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ORIGINS AND DEVELOPMENT OF A SCIENTIFIC DISCIPLINE: PHYSIOLOGICAL PHYTOPATHOLOGY

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ABSTRACT

The life cycle of the pathogenic oomycetePhytophthorainfestans, which causes late blight in potatoes and was responsible for catastrophic famines in the 1840s, was explained by German scientist Anton de Bary (1831-1888) in 1860. DE BARY (1861) founded the scientific field of physiological plant pathology in a book on the subject released 150 years ago. With reference to Charles Darwin's (1809-1882) theory of descent with modification by natural selection, we outline the life and scientific accomplishments of Anton de Bary, who created the words "symbiosis" and "parasitism." De Bary's discovery of the cause of wheat stem rust disease, which is caused by infections with the fungus Puccinia graminis, is then discussed. We conclude that "nothing in phytopathology makes sense except in the light of Darwinian evolution" since continuous pathogen-host plant co-evolution is widely established in nature. Finally, we discuss the importance of fundamental plant science research in terms of practical applications such as agricultural production maintenance and improvement, as well as food quality.

KEYWORDS: *Evolution, Phsiological, Phytopathology, Scintific, Theory.*

1. INTRODUCTION

The American Phytopathological Society released the inaugural issue of a journal that is being published today a century ago. Erwin F. Smith, a renowned botanist and microbiologist, was requested to write a tribute on the opening page of this new magazine. To the surprise of some of his North American colleagues, a German biologist was honored in Phytopathology Volume 1

(No. 1), with the following words: “Of all the personalities contributing to the advancement of plant pathology from its crude beginnings to the present time, none has been more interesting than De Bary's, none more productive of important results.” De Bary paved the way for all that has come after in plant pathology, and we must always remember him with the respect that a great master deserves.” Anton de Bary was described as an outstanding biologist in Erwin F. Smith's later biography as "gifted with intellect and the instincts of a careful experimental scientist, one who refused to accept or promote any truth as fact unless proven by rigorous technical methods." Anton de Bary was one of many notable 19th-century scientists who continue to live "in the shadow" of Charles Darwin, the renowned British naturalist. This is owing to the fact that he researched "lower creatures" such as plasmodial slime molds, fungi, and plants to a great degree. Only one of de Bary's many works has allusions to "higher creatures" (vertebrates) or humans.

Furthermore, it is seldom recognized that it was Anton de Bary who coined the words "symbiosis" and "parasitism" in relation to plants and Darwin's natural selection principle. A little-known monograph on potato late blight was published one hundred and fifty years ago, launching the scientific field of experimental plant pathology. The accomplishments of Anton de Bary are discussed in this article. After that, pathogenic fungi and bacteria are addressed in relation to the genesis and development of experimental plant pathology. Finally, we use Darwin's Origin of Species to explain theoretical and applied elements of these worldwide research objectives[1].

Anton de Bary (Figure 1) was born in Frankfurt-Main, Germany, on January 26, 1831. He studied medicine at the Universities of Heidelberg, Marburg, and Berlin from 1849 to 1853, earning his doctorate with an unpublished dissertation on a botanical topic. De plantarumgenerationesexuali, the title of this 1853 book, reveals the young physician's main interest: plants and related sessile creatures. At the same time, a 22-year-old junior scientist published his first book, despite the fact that he was already an experienced plant and fungus collector. summarized current knowledge on the smut fungi and the diseases that they cause in plants, with regard to cereals and other crop species, in his Researches on the smut fungi and the diseases that they cause in plants, with regard to cereals and other crop species, and proposed that the true causes of these devastating plant diseases could only be elucidated in the future through proper experiments. De Bary joined the University of Tuebingen as a lecturer (Privatdozent) for botany in 1854. The expert for fungi and plants was appointed professor of botany at the University of Freiburg am Breisgau just a year later. The scientist released his landmark book on potato blight at the Botanical Institute in Freiburg i. Br., which subsequently became one of Germany's major center for plant research. The renowned physicist left Freiburg after twelve years of hard labor to take a more appealing post at the University of Halle, where he remained from 1867 until 1872. De Bary served as the fi rst rector of the newly formed University of Strassburg, where he spent his last and most productive years. The biologist died of a tumor infection on the 19th of January 1888 at Strassburg[2].

