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History of Medical Mycology

File 1 (Prehistoric times-1894)

Prehistoric times

In the ancient times, man had to face not only the opposing forces of nature, wild animals and poisonous organisms, but also diseases, misfortunes that seemed to arise from nowhere. Thousands of years passed before the man began to acquire knowledge concerning the nature, treatment, and prevention of the infectious diseases. Our early progenitors found it natural to attribute the responsibility of the epidemics that they could not rule to a divine will that had to be satisfied with prayers, rites and sacrifices. The difficulties of a rational approach to the understanding of the etiology of infections is well reflected by the lack of any reference known before the Hindu, Greek and Roman civilizations, when the related diseases were described, however, exclusively on the basis of signs, symptoms and treatments [Ajello, 1998].

~ 3500 B.C.

The interaction between man and fungi began in the remote past. A juice extract from the stalks of a certain plant has been probably the first hallucinogen utilized by the Aryans as cryptic symbolism in the Rigveda, literally “Collection of the verses of wisdom”, the first collection of hymns composed in an archaic form of Sanskrit. Soma, the narcotic God of

olden India, is supposed to have originated from the Aryans, invaders of India, 3500 years ago, from the north (now Afghanistan), who brought their cult of Soma into the Indus Valley. In both Vedic and Zoroastrian tradition, the name of the drink and the plant are the same, and also personified as a divinity, the three forming a religious or mythological unity. There has been much speculation concerning what is most likely to have been the identity of the original plant. Although there is no solid consensus on the question, detailed interdisciplinary studies suggested that Soma was a mushroom and, specifically, *Amanita muscaria* [Ainsworth, 1976].

2000 - 1000 B.C.

The earliest description of a fungal infection is reported in the fourth collection (Samhita) of the sacred scriptures of Hinduism (Atharva Veda). It is attributable to mycetoma of the foot, which was differentiated by filarial elephantiasis and metamorphically defined as "padavalmika" that means "Madura foot" (foot-ant-hill). The term "mycetoma" was introduced (1861) by the anatomist, surgeon, and anatomical artist Henry Vandyke Carter (1831-1897), born in Hull, Yorkshire, U.K. [Ainsworth, 1976; Carter, 1861].

~ 400 B.C.

Hippocrates of Cos (460-370 B.C.), the greek physician recognized as the "father of Medicine" and credited with being the first person to believe that diseases were caused naturally and not as a result of superstition or Gods, described in his writings "Of the Epidemics" as "mouths affected with aphthous ulcerations" the currently recognized oral candidiasis in the form of "thrush" [Ainsworth, 1976; Leff and Leff, 1956].

~ 300 B.C.

The Greek Theophrastus (371-287 B.C.), a native of Eresos, in the island of Lesbos, and disciple of Aristotle, is considered the "father of Botany" and the first to report definitions about fungi, regarded as "imperfect plants, lacking roots, leaves, flowers and fruits". He described four types of fungi: underground (*Tuberacee*), soil-borne and stem cap (mykés), sessile in the hollow form (Pezize), and round-shaped fungi (*Licoperdacee*) [Encyclopædia Britannica, 1911].

~ 14 B.C.

Aulus Cornelius Celsus (ca 25 B.C.-ca 50 A.C.), a Roman encyclopaedist, is remembered for the eight books of "*De Medicina*" (On Medicine), primary source on diet, pharmacy, surgery and related fields. These volumes have been discovered by Pope Nicholas V (1397-1455), founder of the Vatican Library, who promoted the literature and the arts during his pontificate (1447-1455). Books V and VI of the Encyclopaedia of Celsus were published in Florence, Italy (1478), and report the description of the disease "*Tinea favosa*", the reason why the modern dermatologists call this inflammatory form of *Tinea capitis* "*Kerion Celsi*" [Ainsworth, 1976; Ajello, 1998].

1546

The physician, astronomer and poet Girolamo Fracastoro (1478-1553), born of an ancient family in Verona, Italy, and educated in Padua, Italy, where at 19 he was appointed Professor at the University, is now recognized as the father of the "germ theory of infectious diseases". Following extensive studies on the prevalence of plague that was regularly spreading in Europe, he theorized that pandemics were originated by the transmission of tiny particles or "spores" through direct, indirect or without contact with humans or fomites, even over long distances (1546). Fracastoro is also the author (1530) of the poem "*Syphilis, sive Morbus*

Gallicus" (Syphilis, or the French Disease) composed in his villa in Incaffi, on the shoreline of Lake Garda, divided between the provinces of Verona, Brescia and Trento, Italy. The name of the hero of the poem, the shepherd *Syphilus*, is the reason why the term syphilis has been adopted for the chronic venereal disease caused by *Treponema pallidum* [Ajello, 1998; Nordenskiöld, 1928; The New Columbia Encyclopedia 1975].

