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THE DISTRIBUTION OF POISONS IN MUSHROOMS[1]

HISTORICAL INTRODUCTION

EDIBLE and poisonous mushrooms have been of great popular interest from time immemorial, and the earliest histories attest the extensive use to which the harmless varieties were put, both by the peasant population of the world, forced by dire necessity to eat everything that grows, and by the wealthy classes, driven to the same end by the demands of the epicure's palate. Paulet[2] with whose "Traité des champignons" all mycologists must begin their studies, relates that mushrooms have from antiquity been sold, especially during Mid-Lent, in the public markets of Pekin, St. Petersburg, Florence and in other cities and towns in Tuscany. The ancient Babylonians and early Romans employed the edible species in great quantity, and the amanita which seems to me the most beautiful of all agarics, especially when the developing plants are seen in the mountains of North Carolina, the *Amanita cæsaria,* owes its name to a Latin ruler.

The most interesting of the early cases of mushroom or, as commonly described, toadstool poisoning and one of the first authentic cases on record, occurred in the family of the Greek poet Euripedes, who lost in one day, wife, daughter and two sons, who in the poet's absence partook of the deadly species. Among the great ones whose lives were sacrificed to the same ignorance may be mentioned the Pope Clement VII., the Emperor Jovian,

[1] Address delivered before a special meeting of the Boston Mycological Club, June 14, 1909.

[2] Paulet, "Traité des champignons," Paris, 1793.

the Emperor Charles VI., Berronill of Naples and the widow of the Tsar Alexis. The death of the Emperor Claudius is also assigned to this cause, but the reason and the manner of the accident are not certain. It is related that this worthy emperor wishing to rid himself of an uncongenial spouse, disposed of her by one of the many methods suitable for this beneficent purpose, and promptly took unto himself a younger, but alas, no better helpmate. His second choice failed to appreciate the kindly qualities of the emperor and compassed his death by substituting poisonous for edible mushrooms in his favorite meal. According to the pure toxicologists the same end was effected by the simple addition of mineral acid to the agarics served at the emperor's dinner, but as a loyal mycologist, I prefer to believe that the wily woman performed the more skilful trick of substitution.

Next to Paulet, mycologists owe more to Bulliard,[3] the famous French scientist, who was the first to systematically study and classify mushrooms and many of whose species are accepted to-day. We got from him our name "destroying angel" for the *Amanita verna* and modern investigation has but confirmed the conclusions of this fine old savant. In addition to Paulet and Bulliard the list of French authors who have contributed to our knowledge of the toxicology of the subject is long and includes such names as Cordier,[4] Bardy,[5] Gillot,[6] Guillaud,[7] Bourquelot[8] and many others, together with the various contributors to the monthly *Bulletin de la Société Mycologique de France,* now in existence since 1886. Important papers have been published also in Germany, in Italy, in England and in this country, and we now have a very considerable literature of both clinical and scientific interest.

Amanita Phalloides Bulliard

The "white or deadly amanita" is the cause of the greatest number of the cases of mushroom intoxication, if we include in this group the forms described as *Amanita verna, Amanita bulbosa, Amanita alba, Amanita virescens, Amanita mappa* and many other species known by various names in different localities. The group is indicated in Germany by the designation "Knollen-blätterschwamm." Its description and identification need not concern us at the present time, since there are many deaths on record with the same symptoms during life and identical post-mortem findings which indicate that one species, speaking now from the toxicological point of view, is responsible for the poisoning. The intoxication is characteristic in its course and in its result. The fungi are usually eaten by ignorant individuals, who gather what they find in the woods and consume them either raw or after thorough cooking. A small amount of the fresh material is sufficient to cause profound illness with fatal outcome, so potent is the poison contained in its meshes, and the raw plant seems usually more toxic than the cooked specimens. Two or three "deadly amanitas" suffice to bring on disastrous results, and Plowright[9] reports the death of a child of twelve from eating a third of the pileus of a small raw

[3] Bulliard, "Histoire des champignons de France," 1791–1812.