Anton de Bary began his work as a field naturalist in the surrounding countryside, collecting plants and fungus. Despite his official training as a surgeon, his desire to study plants, fungi, and other "lower creatures" such as myxomycetes eclipsed his interest in medicine. He pioneered advanced laboratory methods for studying the life cycles of plant parasites, myxomycetes, and other "primitive" living organisms. Anton de Bary was a botanist, plant physiologist, myxomycetologist, and phytopathologist as a result of his studies. Furthermore, the laboratory scientist became one of the founding fathers of modern bacteriology with the publishing of his Lectures on Bacteria[3].

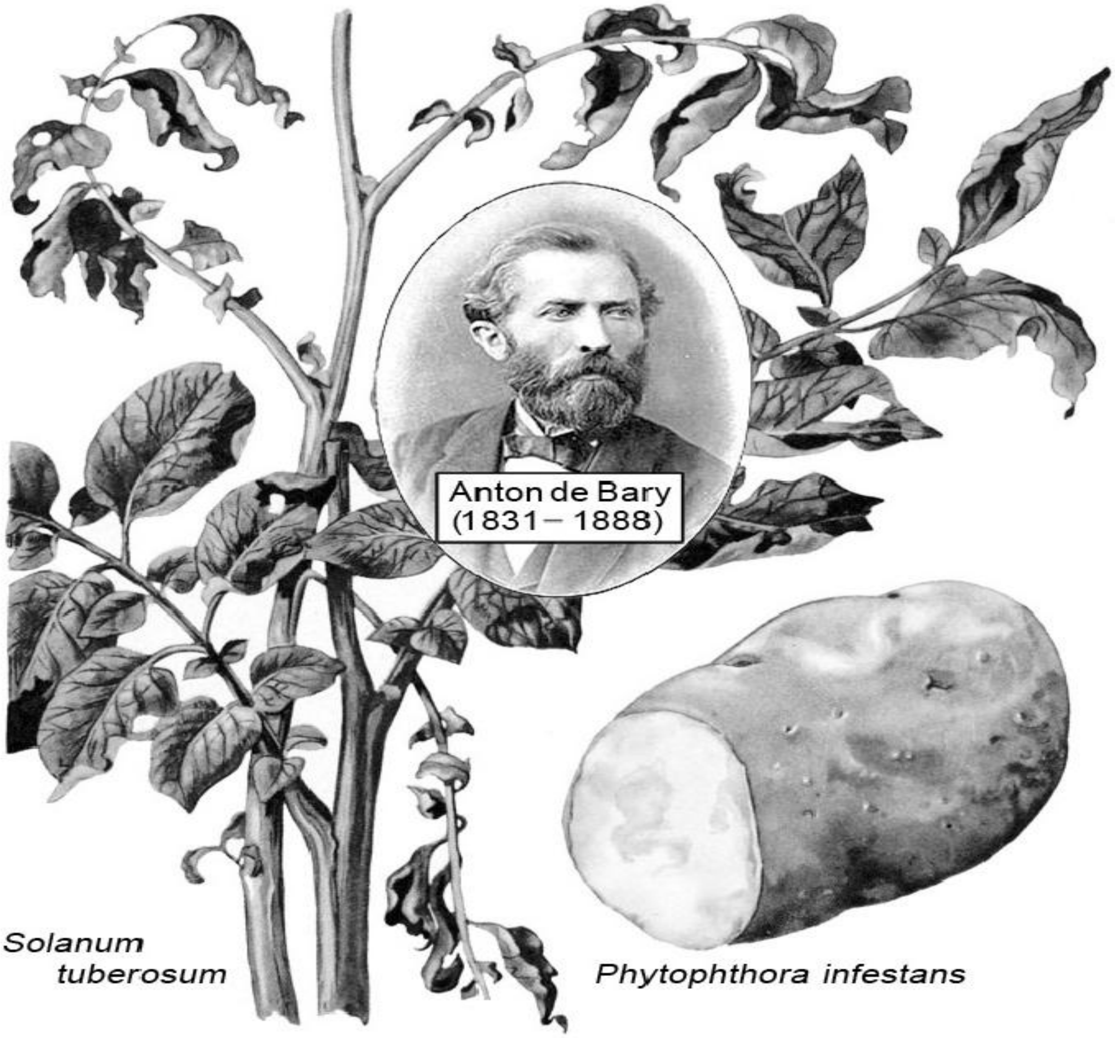


Figure 1: Photograph of the founding father of experimental plant pathology and his research object, potato plants (Solanumtuberosum), infected by the oomycete Phytophthorainfestans. The name "infectious plant destroyer" for this pathogenic fungus was coined by Anton de Bary in 1876[4]**.**