1588

The merit of having published the first description of fungal spores can be attributed to Giambattista Della Porta (1538-1615), mathematician, naturalist, alchemist, philosopher and playwright, born in Vico Equense, Naples, Italy, who published "*Phytognomonica*" (1588), in which he listed plants according to geographical location and described the "seeds" of a wide variety of fungi. Della Porta, however, made no experiments to demonstrate that the fungal spores germinate, giving rise to colonies of the parental strains. His remark, therefore, did not contradict the ancient and widespread belief that all fungi and many other organisms could arise spontaneously and were not simply the product of the degradation of organic matter [Ainsworth, 1976; Ajello, 1998; Della Porta, 1588].

1648

The Flemish chemist, physiologist, and physician Jan Baptist van Helmont (1579-1644), born in Brussels, Belgium, is remembered not only for his experiment of five years on a tree, and the introduction of the term "gas" in the scientific vocabulary, but even for his persisting ideas on spontaneous generation of life. His works were collected by his son Franciscus Mercurius van Helmont and published posthumously by Lodewijk Elzevir in Amsterdam, The Netherlands, under the title "*Ortus medicinae*" (The dawn of medicine) (1648). The misleading theory of spontaneous generation of organisms is already found in the "*Historia*

Animalium" (History of Animals) written by the Greek philosopher and polymath Aristotle (384 B.C.-322 B.C.), born in Stageira, Chalcidice, student of Plato, in turn a student of Socrates, and teacher of Alexander the Great. His writings covered many subjects, including physics, poetry, theater, music, logic, rhetoric, politics, ethics, biology and zoology. Aristotle assumed that many animals were generated *de novo* in the decomposing material and not from parental organisms. This theory has resisted even the experimental evidence of Pietro Antonio Micheli (1729) on the germination of fungal spores and the consequent development of corresponding colonies. Aristotle's concept was so ingrained to believe that the mice could arise from piles of dirty rags or bran [Ainsworth, 1976; Ajello, 1998; van Helmont, 1648].

1665

The first observation and representation of microorganisms, including fungi, is due to Robert Hooke (1635-1703), born in Freshwater, U.K., astronomer, inventor and physicist, who described microorganisms in his "*Micrographia*" (1665). Anthonie Philips van Leeuwenhoek (1632-1723), from Delft, The Netherlands, a cloth merchant and amateur scientist, is known for his work on the improvement of the microscope and is considered the "father of Microbiology", because he was the first to describe single-celled organisms, which he originally referred to as "*animalcules*", in his letters (1673) to the journal Philosophical Transactions of the Royal Society of London, U.K., founded in 1660, possibly the oldest such society in existence. Marcello Malpighi (1628-1694), born in Crevalcore, Bologna, Italy, Professor of Anatomy at the University of Bologna, Italy (1666-1691), published his "*Marcelli Malpighii Philosophi & Medici Bononiensis e Regia Societate Opera Omnia*" (Complete work of Marcellus Malpighi philosopher and physician from the Royal Society of Bologna) in 1686. These first observed the sporangia and mycelium of species of *Mucor*, *Saccharomyces cerevisiae* cells in the beer, the teliospores of *Phragmidium mucronatum*,

cause of the "rust of roses" and many other fungi, including the zygomycete *Rhizopus stolonifer* [Ainsworth, 1976; Ajello, 1998; Hooke, 1665; Malpighi, 1686].

1668

The experiments of the physician, naturalist and poet Francesco Redi (1626-1697), born in Arezzo, Italy, and those in Pavia, Italy, of the naturalist Lazzaro Spallanzani (1729-1799), born in Scandiano, Reggio Emilia, Italy, were crucial to demolish the pernicious aristotelian theory of "spontaneous generation of life" that received the coupe of grace by the studies of Louis Pasteur (1860). Redi, in his "Esperienze Intorno alla Generazione degl'Insetti" (Experiences about the generation of insects) (1668), demonstrated experimentally that larvae could develop in the rotting flesh from eggs deposited by flies and not by spontaneous generation. Protecting the meat with a layer of gauze, the larvae were not produced in spite of the decay process to be realized. Spallanzani, through rigorous controlled experiments, showed that moulds could not grow on organic matter if there were no fungal spores. In his "Opuscoli di fisica animale e vegetabile" (Brochures of plant and animal physics) (1776), he showed, moreover, that airborne spores of fungi were originating moulds that grew on experimental substrates. For these reasons, Spallanzani was considered by Raffaele Ciferri as the "founder of modern biology". Pasteur, in his classic studies on fermentation, showed that microorganisms were not the product of chemical changes, but living entities that were generated by multiplication of organisms already in existence [Ainsworth, 1976; Ajello, 1998; Spallanzani, 1776].

