the first globalization power, Portugal, who brought back to Europe thousands of plants and animals unknown (at the time). Garcia de Orta, who spent most of his time in Goa (India), stands out as the pioneer and most important

botanist of the time. This wealth of knowledge, continued by many other explorers and naturalists, from Spain, France, England, The Netherlands and others would be paramount for the foundations of modern plant classification (Linaeus, XVIIIth century), plant domestication, and agriculture.

The biological foundations of plant breeding (until then a more or less empirical activity) were laid down by an Augustinian monk living in the city of Brno, now Czech Republic (at the time, around 1850, it was the Moravian region of the Austro-Hungarian Empire). His name: Gregor Mendel (Fig. 2):

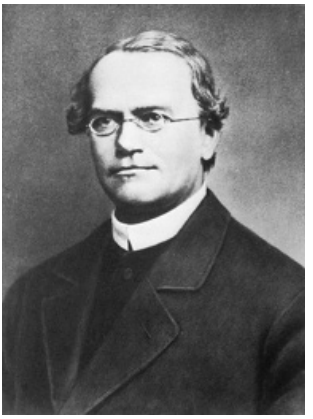

Fig. 2 – Gregor Mendel

The famous pea experiments resulted in an understanding of the basic, simple principles of hereditary transmission, which later became known as the science of Genetics.

The early XXth century, besides the "re-discovery" of Mendel's laws of inheritance, saw an extraordinary expansion of the biological knowledge which provided basis for a betterment of new crops and animals. The exact location of genes, responsible for providing the

characteristics of all plants and animals (as well as of microbes), culminating in the discovery of the physical structure of the DNA molecule (Watson & Crick, 1953) (Fig. 3), made it possible to cross-breed and develop better and more productive plants and animals. This became evident following World War II, when Humanity drastically needed to feed a desperate population of survivors, as well as of millions of destitute people around the world.

Fig. 3 – DNA Model by Watson & Crick

A central figure here is Norman Borlaug (Fig. 4), who made extraordinary experiments in plant breeding, with cereals (mainly wheat), creating new and much more productive varieties, saving the lives of millions, especially in Mexico, India and the far East. This was known as the "Green Revolution". For his vast achievements, he received the 1970 Nobel Peace Prize.

Fig. 4 – Norman Borlaug

Borlaug's work has been steadily continued throughout the XXth century, and now in the XXIth century, with modern plant biotechnology, establishing new varieties of plants, more productive and protected against pests and pathogens. Today, nearly 2 billion ha of biotech crops (as they became known), such as soybean, maize, cotton, rice (the famous "golden rice"), tomato and so on, have been planted throughout the world (Fig. 5). This new "green revolution" has brought with it concerns in terms of food safety and security, but humans have been capable of evaluating the risks of these GM.

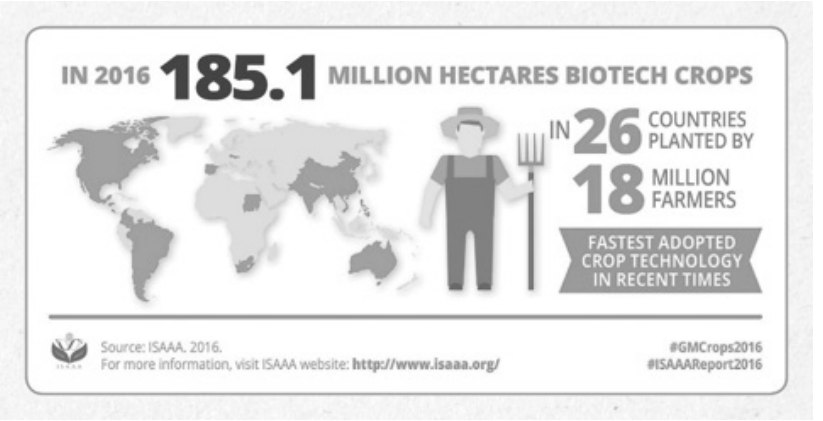

Fig. 5 – GM Crops

In summary, Biology has been central to the main discoveries related to the agricultural sciences (plant crops and domestic animals), and has contributed to the bettering of humanity, feeding it at a steady rate, with better, more productive and healthier products, such as cereals, milk and meat, to mention just a few examples.

3. *Environment*

Perhaps the most recent scientific branch, or application related to Biology is Environmental Science, or Ecology. The prefix "eco" derives from the Greek "oikos", which means "home", and in fact our planet, and more specifically the Biosphere, is our home.

For centuries, perhaps without realizing it, humanity adapted to its "home", but without understanding the need to keep it in good shape. In pristine days, most of the planet was unexplored, virgin in many ways, with forestas, mountains, etc… still kept in balance with the animal populations including the human species.

It is estimated that only around 200 million people lived around the year 1 AD. The first billion (thousand of million) people was reached only in 1800, and only nearly 200 years later we are now almost 8 billion people.

When the Portuguese arrived in Brasil in 1500, the coastal area was furrowed in a lush mantle of forests known as the "Mata Atlântica" (Atlantic Forest). Today, it is residual (Fig. 6).

Fig. 6 – Atlantic Forest

The geometrical population growth since 1800, coupled with devastating wars, in Europe but elsewhere, have brought increasing pressure to the environment and to the numerous terrestrial and aquatic ecosystems. But for a long time this went basically unnoticed. Practically no one, not even the brightest scientists of the XIXth century, even those close to the "Romantic" movement, raised any concern or alerts regarding the environment.

In the mid- and late XIX century, the Industrial Revolution put extraordinary pressure on the major European cities. Rural populations flocked to the industrial centers where jobs and money was available. Slowly, people started realizing the issues related to this sudden social change. Early pioneers in the conservationist movement included the famous American naturalist and philosopher Henry David Thoreau (1817-1862), but the first great contribution to the environment and concern for humans, came with John Muir (1838-1914) (Fig. 7) who in 1892 founded the Sierra Club, still active today.