2. REVIEW OF LITERATURE

D. Andrivon in his study discloses about the genesis of the first European populations of the potato late blight disease Phytophthorainfestans is discussed using historical and scientific data. It demonstrates that the existing hypotheses of a direct introduction of the fungus into Europe and North America from a Mexican or Andean origin and diversification center are suspect. A three-step process involving I migration from central Mexico to South America several centuries ago; (ii) migration from South America to the United States in 1841–1842, and (iii) migration to

Europe from either South America, the United States, or both in 1843–1844, is in good agreement with both historical records and the genetics and structure of current populations[5].

Winslow R Briggs in his study discloses that from amateur taxonomy of Minnesota wildflowers to discovery of the phototropin family of blue-light receptors, he took a winding route. He also cites those who influenced his decision to pursue a profession in plant taxonomy, plant development, and ultimately plant photobiology (and out of music). He highlights the numerous detours that a research career may take, including those that lead to dead ends. He also highlights the cyclical character of his career, which has seen him go back and forth between the Atlantic and Pacific seas (with occasional excursions to Freiburg, Germany) and between red-light and blue-light receptors. He discusses his long-standing connection with California's Henry W. Coe State Park during a brief interlude. Finally, he describes how he traced an unexpected route from plant blue-light receptors to a blue-light receptor needed for a bacterial animal pathogen's maximum virulence[6].

G Drews in his study focuses on experimental method and idea, based on Darwin's theory of evolution, were the beginning principles for a phylogenetic taxonomy that could not be realized till now. Experimentally, he defined many species and subspecies, as well as their delimitation. De Bary also accurately described the whole process of fungus infecting plants. Based on his experiments, the words parasitism, symbiosis, heterospory, and heteroecy were created or redefined. His many research on algae, lichens, ferns, and higher plants contributed to the current state of knowledge. De Bary was a highly contemporary instructor who encouraged self-reliance, observation skills, self-control, and a critical assessment of one's own findings and conclusions rather than being dictatorial. He was well-known globally, and many scientists from across the globe came to see his state-of-the-art laboratory[7].

3. DISCUSSION

3.1 Potato blight and the origin of physiological phytopathology:

Fungus-like parasites (oomycetes), such as the potato blight disease Phytophthorainfestans, and their infection tactics are detailed in a recent paper titled "Genome evolution in plant pathogens" DODDS, 2010). However, the author of this well-known overview of potato blight studies failed to note that the field of physiological plant pathology was founded 150 years before his article was published. The life cycle of P. infestans was discovered at that time. This finding, which was described in a landmark publication titled The presently spreading potato illness, its cause, and prevention, was published in November 1861. A research based on plant physiology principles (Figure 2). The author established the field of experimental phytopathology, or the scientific study of plant diseases, with this paper.

Anton de Bary, a German botanist, detailed how the vegetative body (mycelium) of P. infestans spreads through the leaf tissue of infected potato (Solanumtuberosum) plants in February 1861. (Figure 1). De Bary documented the symptomatic course of the plant disease ‘late blight' versus the developmental phases of P. infestans in a series of clever studies. De Bary concluded that the oomycete is the causative agent of the potato plant disease based on these investigations, which showed a good connection between the life cycle of P. infestans and phases of plant disease development[8].