1686

Many infectious diseases, shown centuries later to be mycoses, have been described or portrayed in works of art. Among these, what the English buccaneer and navigator Sir

William Dampier (1651-1715) called, after a visit to Philippines (1686), "a short of Leprosie, the same we observed in Guam" that became known as "Tokelau disease", and was lately described by the Medical Officer to the Imperial Maritime Customs at Amoy, China, the Scottish physician Sir Patrick Manson (1844-1922). Manson, born in Oldmeldrum, Aberdeenshire, Scotland, who obtained the Bachelor of Medicine (1865), the Master of Surgery (1866) and the Medical Doctorate and Doctor of Law (1866) at the University of Aberdeen, Scotland, is considered the "founder of the Tropical Medicine field". He observed the presence of mycelium in the skin fragments and succeeded in reproducing experimentally the infection in one of his Chineese assistants, thus demonstrating the fungal etiology of the disease that he called "*Tinea imbricata*", because of the concentric pattern in the infected skin (1878). The entomologist Raphael Blanchard (1857-1919), born in St. Christoph, Indre et Loire, France, identified (1896) the etiologic agent and named it *Trychophyton concentricum* (Blanchard, 1896). The renowned Spanish painter Bartolomè Esteban Murrillo (1618-1682) painted, in the Hermandad de la Santa Caida, in Seville, Spain, St Elizabeth of Hungary curing the head of a child apparently suffering from *favus* (1671-1674). A. C. Mayer from Bern, Switzerland, illustrated what looks likely aspergillosis in the lung of a European jay (*Garrulus glandarius*) (1815) [Ainsworth, 1976; Ajello, 1998; Manson, 1878; Mayer and Emmert, 1815].

1729

The Italian botanist and mycologist Pietro Antonio Micheli (1679-1737), born in Florence, Professor at Pisa, Italy, Prefect of the Botanical Garden of Florence, Italy, and founder of the Italian Botanical Society (1716), was the first to show that the fungi produce spores giving rise by germination to colonies of the species which had produced them. The results of his basic observations have been published and discussed in the monumental "*Nova Plantarum*

Genera" (New genera of plants) (1729). In this work, fundamental for the botany and mycology, he described nearly 900 different fungi, including species of *Aspergillus*, *Botritys*, *Clathrus*, *Geaster*, *Mucor* and *Polyporus* and the rust genus *Puccinia* of the *Uredinales*, so named in honor of Tommaso Puccini, a Professor of Anatomy in Florence, Italy. Micheli described for the first time the production of tetrads of spores in basidia and asci and ascospores in mushrooms and truffles [Ainsworth, 1976; Ajello, 1998; Lazzari, 1973; Micheli, 1729].

Giacomo Lazzari, author of "Storia della Micologia Italiana" (History of Italian Mycology) (1973), and the pharmaceutical chemist, botanist, plant pathologist and mycologist Geoffrey Clough Ainsworth (1905-1998), born in Birmingham, U.K., author of "Introduction to the History of Mycology" (1976), rightly regarded Pietro Antonio Micheli as the "father of Mycology" with its date of birth set in 1729. Ainsworth's assumption was that "if, however, a date must be set for the birth of Mycology, it is 1729, the year of publication in Florence of Pietro Antonio Micheli's *Nova Plantarum Genera*, a germinal work much in advantage of its time" [Ainsworth, 1976; Ajello, 1998; Lazzari, 1973].

1735

The botanist, physician and zoologist, Carl Nilsson Linnaeus (1707-1778), born in the countryside of Småland, in southern Sweden, Professor of Botany at the Uppsala University, Sweden, author of "*Systema naturae*" (System of nature) (1735), gave a fundamental contribution to taxonomy, as he ordered in a final way, valid even today, all plants on the basis of a guiding principle universally applicable. He based his system on the sexual elements of plants and, for the classification of an entity vegetable, invented the dichotomous system, also called "combination", consisting of a name (genus) followed by a name (species). Exalted in botany in general, Linnaeus did not take any step to mycology, indeed

damaged, according to Elias Magnus Fries (1794-1878), born in Fremsio, Sweden, Professor of Botany and Prefect of the Botanical Garden of Uppsala University, Sweden, author of "*Systema mycologicum*" (Fungal system) (1821-1832), as Linnaeus was not using the microscope and was not able to apply to fungi research based on sexual elements as for plants [Lazzari, 1973].

1755

In the late eighteenth and early nineteenth centuries, yeasts were not considered to be living organisms. In his English dictionary (1755), the poet, essayist, moralist and lexicographer Samuel Johnson (1709-1784), born in Lichfield, Staffordshire, U.K., a devout Anglican and political conservative, described as "arguably the most distinguished man of letters in English history", defined the yeast as "the ferment put into drink to make it work; and into bread, to lighten and swell it". The first scientific research on yeasts was done by chemists, particularly interested in alcoholic fermentation. The French nobleman Antoine-Laurent de Lavoisier (1743-1794), born in Paris, naming both oxygen (1778) and hydrogen (1783), helping to construct the metric system, to put together the first extensive list of elements and to reform chemical nomenclature, elected at the age of 25 a member of the French Academy of Sciences, France's most elite scientific Society, considered the "founder of modern chemistry", described the phenomenon of alcoholic fermentation as "one of the most extraordinary in chemistry" [Barnett, 1998].

