**Significant landmarks in the field of plant pathology- Contributions of Anton DeBary, Millardet, Burrill, E.Smith, Adolph Mayer, Ivanowski, Diener, Stakman, H.H.Flor,VanDer Plank, molecular Koch’s postulates**

Anton de Bary – the Father of Plant Pathology

De Bary was a model scientist: an inspiring teacher – gifted with intelligence, thoroughness and vision. His extensive studies of fungi and cyanobacteria were landmarks of biology. He was the first to unambiguously demonstrate that microorganisms were the cause and not the consequence of plant diseases.

**What causes plant diseases? De Bary’s work on wheat rust and potato blight.**



*Drawing of the potato blight pathogen in Die gegenwärtig herrschende Kartoffelkrankheit, ihre Ursache und ihre Verhütung (1861).*

De Bary’s major scientiftic achievement was that “he brought clarity to the study of fungi and fungal diseases in plants.

 He demonstrated that the spores of Puccinia graminis – the causal agent of [wheat rust](https://microbeseatmyfood.wordpress.com/2014/10/30/cereal-killer-stem-rust-threatens-world-wheat-supply/) – were formed from fungal mycelium and not by spontaneous generation. Later, he combined thorough experimentation with microscopic observation to unravel the complicated life cycle of the wheat rust fungus.

During De Bary’s childhood, the potato blight disease – that caused the [Irish potato famine](https://microbeseatmyfood.wordpress.com/2015/01/05/the-irish-potato-famine-pathogen/) – occurred in Germany too, but not so destructively. Following his work on the rust life cycle, De Bary in 1860 turned his attention to the potato blight pathogen. He was the first to observe the swimming spores of Phytophthora emerge from their sporangia and penetrate leaves. Soon, he succeeded in infecting healthy potato plants with sporangia taken from diseased leaves.

**Pierre-Marie-Alexis Millardet**, (born Dec. 13, 1838, Monmerey-la-Ville, France—died Dec. 15, 1902, Bordeaux), French botanist who developed the Bordeaux mixture, the first successful [fungicide](https://www.britannica.com/science/fungicide). He also saved the vineyards of [France](https://www.britannica.com/place/France) from destruction by *Phylloxera,* a genus of [plant](https://www.britannica.com/plant/plant) lice.

Millardet is chiefly remembered for his work dealing with plant pests. In the 1860s the vineyards of France were infested by the destructive [Phylloxera](https://en.wikipedia.org/wiki/Phylloxera%22%20%5Co%20%22), an [aphid](https://en.wikipedia.org/wiki/Aphid)-like pest inadvertently introduced to Europe from the [United States](https://en.wikipedia.org/wiki/United_States). Millardet and fellow botanist [Jules Émile Planchon](https://en.wikipedia.org/wiki/Jules_%C3%89mile_Planchon) (1823-1888) controlled the infestation by using American [grape vines](https://en.wikipedia.org/wiki/Grape_vine) that were resistant to Phylloxera as [grafting](https://en.wikipedia.org/wiki/Grafting) stock. American horticulturalist, [T.V. Munson](https://en.wikipedia.org/wiki/T.V._Munson), was instrumental in identifying and provisioning the American rootstock that was resistant to Phylloxera and suitable for French growing conditions.

He was also responsible for protecting grape vineyards from [downy mildew](https://en.wikipedia.org/wiki/Downy_mildew) [fungus](https://en.wikipedia.org/wiki/Fungus) (*[Plasmopara viticola](https://en.wikipedia.org/wiki/Plasmopara_viticola%22%20%5Co%20%22Plasmopara%20viticola)*). He accomplished this feat by implementing a [fungicide](https://en.wikipedia.org/wiki/Fungicide) consisting of [hydrated lime](https://en.wikipedia.org/wiki/Hydrated_lime), [copper sulfate](https://en.wikipedia.org/wiki/Copper_sulfate) and water, a mixture that was to become known as the "[Bordeaux mixture](https://en.wikipedia.org/wiki/Bordeaux_mixture)". It was the first fungicide to be used worldwide and is still used today.

**Thomas Jonathan Burrill** was a [pioneer](https://www.annualreviews.org/doi/pdf/10.1146/annurev.py.30.090192.000313) in the field of plant pathology. He also had several administrative and teaching responsibilities at the University of Illinois, where he worked for 50 years. His distinguished career included significant contributions to science, education, and the public community.

In 1868 Burrill became an algebra teacher at the University of Illinois. However, due to his interest and work in horticulture, he was made a Professor of botany and horticulture in 1870. He was involved in starting the university forest plantation, which still persists as the Illini Grove Park.