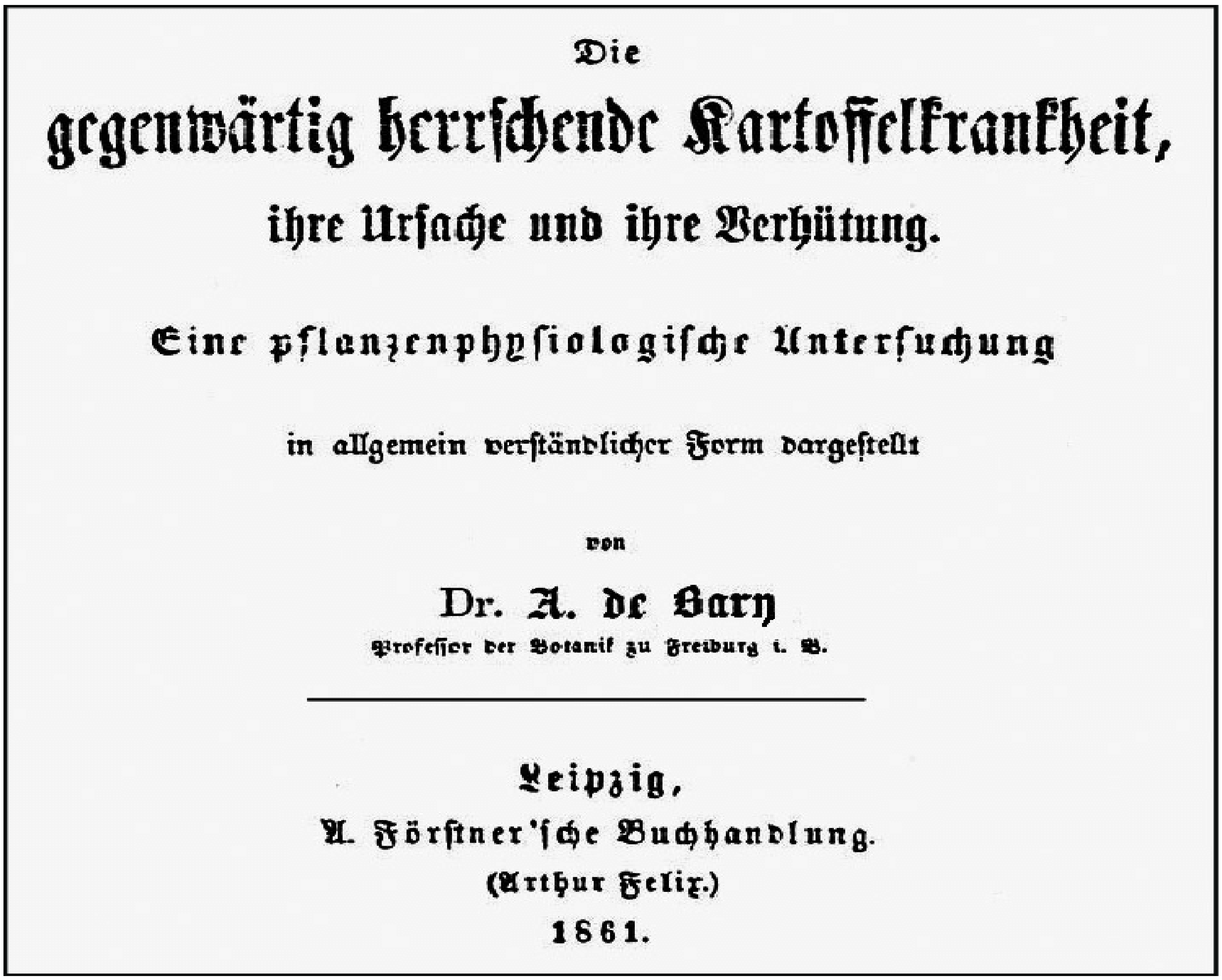
Anton de Bary presented experimental proof that potato tubers are infected by the fungus through the brown, blighted leaves and detailed the disease's progress in the field in this monograph (Figure 2), which was largely based on his own study. DE BARY (1861) produced precise cross sections through the leaves of infected potato plants, demonstrating the vegetative structure (mycelium) moving through the intercellular gaps of its host organism (Figure 3 A). He also kept track of the conidiophores' growth as they emerged from the pores of the stomata (Figure 3 B) and the germination of isolated P. infestans spores (Figure 3 C). The author concluded that “The disease of the leaves, stems, and fruits is caused by a pathogenic fungus, P. infestans, and the disease of the tubers occurs via infection from the leaves” based on these and other observations made according to the principles of experimental plant physiology, a scientific discipline founded in Germany in the 1850s by Julius Sachs. Furthermore, the expert stated that “it would never be feasible to drive the parasite P. infestans to extinction... nevertheless, a careful selection of uninfected tubers for agriculture will be sufficient to avoid large-scale outbreaks of this catastrophic plant disease.” At the conclusion of the book, he advised farmers on how to avoid another catastrophic potato blight outbreak, such as the one that ravaged Ireland from 1845 to 1848, resulting in crop losses and famine[9].