1785

The Uppsala University Culture Collection (Mykoteket) (U.P.S.C.), Sweden, had intermingled origin with that of the Botanical Museum at Uppsala University, Sweden, owning an extensive herbarium of plant, algae and fungi dating back (1785) to the botanist

Carl Peter Thunberg (1743-1828), born in Jönköping, Sweden, a disciple of Carl Nilsson Linnaeus, and, more specifically, to Elias Magnus Fries fungal herbarium of mid-1800 [Sleytr and Messner, 2003].

1809

The biologist, botanist and naturalist Johann Heinrich Friedrich Link (1767-1851), born in Hildesheim, in the lower Saxony, Germany, first Professor of the new Department of Chemistry, Zoology and Botany at the University of Rostock, Germany (1792), introduced to the study of aspergillosis describing, among others, *Aspergillus candidus* and *A. flavus* (1809), while the physician and botanist Johann Baptist Georg Wolfgang Fresenius (1808-1866), born in Frankfurt am Main, Germany, known for his work in the field of phycology, reported the first observation of *A. fumigatus* in his treatise "Beiträge zur Mykologie" (Contributions to Mycology) (1850-1863) [Fresenius, 1863; Link, 1809].

1832

Description of:

Geotrichum candidum Link:Fies, 1832/*Galactomyces geotrichum* (Butler & Petersen) Redhead & Malloch, 1977

1835

The fundamental merit of having demonstrated in an exemplary way that a microorganism may be the causative agent of an infectious disease in animals must be recognized to Agostino Bassi (1773-1856). Bassi, a civil servant and self-taught scientist born in Mairago, Lodi, Italy, published the results of his epochal studies, lasted 25 years, on the disease of the silkworm, the larva of the mulberry moth (*Bombyx mori*), which was destroying the

flourishing silk industry in Italy and France (1835). Bassi also stated the idea that not only animal (insect), but also human infectious diseases were caused by other living organisms (1844). Through meticulous experiments, Bassi showed that the cause of death of the silkworm was an entomogenous fungus "una pianta del genere delle crittogame, un fungo parassita" (a plant of the kind of cryptogams, a parasitic fungus). Bassi not only defined the cause of the disease, but also developed effective methods of control. His treatise is lenghtly entitled "Del Mal del Segno, Calcinaccio o Moscardino, Malattia che Affligge i Bachi da Seta e sul Modo di Liberarne le Bigattaje anche le più Infestate" (About the Mal del Segno, Calcinaccio or Moscardino, disease that afflicts the silkworms and the mode to liberate the cocoon rooms even the most infested). In his honor, the naturalist Giuseppe Gabriel Balsamo-Crivelli (1800-1874), born in Milan, Italy, Professor of Mineralogy and Zoology (1851) and appointed Professor of Comparative Anatomy (1863) at the University of Pavia, Italy, called the fungus *Botrytis bassiana* (1835). The Bassi's eponymous fungus, *Beauveria bassiana* (Balsamo) Vuillemin 1912, (*Cordyceps bassiana* Z.Z. Li, C.R. Li, B. Huang & M.Z. Fan, 2001), has shown to be widespread geographically and is currently used as a biological agent for the control of important insect pests in agriculture. Bassi is rightly acknowledged to have been the first to refer the etiology of an animal disease to a microbial infection and is universally regarded as the "father of Medical Mycology" [Ajello, 1998; Bassi, 1835; Ferron et al., 1991].

1836

The French physicist and engineer Charles Cagniard-Latour (1777-1859), born in Paris, inventor in the acoustics of the improved siren, which he named (1819), using a microscope giving high magnification (500 diameters), followed by other yeast pioneers as the algologist Friedrich Traugott Kutzing (1837), from Halle, Germany, and the physiologist Theodor

Schwann (1837), from Berlin, Germany, made observations on the yeasts of beer and wine. He described them as composed of "globules", considered "to be organized beings, which are probably of the vegetable kingdom" and reported that "they can reproduce themselves". In doing so, Cagniard-Latour established yeast as a living organism and made an accurate estimate of the diameter of the yeast cell (about 7 μm), also giving the first descriptions of yeast budding and bud scars. Regretfully, his description of bud scars was ignored until they were described by Andrew A. Barton, from the Distillers Company Ltd., Research and Development Department, Great Burgh, Epsom, Surrey, U.K., who observed them in fixed and stained cells of *Saccharomyces cerevisiae* (1950) [Barnett, 1998; Barton, 1950; Cagniard-Latour, 1836; Cagniard-Latour, 1838].