Fig. 7 – John and Teddy

One of his famous statements was: "*Keep close to nature's heart, and break clear away, once in a while, and climb a mountain or spend a week in the woods. Wash your spirit clean*". How modern and ahead of his time! Muir had a powerful ally in this quest, President Theodore Roosevelt; it was early in his presidency (1901) that Roosevelt created the United States Forest Service, and

the Natural Parks (150 national forests) and 5 Great National Parks. The pioneer US system constituted a model for all major natural parks around the world. He stated then: *"We have fallen heirs to the most glorious heritage a people ever received, and each one must do his part if we wish to show that the nation is worthy of its good fortune"*.

Despite the rapid and powerful developments of the Western world's XXth century, Muir's message was not forgotten. Aldo Leopold (1887-1948) became a new pioneer for the last century, by writing abundantly about Nature and Man, and establishing the contrasting views "Eco-Ego". But world had undergone two major conflicts, in 1914-1918 and 1939-1945, so concerns with the environment took a back seat in the priorities of countries and rulers who needed to solve hunger problems; a time when huge amounts of pesticides and other agro-chemicals were used. The alarm sounded in 1962 with the famous Rachel Carson book "Silent Spring".

In the 1970s, and having the US as a pioneer country, a series of legislative initiatives such as , e.g., the "Clean Air Act", "Earth Day", etc… followed by a series of important international conferences (Stockholm, 1972; Montreal, 1987; Rio, 1992; Kyoto, 1997; and more recently Copenhagen, 2009) consolidated a strong environmental and conservationist movement which lasts until today.

Biologists and ecologists have been playing a pivotal role in providing the know-how and research which is paramount for decision-makers. Zoologist Edward Wilson (Fig. 8), from Harvard University, has contributed immensely to our knowledge on Biodiversity, and the need to conserve it. Scientists working on sensitive and iconic ecosystems such as the Amazon rainforest or the Galapagos Islands have provided help in making the planet a better place to live.

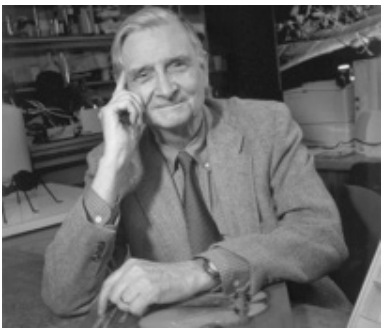

Fig. 8 – Edward Wilson

4. Medicine

Since the early ages of the human species, its health has been a central concern; firstly to protect the family and the tribe, in a very empirical and primitive form, and later on in a more organized fashion, with the emergence of specialists in different areas of the medical science.

From mysticism to the scientific revolution of the XVIIth century, all kinds of "witch doctors", surgeons, dentists, etc… did their best to heal wounds and suffering. But the lack of proper instruments and above all a mental and scientific framework in all societies, hindered progress. The microscope (van Leuwenhoek and Hooke, ca.1665) made a decisive contribution, namely in bettering our knowledge of human anatomy, still stuck in the old anatomies of Galen and Vesalius. An understanding of the human blood circulation, e.g., by Harvey in England (1628, "*De motus cordi*") and a demonstration made to King Charles I, very impressive events at the time. New surgical methods could now be implemented, bettering operations and the chance of survival.

Another good example of a major contribution is vaccination. A simple country doctor, Edward Jenner (1749-1823), observed that

the ladies who were milking cows, which suffered from what was then known as "cow pox" were apparently free from developing the disease, and developed in their arms smaller pustules, which he named "small pox" (until today, as referred as "variola"). By applying a diluted shot of these pustules to a young suffering boy, he became cured very quickly.

It took more than 50 years for this technique (thought at the time by the general public as crazy) to become scientifically established, by the man who founded modern Microbiology, Louis Pasteur (1822-1895) (Fig. 9).

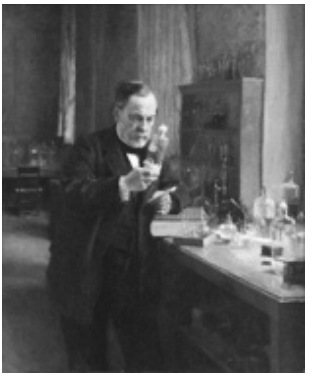

Fig. 9 – Louis Pasteur 1885

The contributions of this biologist to the bettering of humanity are infinite, from the study of crystals (enantiomers) (1847), understanding the chemical basis of fermentation (1857), definitely refuting the "spontaneous generation" theory (1860), saving France's silk industry from disease and destruction (1865-1870), it's cattle industry from anthrax (1877-1881) and the establishment of the rabies vaccine. His legacy has been kept until today, with the establishment of the Pasteur Institute, a major research institute which today provides all kinds of vaccines, such as e.g. against the various flu epidemics.

Microbiology indeed has been a major area in Biology, as well as medical science, where more contributions have been made to provide humans with a longer and better life. Such is the case of penicillin and all the later antibiotics, initiated in 1928 by Alexander Fleming (1881-1955). Or, more recently, the discovery of the polio vaccine by Jonas Salk (1914-1995) (Fig. 10), who saved the lives of millions of children.

Fig. 10 – Jonas Salk

Present day scientific domains within Biology, such as immunology to understand and treat diseases such as lupus and other auto-immune diseases, or the use of stem cells, to treat Alzheimer's disease or stroke, or the area of reproductive biology, where new discoveries and techniques of embryonic development, have been able to provide infertile parents with children, have made tremendous contributions to bettering humanity. There is no question about this.