[4] Cordier, "Essai sur la toxicité de quelques champignons avant et après leur dessication," Lyon, 1899.

[5] Bardy, *Bull. Soc. Philomat. des Vosges,* 1883–84, 9.

[6] Gillot, "Etude medicale sur l'empoisonement par les champignons," Lyon, 1900.

[7] Guillaud, *Bull. Soc. Mycol. de France,* 1885, 1, p. 123.

[8] Bourquelot, article entitled "Champignons" in Richet's Dict. de phys., Paris, 1898, 3, p. 271.

[9] Plowright, *Lancet,* December, 1879, Vol. 2, p. 941.

plant. The extreme toxicity of this species illustrates the dangerous consequences which the admixture of two or three specimens to a dish of edible mushrooms entail.

Following the consumption of the fungi there is a period of six to fifteen hours during which no symptoms of poisoning are shown by the victims. This corresponds to the period of incubation of other intoxications or infections. The first sign of trouble is sudden pain of the greatest intensity localized in the abdomen, accompanied by vomiting, thirst and choleraic diarrhœa with mucous and bloody stools. The latter symptom is by no means constant. The pain continues in paroxysms often so severe as to cause the peculiar Hippocratic facies, "la face vulteuse" of the French, and though sometimes ameliorated in character, it usually recurs with greater severity. The patients rapidly lose strength and flesh, their complexion assuming a peculiar yellow tone. After three to four days in children and six to eight in adults the victims sink into a profound coma from which they can not be roused and death soon ends the fearful and useless tragedy. Convulsions rarely if ever occur and when present indicate, I am inclined to believe, a mixed intoxication, specimens of *Amanita muscaria* being eaten with the *phalloides*. The majority of individuals poisoned by the "deadly amanita" die, the mortality varying from 60 to 100 per cent. in various accidents, but recovery is not impossible when small amounts of the fungus are eaten, especially if the stomach be very promptly emptied, either naturally or artificially.

There have been many cases of phalloides intoxication reported in Italy, France, Germany and England, and fatalities from this cause in Canada and the United States are not uncommon. For several years I have collected newspaper accounts of toadstool poisoning and I should estimate that twelve to fifteen deaths occur annually in this country from this species alone. The most horrible of all epidemics ever reported occurred in France at the Orphanage of St. Louis near Pont de la Maye, Gironde, where eleven children died from one meal of *Amanita phalloides* gathered by the ignorant attendants.

TOXICOLOGY OF AMANITA PHALLOIDES

With the earlier investigations of Letellier,[10] published in 1826, probably the first work of a chemical nature upon fungi, of Letellier and Speneux,[11] of Bourdier,[12] of Oré,[13] French mycologists to whom we owe the names *Amanitin, Bulbosine* and *Phalloidin,* we need no longer concern ourselves, not because these men did not have in hand the active principle of *Amanita phalloides* at some time or other, but because the fungi employed by them embraced a number of species and included in all probability *Amanita muscaria.* Muscarine indeed seems to have been present in many of the poisonous extracts which they tested.

Our consideration of the properties of this fungus really must begin with the work of Kobert[14] who was the first to study *Amanita phalloides* in any painstaking manner. From carefully selected specimens of this species he obtained by alcohol precipitation a substance which

[10] Letellier, "Thèse de Paris," 1826.

[11] Letellier and Speneux, *Annales d'hyg. pub. et de med. leg.,* p. 71, 1867.

[12] Boudier, "Des champignons au point de vue de leurs caractères usuels, chimiques et toxicologiques," 1866.

[13] Oré, *Arch. de physiol. norm. et path.* (II.), XI., p. 274, 1877.