3.2 Is there really a thing as spontaneous creation of lesser organisms:

De Bary refuted the concept of spontaneous generation with his empirical evidence for the "fungal hypothesis," which says that P. infestans is the causative organism of potato blight. Many scientists thought that “lower” or “primitive” species, such as P. infestans, might arise from dead material under current environmental circumstances in 1861. Experimental data showed that the oomycete grows exclusively from its own spores and never emerges from scratch, according to the doyen of phytopathology. The notion in "generation without parents," which had never been backed by unambiguous evidence, vanished permanently from the scientific literature with the publishing of these evidence-based findings, which corroborated the similar "microbe-experiments" of Louis Pasteur. As a result, the birth of plant pathology 150 years ago resulted in the collapse of a doctrine that had sparked unending discussion among naturalists and philosophers. DARWIN disregarded the "spontaneous generation argument" in his book On the Origin of Species because, in his opinion, the evidence for this idea had always been poor and contentious[10].

3.3 Wheat stem rust: Infection experiments and their consequences:

The brownish uredia and uredospores of the stem rust, which is caused by the fungus Puccinia graminis (Figure 4 A-C). Based on de Bary’s seminal work of 1865 and subsequent studies, the complex life cycle, with alternation of generations on different host plants, has been elucidated in detail. Due to the elegant studies of DE BARY we know that the common barberry (Berberis vulgaris), as well as a grass species, is required for the stem-, black- or cereal rust (Puccinia graminis) to complete its life cycle. During the spring and early summer, stem rust infections on wheat and other cereal species (Figure 4 A, B) produce dikaryoticurediniospores. These propagules, which are produced within the uredinia, are distributed by the wind to nearby conspecifi cs. Here they germinate on the stems or leaves and then infect their new host plant through the stomata. This asexual summer circle, which spreads the infection over wide areas, is indicated in Figure 4 C as a circle. At the end of the growing season, the cereal rust produces dikaryoticteliospores, which, during the next spring, develop into basidiospores. These propagulescan not infect cereal plants. However, they are carried by the wind to a second host plant, barberry (Berberis vulgaris) and related species. There, the basidiospores infect young leaves via the penetration of the epidermal cells. The resulting infection structures (pycnia or spermagonia), which represent the sexual stage of the life cycle, form, after fertilisation, so-called aecia. These structures produce aeciospores, which are carried by the wind to cereal plants. After infection, the aeciospores develop into uredinia, and thus the next life cycle of the pathogenic fungus P. graminis begins (Figure 4 C). The elucidation of this “sophisticated” (i.e., evolved) life cycle of a plant pathogen, that still causes severe problems in Africa today. These insights were based on careful infection experiments and the use of different host plants and spore. One practical consequence rapidly emerged from this elegant work: the systematic removal of barberry plants close to crop fi elds. It should be noted that Anton de Bary’s research was based on the principles of experimental plant physiology (see the sub-titles of the monographs, a scientifi c discipline that was still in its infancy when the botanist-mycologist carried out his seminal work[11].


Die
gegenwärtig herrschende Kartoffelkrankheit,
ihre Ursache und ihre Verhütung.
Eine pflanzenphysiologische Untersuchung
in allgemein verständlicher Form dargestellt
von
Dr. A. de Bary
Professor der Botanik zu Freiburg i. B.

Leipzig,
A. Förstner'sche Buchhandlung.
(Arthur Felix.)
1861.