1839

The publication of the seminal work of Agostino Bassi (1835) has inspired clinicians, particularly French and Germans, to investigate whether fungi could also be the cause of infectious diseases in humans. Johann Lucas Schönlein (1793-1864), born in Bamberg, Germany, Professor of Therapeutics and Pathology at the University of Berlin, Germany, and one of the first German Medical Professors to lecture in the native tongue instead of Latin, first observed and published that fungal elements were present in lesions of human *favus*, a widespread and virulent disease of the skin and scalp, which infested children and adults in Europe (1839). The infection, caused by a fungus called today *Trychophyton schoenleinii* (Lebert, 1845) Nannizzi, in Schönlein's honor, was studied independently by the German embryologist and anatomist Robert Remak (1815-1865), born in Posen, Prussia (now Poland), who achieved enough eminence to obtain a lectureship at the University of Berlin, despite Prussian laws barring Jews from teaching, and the Hungarian physician David Gruby (1810-1898), born in the village of Kis-Kér (now Bačko Dobro Polje, Serbia). Gruby also

described (1843) a fungus, named in honor of the French naturalist, entomologist, ornithologist and malacologist Jean Victor Audouin (1797-1841), born in Paris, Professor of Entomology at the Muséum National d'Histoire Naturelle in Paris, member of the French Academy of Sciences (1838), and foreign member of the Royal Swedish Academy of Sciences (1833), *Microsporum audouinii* (Gruby, 1843), that causes a type of ringworm sometimes referred to as "Gruby's disease". During the early years of anaesthesia, Gruby performed important experiments with chloroform and ether on animals [Ainsworth, 1976; Ajello, 1998; Gemeinhardt, 1990; Schönlein, 1839; Ziegler-Bohme and Gemeinhardt, 1990].

The surgeon Bernhard Rudolf Konrad von Langenbeck (1810-1887), born at Padingbüttel, Germany, Professor of Surgery and Director of the Friedrichs Hospital at Kiel, Germany (1842), and then Director of the Clinical Institute for Surgery and Ophthalmology at the Charité in Berlin (1848), as a young Assistant Professor at the University of Göttingen, Germany, published the first case of candidiasis of the oesophageal mucosa of a patient who died of typhoid fever (1839). Oropharyngeal and esophageal thrush with pseudomembranes were found at autopsy. He described in detail what is now recognized to be septate hyphae, branched pseudohyphae and blastoconidia "Under the microscope magnified, the pseudomembranes consisted of an immense number of fungi". Langenbeck, specialised in military surgery, became the developer of the Langenbeck's amputation and an authority in the treatment of gunshot wounds. He is also remembered as the "father of the Surgical Residency" as, under his tutellage at the Charité in Berlin, he conceived and developed a system whereby new medical graduates would live at the hospital as they gradually assumed a greater role [Knoke and Bernhardt, 2006; Langenbeck, 1839].

Three leading chemists of the time were Friedrich Wöhler (1800-1882), born in Eschersheim, Germany, a physician best known for his synthesis of urea, co-discoverer of beryllium, silicon and silicon nitride, Professor of Chemistry in the University of Göttingen, Germany,

Justus Freiherr von Liebig (1803-1873), born in Darmstadt, Germany, Professor of Chemistry at the age of 21 at the University of Giessen, Germany, elected a member of the Royal Swedish Academy of Sciences (1837), known as the "father of the fertilizer industry" for his discovery of nitrogen as an essential plant nutrient, and Jöns Jacob Berzelius (1779-1848), born in Väversunda in Östergötland, Sweden, a physician appointed Professor in Chemistry and Pharmacy at the Karolinska Institute, Stockholm, Sweden (1807), member of the Royal Swedish Academy of Sciences (1808), foreign Honorary Member of the American Academy of Arts and Sciences (1822), credited with having made the identification of the chemical elements silicon, selenium, thorium and cerium, and the first distinction between organic (those containing carbon), and inorganic compounds. Wöhler, von Liebig and Berzelius made strong opposition to the concept of yeasts as living organisms (1839) with a view strikingly similar to that exposed (1697) by the German chemist and physician Georg Ernst Stahl (1660-1734), born in Ansbach, Professor of Medicine in Jena, Germany, and then Professor of Medicine and Chemistry in Halle, Germany (1693-1716), remembered for his phlogiston theory of combustion. Berzelius also stated that the apparent microscopical evidence of yeasts was due to a precipitate of alumina (1839) and fermentation occurred by means of catalysis. Since von Liebig, particularly, was one of the most influential of all contemporary scientists, his detrimental belief probably stopped the development of mycology for at least a generation [Barnett, 1998; Berzelius, 1839; Liebig et al., 1888; Stahl, 1697].

1842

John Gill, an English physician, first described mycetoma in his dispensary report in the Madura district of South India (1842), hence the term "Madura foot". John Godfrey, working as garrison surgeon in Bellary, India, first described the disease as "*morbus tuberculosis pedis*" (disease of the tuberculosis of the foot) in the medical literature (1846). H. Vandyke

Carter (1861) and George Bidie (1862) named the condition “mycetoma”, describing its fungal etiology [Bidie, 1862; Carter, 1861; Ghosh et al., 1950; Godfrey, 1846].