[14] Kobert, *St. Petersburger med. Wochenschr.,* XVI., pp. 463, 471, 1891.

had the remarkable property of dissolving red blood corpuscles, a substance known as an *hemolysin,* and which he named phallin. Very minute traces of this substance brought in contact with the red-blood cells of man or with those of many species of animals, produced within a short space of time, fifteen minutes to one or two hours, a complete solution of these corpuscles—a laking of the blood. So powerful was this hemolytic action that even in a dilution of 1–125,000 it was still operative upon the red cells of ox blood. This peculiar phenomenon was so striking that Kobert's attention was naturally riveted upon the substance producing it, since it corresponds so closely to *helvellic acid,* the first hemolytic substance described in fungi, and the active principle of the poisonous helvellas. The fact that phallin was precipitated by ethyl alcohol, resisted dialysis, etc., and that his extracts contained a little coagulable proteid, led Kobert to characterize it as a *toxalbumin,* a name now largely employed by serumologists to indicate a complex poison either itself proteid or so closely bound to proteid, that it must be regarded as proteid or albumin in its chemical nature. Despite certain peculiarities in the behavior of phallin which militated strongly against its acceptance as the active principle of *Amanita phalloides,* especially the destruction of the substance at 70° C., that is, much below the boiling point, Kobert concluded that it was the essential poison of this fungus and stated that the clinical symptoms and the post-mortem changes could be explained by its action. The publication of Kobert that *Amanita phalloides* owed its toxicity to a powerful blood-dissolving substance which, absorbed through the walls of the stomach circulated in the blood plasma, destroying the blood corpuscle as they met it, was a peculiarly enticing explanation for the mysterious phenomena induced by this most powerful of all poisonous fungi, and his explanation was universally accepted, especially in popular treatises on mycology. Kobert,[15] however, continued his study of specimens of *Amanita phalloides* and a few years later announced that the blood-laking principle phallin was occasionally absent from specimens of this species, but that all typical forms contained an alcohol-soluble poison, which killed animals in small doses but did not produce the typical lesions seen in man. This second substance Kobert believed to be a poisonous alkaloid, but gave no satisfactory reason for his characterization of this poison as such.

The second communication of Kobert's had little or no circulation and was never known, I believe, to the majority of mycologists. Personally I was quite ignorant of its existence for some time after I began investigations in this field. During the summer of 1903, now six years ago, I collected a considerable number of specimens of *Amanita phalloides* in Blowing Rock, N. C., only the plants corresponding closely to the classic descriptions and which could be regarded as typical being accepted. During the following winter a careful study of these fungi was instituted. The thoroughly dried material was extracted with distilled water, the extract passed through a Berkefeld filter, and its action studied upon all varieties of blood corpuscles, and upon animals. Subsequently during the summer of 1904 and 1905 I collected in the Blue Ridge Mountains of Maryland and a year later in Woods Holl, Mass. The following season

[15] "Sitzungsberichte der naturforschenden Gesellscheft zu Rostock," p. 26, 1899, Anhang to the *Archiv des Vereins der Freunde der Naturgeschichte in Mecklenberg,* III., 1899, II. Abtheilhung.

Dr. Abel, professor of pharmacology in the Johns Hopkins University, collected in New York state, and then again in New Hampshire. We have thus had a considerable amount of material for study, gathered from widely separated areas.

During the first winter's work[16] I was able to confirm Kobert's assertions as to the presence of a powerful hemolysin in *Amanita phalloides*. I found it acted upon blood corpuscles from nearly every animal tested, and that it corresponded somewhat in its action to hemolysins derived from bacterial filtrates. At the same time it was at once apparent that this fungus always contained another poison which differed from the hemolysin in being resistant to heat and digestion, the blood-laking substance phallin, being destroyed by heating to 70° C., and by the action of the digestive ferments. To this second substance I gave the name amanita-toxin[17] reserving for the blood-laking principle the name amanita-hemolysin, in order to clearly differentiate between these poisons, regardless of any question as to the active principle. The work was now taken up from the chemical standpoint and under Dr. Abel's direction a number of important problems have been solved. In the first place he and I[18] have shown that aqueous extracts of *Amanita phalloides* contain two poisons which may be separated by concentration to a small bulk and precipitation by ethyl alcohol. The precipitate contains the amanita-hemolysin, the filtrate the amanita-toxin. This hemolytic substance we have shown to be not a toxalbumin, as Kobert believes, but a very sensitive glucoside, that is, a substance which contains sugar in its molecule, and which when split up into its component parts will give the most important reactions for sugar, namely, the reduction of Fehling's solution and ammoniacal silver nitrate. Furthermore we[19] have developed a method for the isolation and purification of this substance, and have finally been able to show that it is an extremely complicated poison containing fixed amounts of carbon, nitrogen, hydrogen and sulphur. The importance of these observations lies not only in the practical application of the method we have developed to the examination of other fungi, but also in certain theoretical questions of immunity. This substance is the poison in *Amanita phalloides* to which a high grade of immunity can be established in animals and for which I have repeatedly obtained an anti-poison or an anti-hemolysin, the action of which is to completely neutralize its blood-laking properties.