Figure2: Title page of Anton de Bary’s monograph on the potato late blight. This book also contains recommendations how to prevent the spread of this devastating plant disease[12]**.**

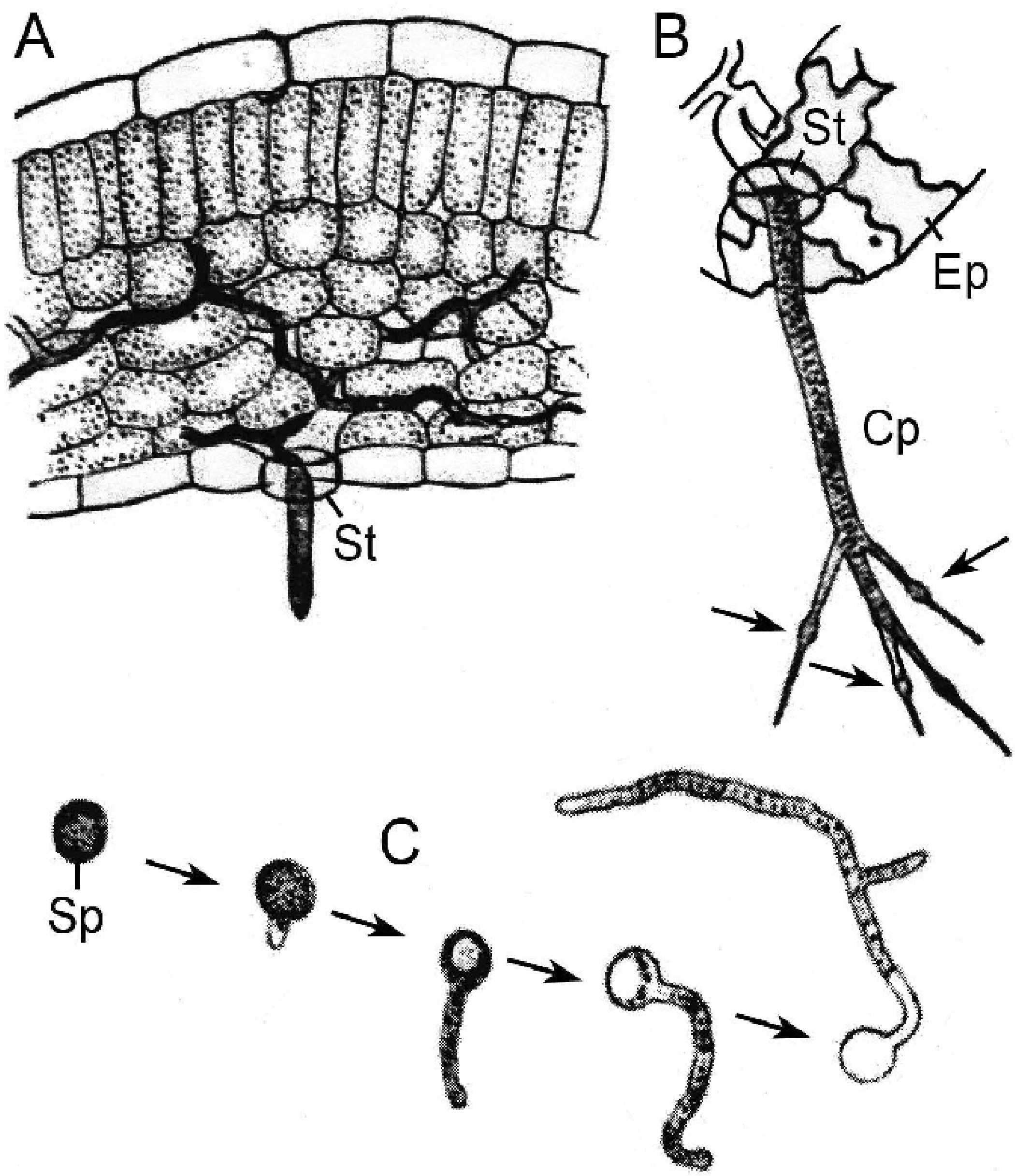


Figure 3: The discovery of the life cycle of the late blight oomycete Phytophthorainfestans by Anton de Bary. The mycelium of P. infestans in a leaf of a potato (Solanumtuberosum) plant (A), spore germination in liquid culture (C), and a conidiophore (with sporecontaining conidia, arrows) that emerges from a stomatum on the underside of a leaf (B). Cp = conidiophore, Ep = epidermis, Sp = spore, St = stomatum[13]**.**