1846

The gynecologist and University Professor Carl Ferdinand Eichstedt (1816-1892), born in Greifswald, Germany, worked in his hometown as a general practitioner and then he became Professor of Obstetrics (1852) at the University of Greifswald. Eichstedt identified a fungus (1846), subsequently named *Microsporum furfur* (C. Robin, 1853), as the causative agent of the contagious *Pytiriasis versicolor* [Eichstedt, 1846; Knoke and Schwesinger, 1994].

1847

The student of medicine Theodor Sluyter (1817-1895) from Greifswald, Germany, published his thesis in Berlin, Germany, including the first well-documented case of human pulmonary aspergillosis (1847). Rudolf Virchow classified the depicted fungus as an *Aspergillus* species (1856) and, possibly, Carl Ferdinand Eichstedt carried out the autopsy [Knoke and Schwesinger, 1994].

1848

Description of:

Trichophyton tonsurans Malmsten, 1848

1853

Although Bernhard Rudolf Konrad von Langenbeck was the first to document an association of a fungus with thrush, he made no direct relationship between them (1839). The anatomist, biologist and histologist, Charles Philippe Robin (1821-1885), born in Jasseron, Département

Ain, France, classified the fungus causing thrush as *Oidium albicans* (1853). The botanist Whilelm Zopf (1846-1909), born in Roßleben, Germany, Director of the Botanical Garden at Munster, Germany, changed its name to *Monilia albicans* (1890), giving rise to the erroneous convention of naming the clinical disease caused by this fungus as "moniliasis". The currently accepted name, *Candida albicans*, was introduced by the Dutch mycologist Christine Berkhout (1893-1932) in her Doctoral thesis in Natural Sciences (1923). This event was later described as marking the "beginning of the rational systematics of the anascosporogenous yeasts". Unfortunately, Berkhout suffered ill-health from the time of her thesis and seems to have occupied no other work position. However, it was not until the Eighth Botanical Congress held in Paris, France (1954), that the binomial *Candida albicans* was officially endorsed as the *nomen conservandum* thus ending the almost 200 year long taxonomic controversy over the etiological agent of candidiasis [Barnett, 2004; Berkhout, 1923; Robin, 1853; Zopf, 1890].

The anatomist and physiologist Georg Meissner (1829-1905), born in Hannover, Germany, best known for the "Meissner corpuscle" found in the surface layer of the dermis, as a student at the University of Göttingen, Germany, first described *Tinea unguium* based on the detection of a fungus in the nail material as the etiologic agent (1853). Accordingly, Rudolf Virchow created the name "onychomycosis" (1854) to define that kind of disease [Meissner, 1853; Virchow, 1854].

1860

Louis Pasteur (1822-1895), born in Dole, in the Jura region of France, began as an outstanding research chemist and became one of the most distinguished microbiologists of all time. He gained degrees in Letters and in Mathematical Sciences before entering the École Normale Supérieure in Paris, France, became Professor of Chemistry at the Faculté (College)

of Strasbourg, France, and then at the University of Strasbourg (1848), Dean of the new Faculty of Sciences in Lille, France (1854), and founded the Institut Pasteur in Paris (1887). Pasteur is remembered for his fundamental discoveries in the causes and preventions of infectious diseases, creating the first vaccines for rabies and anthrax. His studies supported the germ theory of disease. Pasteur also discovered anaerobiosis, whereby some microorganisms can develop and live without air or oxygen, a phenomenon called "the Pasteur effect". He is also known for inventing a process of treatment of milk and wine called "pasteurization". He grew yeasts in a chemically defined medium containing sugar, ammonium tartrate and inorganic phosphate (1860), so that nothing was present that could be putrefied by oxygen and extend its instability to the sugar, as Justus Freiherr von Liebig had stated (1839). In this way, Pasteur finally refuted von Liebig's assertion that yeast originates from the action of oxygen on the nitrogenous matter of fermentable liquid. Hence, alcoholic fermentation is a physiological process. Pasteur observed that the growth yield of brewer's yeast per gram of sugar consumed was many times greater in aerobic than in anaerobic conditions (1861). This finding had great significance in the understanding of the biochemstry of many microorganisms capable of both aerobic and anaerobic metabolism [Barnett, 2000; Liebig, 1839; Pasteur, 1860; Pasteur, 1861].

1862

The German pathologist Friedrich Albert von Zenker (1825-1898), born in Dresden, Professor of Pathological Anatomy and Pharmacology at the Erlangen University, Germany, celebrated for his discovery of trichinosis, first described a case of disseminated candidiasis as metastasis to the brain, commenting that the infection was probably bloodborne from the thrush lesions of the tongue and gullet (1862) [Zenker, 1861-1862].