Schlesinger and I[20] at the same time have shown that the amanita-toxin can be isolated and purified by certain well-defined methods, and in its pure state is one of the most powerful poisons of organic origin known, four tenths of one milligram killing a guinea-pig within twenty-four hours. At first thought to be a conjugate sulphate, I have recently found, in association with Mr. Prouty, that conjugate sulphate can not be split off from the amanita-toxin. The exact character of this poison is still under investigation. These two substances, the amanita-hemolysin and the amanita-toxin, are the only poisons we have thus far encountered in *Amanita phal-*

[16] Ford, *The Journal of Infectious Diseases*, Vol. III., No. 2, April, 1906, pp. 191–224.

[17] Ford, *The Journal of Experimental Medicine*, Vol. VIII., No. 3, May 26, 1906, pp. 437–450.

[18] Abel and Ford, *The Jour. of Biol. Chem.*, Vol. II., No. 4, January, 1907, p. 273.

[19] Abel and Ford, *Arch. f. exp. Path. et Pharm.*, Supplement-Band, Schmiedeberg Festschrift, 1908.

[20] Schlesinger and Ford, *Jour. of Biol. Chem.*, Vol. III., No. 4, September, 1907, p. 279.

loides. The hemolysin we believe to play no rôle in human intoxications, the toxin being the active principle—since it can be boiled and resists the action of the gastric juice. I have furthermore pointed out[21] that the lesions seen in fatal cases of poisoning in man can be reproduced in animals by the amanita-toxin alone, but I am by no means certain that the amanita-hemolysin can be entirely eliminated in human intoxications. This substance is at times present in *Amanita phalloides* in the greatest abundance, and is more resistant to heat than is usually believed. Should the fungi be eaten raw or only partially cooked, this poison might escape the action of the digestive ferments, especially if these be deficient in quantity or quality, and assist the amanita-toxin in its deadly work. Against this possibility we have the fact that *Amanita rubescens,* considered by the majority of mycologists to be an edible mushroom, contains a hemolysin equally powerful with that of *Amanita phalloides.* We can only say that the heat-resistant amanita-toxin is the active principle in the sense that by itself it is capable of causing a fatal intoxication even if the hemolysin is inactive. Nevertheless the fact that the amanita-hemolysin may exert an adjuvant action in cases of poisoning raises at once the question whether fungi containing hemolytic substances should be regarded as entirely safe.

Kobert[22] in the chapter on fungi in his recent text-book ascribes to *Amanita phalloides* first, a blood-laking substance, phallin, which he states to be a toxalbumin despite the observations of Dr. Abel and myself which prove that the hemolysin in this fungus is a glucoside, secondly, an alcohol-soluble poison, not producing fatty degeneration, which he believes to be an alkaloid, and finally a third hypothetical poison, a toxalbumin like thujon and pulegon, certain complex substances found in plants (pennyroyal). In the second poison Kobert is probably dealing with the amanita-toxin, which is not an alkaloid and which I think does produce fatty degeneration, and his third poison is purely supposititious. He himself presents no evidence of its existence, and while we can not deny that *Amanita phalloides* may contain at times other poisons not noted by us, we are inclined to the opinion that the amanita-hemolysin and the amanita-toxin are the most important, if not the only ones.