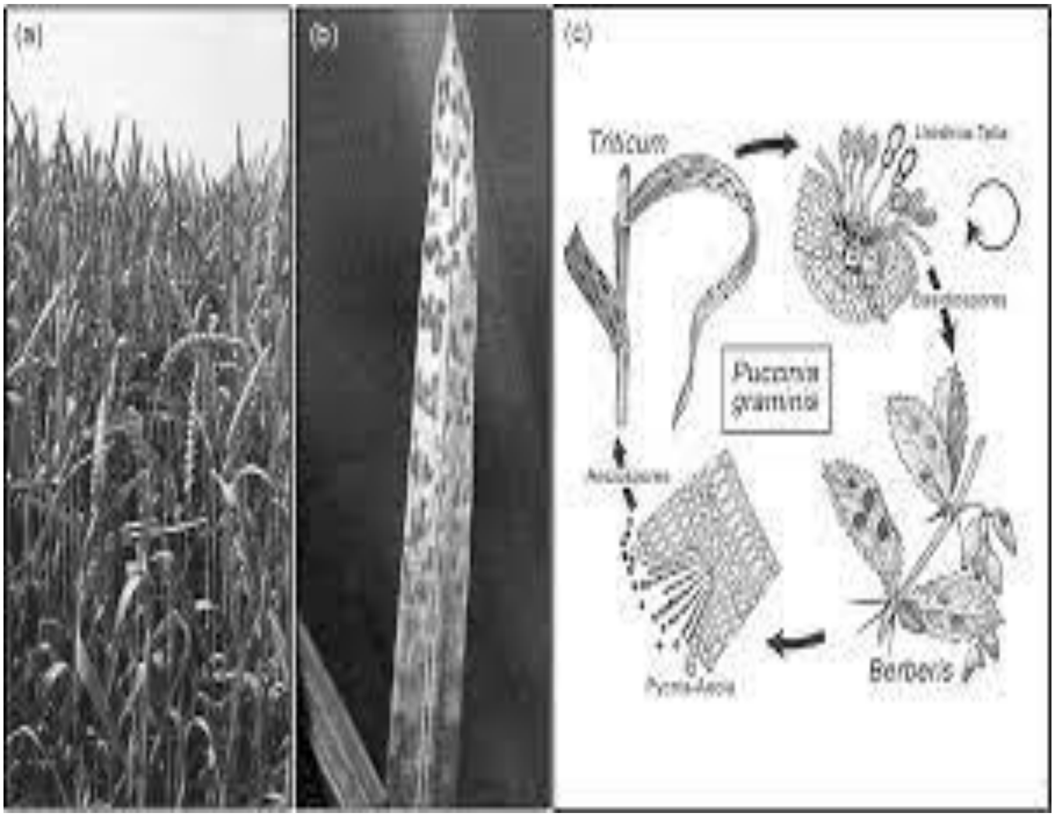


Figure 4: Healthy wheat (Triticumaestivum) plants in the fi eld (A) and a dying wheat leaf (B) that is infected by the pathogenic fungus Puccinia graminis, which causes this plant disease (stem- or cereal rust). Diagram of the life cycle of P. graminis via uredinia-telia (C). These propagules spread asexually on the infected Triticum plants (circle), release basidiospores that infect barberry (Berberis vulgaris) plants, where they reproduce sexually via pycnia-aecia, and fi nally re-infect wheat plants via aeciospores. Anton de Bary, who elucidated this grass (Triticum) host 1- alternate (Berberis) host 2- cycle, recommended removing barberry plants in the vicinity of wheat fi elds to prevent the spread of the cereal rust[14]**.**