1865

The German anthropologist, pathologist, prehistorian, biologist and politician Rudolf Ludwig Carl Virchow (1821-1902), born in Swidwin, Poland, Professor of Pathology at the Berlin University, Germany (1847-49), Pathological Anatomy at the Würzburg University, Germany (1849-56), and Pathology newly at the Berlin University (1856-93), is cited as the first to recognize leukemia cells, to elucidate the mechanism of pulmonary thromboembolism, coining the term "embolism", and to develop a standard method of autopsy procedure. Virchow is also known for his advancement of public health and referred to as "the father of Modern Pathology", and one of the founders of "Social Medicine". In his comment to Schönlein's discovery, he reported that mould diseases may be summarized, referring in this connection to his description of onychomycoses (1854), with the definition of "Mykosen" (mycoses) (1865), a term then adopted as a title of the official journal of Deutschsprachige Mykologische Gesellschaft (German-Speaking Mycological Society), based in the city of Essen, Germany (1961), for all scientists interested in medical and veterinary mycology [Virchow, 1865].

1867

The British Mycological Society (B.M.S.) took origin tracing back to the Woolhope Naturalists' Club at Hereford, U.K., and to the Yorkshire Naturalists Union, U.K. (1867). The Woolhope Club was based on the Hereford Museum to encourage interest in mushrooms through the organization of an annual event, traditionally held in Hereford during the first week of October. The meeting of the Woolhope Club became increasingly important for mycologists from Britain and abroad, resulting in the idea to create, in England, a National Mycological Union (1895) and, then, a formal British Mycological Society (1896). George Edward Massee (1850-1917) (President), Charles Crossland (1844-1916) (Treasurer), and

Carleton Rea (1861-1946) (Secretary) were the first officers. The British Society for Mycopathology (B.S.M.), publishing the Bulletin of the British Mycological Society, was established (1964) with the support of the Medical Research Council (M.R.C.), and comprising separated medical and scientific specialties as Dermatology, Plant Pathology, Tropical Medicine, Veterinary Medicine, Chest Medicine [Homei, 2008].

Description of:

Aspergillus niger van Thieghem, 1867

1873

Following these discoveries, a number of other fungi, in addition to dermatophytes, were considered as etiologic agents of infectious diseases in humans. The veterinarian and bacteriologist Sebastiano Rivolta (1832-1893), born in Casalbagliano, Alessandria, Italy, as Professor at the University of Pisa, Italy, provided conclusive evidence that a common equine disease, variously known as "farcino di Napoli" (farcy of Naples), "farcino d'Africa" (farcy of Africa), "linfangite epizootica" (epizootic lymphangitis), was caused by a yeast-like organism that he considered to be a species of *Cryptococcus* (1873), later called *C. farciminosus* (1883), in collaboration with Ignazio Micellone (1833-1902). Micellone, born in Bussolino, a mountain village in the Province of Turin, Piedmont, Italy, was then a major in the Veterinary Corp of the Royal Italian Army, and obtained his degree in Turin's Veterinary School (1857). The findings of Rivolta and Micellone were fundamental to solve the confusion that was then prevalent regarding the distinction between glanders (morva), caused by the bacterium *Pseudomonas mallei,* and epizootic lymphangitis, caused by a fungus [Ajello, 1998; Julini and Marchisio, 1992; Rivolta, 1873; Rivolta and Micellone, 1883].

1881

Description of:

Fusarium solani (Martius) Saccardo, 1881/*Nectria haematococca* Berkeley & Broome, var. *brevicona* (Wollenweber) Gerlach, 1981

1883

Description of:

Saccharomyces cerevisiae Meyen ex Hansen, 1883

1889

Description of:

Malassezia furfur (Robin) Baillon, 1889

1890

The physician, surgeon and Professor of the University of Buenos Aires, Argentina, Alejandro Posadas (1870-1902), born in Saladillo, Buenos Aires, studied as a medical student at the Experimental Pathology Laboratory headed by Roberto Joahan Wernicke (1854-1922), son of German immigrants and Professor of Pathology in the School of Medicine in Buenos Aires, the case of a patient mistakenly diagnosed with mycosis fungoides. Posadas observed microscopically an organism that resembled a protozoan referable to the group of *Coccidia*, being structurally characterized by a cystic structure and endocistic cells (1890). The organism was therefore called *Coccidioides immitis* (*Coccidioides*, coccidian-like, *im*, not, *mitis*, mild). The fungal nature of *C. immitis* remained hidden until a filamentous mould, supposed for many years to be a contaminant of cultures, was demonstrated, by inoculation in laboratory animals, to assume a morphology resembling a protozoan, thus providing evidence

of the dimorphic nature of the organism (1896) [Lobo, 1933; Pappagianis, 1998; San-Blas, 2000].

1892

A culture collection of filamentous fungi and yeasts was founded in Louvain, Belgium, by Philibert Melchior Joseph Ehi Biourge (1864-19?), microbiologist at the Brewery High School of the University in Louvain (1892), and officially recognized as the "Mycothèque de l'Université Catholique de Louvain" (M.U.C.L.) (1968) [Sleytr and Messner, 2003].