He also developed an interest in plant diseases and published reports on apple scab and bitter rot. His work on fire blight, a disease that affects pear trees, earned him a position in the history of plant pathology. After careful microscopic studies, Burrill was the first to discover that bacteria could cause plant diseases and were responsible for the fire blight disease.

**Erwin Frink Smith, 1854–1927**

Smith obtained a bachelor’s degree in 1886 from the University of Michigan, and in 1889, he was awarded a doctor’s degree for work on peach yellows. In 1886, Smith was employed by the USDA, a position he held for 40 years. Smith played a major role in establishing the field of phytobacteriology, and in his effort to demonstrate the importance of bacteria in plant disease, he showed that the United States was becoming a leader in plant pathology research. His interest in bacteriology was driven partially by his desire to discover the cause of peach yellows. He also spent a portion of his career working on *Fusarium*diseases of a variety of crops. He collaborated with W. A. Orton, and their work led to the development of disease resistance. Smith was a charter member of American Pythopathological Society.

 **Adolf Eduard** **Mayer** (9 August 1843 – 25 December 1942) was a [German](https://en.wikipedia.org/wiki/Germany) [agricultural chemist](https://en.wikipedia.org/wiki/Agricultural_chemistry) whose work on [tobacco mosaic disease](https://en.wikipedia.org/wiki/Tobacco_mosaic_virus) played an important role in the discovery of [tobacco mosaic virus](https://en.wikipedia.org/wiki/Tobacco_mosaic_virus) and [viruses](https://en.wikipedia.org/wiki/Virus) in general.

 Mayer published a paper in 1886 on the disease, which he named "mosaic disease of tobacco", and described its symptoms in detail. He demonstrated that the disease can be transmitted by using the sap from the affected tobacco plants as the [inoculum](https://en.wikipedia.org/wiki/Inoculation%22%20%5Co%20%22Inoculation) to infect healthy plants. At the time, this disease was thought to be spread by very small [bacteria](https://en.wikipedia.org/wiki/Bacteria) or [toxins](https://en.wikipedia.org/wiki/Toxin), yet some years later the [tobacco mosaic virus](https://en.wikipedia.org/wiki/Tobacco_mosaic_virus) (TMV) was shown to be the culprit. Mayer employed [optical microscopy](https://en.wikipedia.org/wiki/Optical_microscopy) to seek signs of fungi or bacteria in the infected sap, yet he did not find any, since the TMV is too small to be detected in an [optical microscope](https://en.wikipedia.org/wiki/Optical_microscope). Mayer still concluded that the infectious agent was some sort of bacteria and erroneously claimed that he was able to obtain "clear filtrate" from the infected sap using filter paper in several repetitions. Filtration experiments with paper and finest porcelain [Chamberland filters](https://en.wikipedia.org/wiki/Chamberland_filter%22%20%5Co%20%22Chamberland%20filter) were replicated by [Dmitry Ivanovsky](https://en.wikipedia.org/wiki/Dmitry_Ivanovsky) in 1892 and [Martinus Beijerinck](https://en.wikipedia.org/wiki/Martinus_Beijerinck%22%20%5Co%20%22) in 1898, who showed that the infectious agent of the tobacco mosaic disease was in fact infilterable. [Martinus Beijerinck](https://en.wikipedia.org/wiki/Martinus_Beijerinck%22%20%5Co%20%22Martinus%20Beijerinck) coined the term of "virus" to indicate a non-bacterial nature of the tobacco mosaic disease. In 1935, the tobacco mosaic virus was the first [virus](https://en.wikipedia.org/wiki/Virus) to be crystallized. Despite the erroneous conclusion, Mayer's pioneer work on the tobacco mosaic disease served as an important step in the discovery of viruses and led to the foundation of the field of [virology](https://en.wikipedia.org/wiki/Virology).

**Dmitry Ivanovsky,** Russian microbiologist who, from his study of [mosaic](https://www.britannica.com/science/mosaic-plant-disease) [disease](https://www.britannica.com/science/disease) in [tobacco](https://www.britannica.com/science/tobacco-mosaic-virus), first detailed many of the characteristics of the organisms that came to be known as [viruses](https://www.britannica.com/science/virus).

**Theodor Otto Diener (born February 28, 1921)**is a Swiss-American [plant pathologist](https://en.wikipedia.org/wiki/Plant_pathologist). In 1971, he discovered that the causative agent of the potato spindle tuber disease is not a virus, but a novel agent, which consists solely of a short strand of single-stranded RNA without a protein capsid, eighty times smaller than the smallest viruses. He proposed to name it, and similar agents yet to be discovered, [viroids](https://en.wikipedia.org/wiki/Viroids%22%20%5Co%20%22Viroids). Viroids displaced viruses as the smallest known infectious agents.