4. CONCLUSION

Anton de Bary (Figure 1), a German scientist, was one of the first to apply experimental botany techniques to investigate the causes of illnesses in important crop species like potato and wheat. He explained the life cycles of pathogenic fungus based on thorough studies, came to the conclusion that these eukaryotic microorganisms are the causal agents of disease development, and so became the founding father of experimental plant pathology. With the publishing of a monograph on potato blight 150 years ago, this scientific field was born (Figure 2). DE BARY (1878) pointed out in his renowned book on plant symbioses and diseases that only a Darwinian viewpoint produces relevant results - in other words, “Nothing in plant pathology makes sense unless in the light of Darwinian (adaptive) evolution.” The study of Anton de Bary on potato blight and wheat stem rust demonstrates the practical importance of fundamental research in maintaining steady agricultural yields and food quality. His discoveries on the mechanism of infection and spread of plant diseases in the field led to the development of strategies to avoid future outbreaks. Furthermore, it was clearly stated that harmful microorganisms such as Phytophtora or Puccinia would never be fully eradicated since living creatures will constantly find methods to adapt to changing environmental circumstances via fast microevolutionary processes. This traditional "Darwinian" perspective on phytopathology was accurate. We now understand that dynamic plant-microbe co-evolutionary processes take place. As a result, new diseases have emerged, such as the modified stem rust strain Puccinia graminis race 1, which was recently identified. Ug99, which has a catastrophic effect on African wheat output, cannot be eradicated. In areas of the world where food production is constantly challenged by plant illnesses, insect catastrophes, droughts, and civil conflicts, these pests will continue to inflict catastrophic crop losses.

REFERENCES

1. D. Andrivon, "The origin of Phytophthora infestans populations present in Europe in the 1840s: A critical review of historical and scientific evidence," *Plant Pathology*. 1996, doi: 10.1046/j.1365-3059.1996.d01-196.x.

2. W. R. Briggs, "A wandering pathway in plant biology: From wildflowers to phototropins to bacterial virulence," *Annu. Rev. Plant Biol.*, 2010, doi: 10.1146/annurev-arplant-042809-112326.

3. K. Bryson and N. J. Msindai, *On the origin of species: By means of natural selection, or the preservation of favoured races in the struggle for life*. 2017.

4. B. Balfour, "Professor Heinrich Anton De Bary," *Trans. Bot. Soc. Edinburgh*, 1889, doi: 10.1080/03746608909468358.

5. P. Skelsey, W. A. H. Rossing, G. J. T. Kessel, and W. Van Der Werf, "Invasion of Phytophthora infestans at the landscape level: How do spatial scale and weather modulate the consequences of spatial heterogeneity in host resistance?," *Phytopathology*, 2010, doi: 10.1094/PHYTO-06-09-0148.

6. R. P. Singh *et al.*, "Will Stem Rust Destroy the World's Wheat Crop?," *Advances in Agronomy*. 2008, doi: 10.1016/S0065-2113(08)00205-8.

7. M. J. Löhr, "Handbuch der physiologischen Botanik, in Verbindung mit H. de Bary, Th. Irmish, N. Pringsheim und J. Sachs herausgegeben von W. Hofmeister. 4ter Band. Handbuch der Experimental-Physiologie der Pflanzen. Untersuchungen über die allgemeinen Lebensbedingungen und die Functionen ihrer Organe, von Professor Dr. Julius Sachs. Mit 30 in den Text eingedruckten Holzschnitten. Leipzig, im Verlage von Wilhelm Engelmann. 1865," *Arch. Pharm. (Weinheim).*, 1866, doi: 10.1002/ardp.18661760181.

8. L. M. Bartoshuk *et al.*, "Food cravings in pregnancy: Preliminary evidence for a role in excess gestational weight gain," *Appetite*, 2016.

9. R. L. Orbach, "Research vital to economic growth," *Science*. 2011, doi: 10.1126/science.1204760.

10. C. Matta, "Spontaneous Generation and Disease Causation: Anton de Bary's Experiments with Phytophthora infestans and Late Blight of Potato," *J. Hist. Biol.*, 2010, doi:

10.1007/s10739-009-9220-1.

11. U. Kutschera and Z. Y. Wang, "Brassinosteroid action in flowering plants: A Darwinian perspective," *Journal of Experimental Botany*. 2012, doi: 10.1093/jxb/ers065.

12. U. Kutschera and K. J. Niklas, "Evolutionary plant physiology: Charles Darwin's forgotten synthesis," *Naturwissenschaften*. 2009, doi: 10.1007/s00114-009-0604-z.

13. U. Kutschera and K. J. Niklas, "Endosymbiosis, cell evolution, and speciation," *Theory Biosci.*, 2005, doi: 10.1016/j.thbio.2005.04.001.

14. [14] C. Darwin, "The Origin of Species, by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life," *The Crayon*, 1860, doi: 10.2307/25528056.