Specimens of small amanitas collected in the Blue Ridge Mountains of Maryland and identified as *Amanita verna* Bulliard were presented in special lots. When examined their properties were quite the same as those of *Amanita phalloides.* The strength of both hemolysin and toxin, however, was considerably greater when the weight of the dried specimens was considered.

Amanita muscaria Linnæus

The species known as the "fly agaric" (Fliegenpilz or Fliegenschwamm of the Germans) has been recognized from early times as deadly poisonous, the first accident on record being possibly that of Madame the Princess of Conti in Fontainebleau in 1751. This, however, did not terminate fatally. *Amanita muscaria* is a beautiful species when fully developed and to a certain extent it resembles *Amanita cæsaria* or *Amanita aurantiaca,* French writers distinguishing between the two species by referring to the edible form as the "oronge vraie" and to the poison-

[21] Ford, *Jour. of Infect. Dis.,* Vol. 5, No. 2, March 30, 1908, pp. 116–132.

[22] Kobert, "Lehrbuch der Intoxikationen," Zweite Aufl., II², p. 625, 1906.

ous species as the "oronge fausse." It can easily be recognized by even beginners in mycology and is now commonly avoided. Poisoning results from ignorance, the species in question being selected for its beautiful color and form, or from mistakes in identification, *Amanita muscaria* being taken for the *cæsaria* or the *aurantiaca*. In addition there is another factor which is possibly the cause of the majority of accidents in this country, especially those occurring with individuals possessing some knowledge of mycology. In Italy and in France and in certain parts of Austro-Hungary *Amanita muscaria* is apparently somewhat reddish in color, while *Amanita cæsaria* is of a lighter yellow tone. The most commonly found *Amanita muscaria* in this country is of a light to a deep yellow in color, not showing the reddish tinge, while *Amanita cæsaria* is either of the reddish-yellow hue or even of a beautiful reddish-brown.

Persons familiar with the two species in the old world might very easily draw wrong conclusions in identifying those found in the new. I base this opinion largely upon a comparison of the colored plates of the text-books of mycology published in different countries and upon the specimens of "Cæsar's agaric" and the "fly agaric" I have myself found in the Blue Ridge Mountains. This assumption is furthermore borne out somewhat by the literature of "muscaria poisoning" for in many instances the victims were Italians or Poles who stated before death that they ate the fungi under the impression that they were eating the "royal agaric." This was apparently the cause of the poisoning of the Count de Vecchi and his physician in Washington which Prentiss[23] has reported with great care. The Count, an attaché of the Italian legation, a cultivated gentleman of nearly sixty years of age, considered something of an expert upon mycology, purchased, near one of the markets in Washington, a quantity of fungi recognized by him as an edible mushroom. The plants were collected in Virginia about seven miles from the city of Washington. The following Sunday morning the count and his physician, a warm personal friend, breakfasted together upon these mushrooms, commenting upon their agreeable and even delicious flavor. Breakfast was concluded at half after eight and within fifteen minutes the count felt symptoms of serious illness. So rapid was the onset that by nine o'clock he was found prostrate on his bed, oppressed by the sense of impending doom. He rapidly developed blindness, trismus, difficulty in swallowing and shortly lost consciousness. Terrific convulsions then supervened, so violent in character as to break the bed upon which he was placed. Despite rigorous treatment and the administration of morphine and atropine, the count never recovered consciousness and died on the day following the accident. The count's physician on returning to his office was also attacked, dizziness and ocular symptoms warning him of the nature of the trouble. Energetic treatment with apomorphine and atropine was at once instituted by his colleagues and for a period of five hours he lay in a state of coma with occasional periods of lucidity. The grave symptoms were ameliorated and recovery set in somewhere near seven o'clock in the evening. His convalescence was uneventful, his restoration to health complete, and he is, I believe, still living. In this instance the count probably identified the fungi as *cæsaria* or *aurantiaca*. From the symp-

[23] Prentiss, *Phil. Med. Jour.*, 1898, 2, pp. 607–611.

toms and termination the species eaten must have been *muscaria.*

These two cases are not typical of this intoxication. In the majority of instances *Amanita muscaria* has a bitter, unpleasant taste and on this account is not eaten in great quantity. Consequently the intoxication is not so profound and the fatalities are fewer in number. Moreover the action of the poison is mainly directed against the nerve centers and if this action be neutralized by atropine, or if the nerve centers are not completely overwhelmed, its effect gradually wears off, without any permanent lesion. Not so with *Amanita phalloides,* where the amanita-toxin is the cause of such profound degeneration in the internal organs, heart, kidney and muscles, as to make recovery a far more arduous task for nature to accomplish.