Carlos G. Malbran (1862-1940), born in Catamarca, Argentina, Professor of Bacteriology at the Faculty of Medicine of the University of Buenos Aires, Argentina, to whom the Instituto Nacional de Enfermedades Infecciosas (National Institute of Infectious Diseases) in Buenos Aires is dedicated, studied as a student a clinical case at the Laboratory of Roberto Joahan Wernicke in Buenos Aires. Malbran observed a microorganism (1892) that remained unpublished until another student, Guillermo Seeber, attending the same laboratory, saw a second case and first described the disease as well as its causative agent in his doctoral thesis (1900). As it was the case for *Coccidioides immitis*, the fungus was erroneously considered to be a protozoan, which was named *Coccidium seeberi* by Wernicke (1903), with reference to the protozoal subdivision *Coccidia* and the name of his pupil. James Hartley Ashworth described the life cycle of the organism, argued that it was a fungus, and proposed the name *Rhinosporidium seeberi* (1923) [Arseculeratne and Ajello, 1998; Ashworth, 1923; Niño, 1938; San-Blas, 2000; Seeber, 1900].

1894

The physician and scientist Francesco Sanfelice (1861-1945), born in Rome, Italy, founder and first Director of the Institute of Hygiene, University of Cagliari, Italy, studied the yeasts

growing in a wide variety of fruit juices (apple, cherry, grape, lemon, orange, peach, pear, tomato, melon and others) (1894). From a peach juice left to ferment in non-sterile containers, he isolated a yeast that was placed in the genus *Saccharomyces* and named *S. neoformans* (1895). The French mycologist Jean Paul Vuillemin (1861-1932), Professor of Natural History at the Faculty of Medicine of the University of Nancy, France, transferred it to the genus *Cryptococcus* (1901). The yeast strain isolated from Sanfelice is the type species of its genus and is correctly classified as *Cryptococcus neoformans* (Sanfelice, 1895) Vuillemin, 1901 [Ajello, 1998; Sanfelice, 1894; Sanfelice, 1895a; Vuillemin, 1901].

The Jewish German dermatologist of the Hospital of Surgery in Greifswald, Abraham Buschke (1868-1943), born in Nakel, in the province of Poznan, dead in the Nazi concentration camp at Theresienstadt, Bohemia, the contemporary Czech Republic, Head of the Department of Dermatology at the Rudolf-Virchow-Krankenhaus, in Berlin, Germany, gave a talk (1894), at an evening lecture of the Medical Society, on a peculiar disease caused by "*Coccidia*", which was followed by another of the pathologist Otto Busse (1867-1922), born in Belgard, Pomerania, Prussia (today Białogard, Poland), who reported on the association between *Cryptococcus neoformans* and a human infectious disease after isolation of a yeast from an abscess on a human tibia that was called *Saccharomyces hominis* (1894). A year later (1895), Francesco Sanfelice received some lymph nodes taken from a Sardinian cow died of liver cancer. From the bovine tissues, he isolated a yeast named *Saccharomyces lithogenes*. *Saccharomyces hominis* and *S. lithogenes* were considered synonyms of *Cryptococcus neoformans* by the renowned Dutch taxonomists Jacomina Lodder (1905-1987), born in Schiedam, of the Centraalbureau voor Schimmelcultures (C.B.S.), then housed in the Laboratory of Microbiology of the University of Delft, The Netherlands, and Nelly Jeanne Wilhelmina Kreger-van Rij, from the Laboratory of Medical Microbiology and Laboratory of Electron Microscopy, Department of Biology, State University, Groningen,

The Netherlands, in their treatise "The Yeasts" (1952) [Ajello, 1998; Busse, 1894; Knoke and Schwesinger, 1994; Lodder and Kreger-Van Rij, 1952; Sanfelice, 1895b].

The American dermatologist Thomas Caspar Gilchrist (1862-1927), born in Crewe, Cheshire, U.K., left England for America (1890) where he became Clinical Professor of Dermatology at the University of Maryland, U.S.A. (1897) and then at the Johns Hopkins Hospital, Baltimore, Maryland (1898). He was President of the American Dermatology Association (1909). Gilchrist, following the seminal studies by the German physician Robert Koch (1843-1910), born in Clausthal in the Harz Mountains, Prussia, then Germany (1871), Nobel Prize in Physiology or Medicine for his tuberculosis findings (1905), and Louis Pasteur in France, described a case of "*pseudo-lupus vulgaris*", related to *Blastomyces* (van Tieghem 1876), at the American Dermatological Society in Washington D.C. (1894) and, in a subsequent publication (1896), described a fungus that was later called *Blastomyces dermatitidis* (Gilchrist & Stokes, 1898) (*Ajellomyces dermatitidis* McDonough & Lewis, 1968) [Espinel-Ingroff, 1996; Gilchrist, 1896; Gilchrist and Stokes, 1898].