**Elvin Charles Stakman** (May 17, 1885 – January 22, 1979) was an American plant pathologist who was a pioneer of methods of identifying and combatting disease in wheat.

 In 1938, in a speech entitled "These Shifty Little Enemies that Destroy our Food Crops", Stakman discussed the manifestation of the plant disease rust, a parasitic fungus that feeds on phytonutrients, in wheat, oat and barley crops across the US. He had discovered that special plant breeding methods created plants resistant to rust.

**Harold Henry Flor** (1900–1991) was a [plant pathologist](https://en.wikipedia.org/wiki/Plant_pathologist) famous for proposing the [gene for gene hypothesis](https://en.wikipedia.org/wiki/Gene-for-gene_relationship) of plant-pathogen genetic interaction whilst working on rust (*[Melampsora lini](https://en.wikipedia.org/wiki/Melampsora_lini_var._lini%22%20%5Co%20%22Melampsora%20lini%20var.%20lini)*) of [flax](https://en.wikipedia.org/wiki/Flax) (*Linum usitatissimum*).

Dr. Flor's research on flax rust showed resistance in flax was dominant to susceptibility and the genes conditioning reaction occurred as multiple alleles at five loci. He then selfed and crossed many races of *Melampsora lini*, the flax rust fungus, and found virulence to be recessive to avirulence and inherited independently. His resesarch suggested that for each gene conditioning resistance in the host, there was a corresponding gene conditioning pathogenicity in the parasite. Furthermore, detection of these genes in the host or parasite was possible only when the other member of the pathosystem was present. Dr. Flor was the first to study simultaneously the genetics of the host and parasite, which allowed him to deduce what is popularly known as the gene-for-gene hypothesis.

Dr. Flor's interpretation of host-parasite genetic interaction has proven to be a critically important paradigm in plant pathology and of extraordinary utility in the breeding of disease resistant cultivars. It has been used extensively to explain genetic relationships in different rusts and in other diseases, as well as in diverse symbiotic relationships such as plants and herbivorous insects.

**Van der Plank** in his 1963 book Plant Disease: Epidemics and Control. Van der Plank observed that under artificial selection the potato variety Vertifolia had stronger vertical resistance to the potato late blight pathogen, *Phytophthora infestans*, as measured by the presence of specific [R genes](https://en.wikipedia.org/wiki/R_genes). However, when the pathogen overcame these [R genes](https://en.wikipedia.org/wiki/R_genes) Vertifolia exhibited a greater loss of [horizontal resistance](https://en.wikipedia.org/wiki/Horizontal_resistance) than varieties with fewer [R genes](https://en.wikipedia.org/wiki/R_genes) and lower [vertical resistance](https://en.wikipedia.org/wiki/Vertical_resistance).[[1]](https://en.wikipedia.org/wiki/Vertifolia_effect#cite_note-Vanderplank1963-1) This effect suggests that when a pathogen evolves an [avirulence gene](https://en.wikipedia.org/wiki/Avirulence_gene%22%20%5Co%20%22) to counteract a variety’s R gene, that variety will be more susceptible to the pathogen than other varieties.

**Koch’s postulate -** During the late 19th century a bacteriologist called Robert Koch laid down a set of rules for confirming that an organism is the cause of a disease. These are now known as ‘Koch’s postulates’. When a plant becomes infected with a fungus (or any other disease causing microorganism), it is likely to become weakened and therefore more susceptible to infection by other microbes. So how do us plant pathologists work out what pathogen has caused a particular disease? We have to apply Koch’s postulates to the disease.

To determine Koch’s postulates:

(a) the organism must be consistently associated with the lesions of the disease;

 (b) the organism must be isolated from the lesions and grown in pure culture;

(c) the organism from pure culture must be re-inoculated into the healthy host and must cause the same disease as was originally observed;

(d) the organism must be re-isolated into culture and shown to be identical to the organism originally isolated.

To determine which microbe caused that fuzzy stuff on your apple you must:

1. Describe the symptoms you see on the infected apple and isolate the suspected fungus pathogen responsible.

2. Isolate the fungus in pure culture (this means grow the fungus on its own, away from the host plant (apple) and without any contaminating microorganisms).

3. Use the fungus that you isolated in pure culture to inoculate a healthy apple.

 4. Record the symptoms that develop on the healthy apple following infection with the cultured fungus. Are your observations the same as recorded previously? 5. Re-isolate the fungus and check that it is the same as observed initially.