The active principle of *Amanita muscaria* is muscarine, an alcohol-soluble crystalline substance first isolated from this species by Schmiedeberg and Koppe[24] and usually classed with the ammonia bases. It will reproduce in animals the intoxication seen in man and is without doubt the chief poison present. Muscarine has also been prepared synthetically, by the oxidation of choline, but the artificial body does not produce quite the same symptoms and it is easily decomposed. Moreover muscarine is apparently not the only poison present in this plant. It has been shown on clinical grounds that even when this drug is completely neutralized by its perfect physiological antidote, atropine, the patients who have eaten *Amanita muscaria* sometimes die, and Harmsen, from a series of carefully conducted experiments, concludes that another poison exists in *Amanita muscaria,* the so-called "Pilztoxin." This fungus is probably most widely known from the habits of the peasants of the Caucasus who prepare from it an intoxicating beverage which produces wildly riotous drunkenness. Death from a muscarine orgy is not uncommon in this part of Russia and a member of the ruling family is said to have lost his life in that way. *Amanita muscaria* collected in the Caucasus is said to be deficient in muscarine, but the universal testimony of medical writers would indicate that this is not the case, but that rather a kind of tolerance develops among the habitual users of the *muscaria* decoctions. We do not know, however, whether muscarine is present in *Amanita muscaria* in the same quantity at different periods of the year nor have we any knowledge of the effect of soil and climate upon its distribution. The only antidote for this poisoning is atropine, which, however, is so potent in this respect as to almost completely neutralize the muscarine and hence the outlook in this intoxication is far more hopeful than in any other.

[24] Schmiedeberg and Koppe, "Das Muskarin," Leipzig, 1869.

RARELY POISONOUS SPECIES

Amanita pantherina De Candolle, a species closely resembling *Amanita muscaria,* is occasionally the cause of mushroom poisoning, but the intoxication is not profound and but rarely does death ensue. The symptoms come on within a few hours after eating, and consist of great excitement, delirium, convulsions and a peculiar drunkenness not unlike that described among the Koraks. The Japanese variety is said by Inoko[25] to represent *Amanita muscaria* for Japan, being used there as a fly poison in place of the latter species, which is rare and devoid of any poisonous quality. Inoko has isolated muscarine from this Japanese *Amanita pantherina*

[25] Inoko, *Mittheil. a. d. Med. Fac. de K. Jap. Univ. Tok.,* 1890, 1, No. 4, pp. 313–331.

and has reported an extensive series of intoxications. The victims showed in addition to vomiting, diarrhœa, and a dilatation of the pupils, peculiar nervous manifestations. The feeling of "bien-être" expressed by singing and laughing, the sensation as of insects crawling over the skin, visions of beautifully colored reptiles and snakes, red, yellow and brown, all contribute to give us a picture of a peculiar mental state, which differs from that described among the Russians, not so much in the kind of drug causing the symptoms as in the different psychology of the Oriental as compared with the Tartar. In all cases the intoxication with *Amanita pantherina* is mild and recovery the rule.

The poisonous fungus *Helvella* or *Gyromytra esculenta* Fries occurs so rarely in this country and is so seldom the reputed cause of illness at the present time, that we need not pay any particular attention to it beyond referring to its active principle, Helvellic acid, isolated by Boehm and Külz.[26] This is a hemolytic or blood-destroying substance, soluble in hot water, which when given to dogs by mouth will reproduce the lesions found in man with all the signs of a hemolytic intoxication. Other species of mushrooms like *Russula emetica* cause profound gastro-intestinal disturbances such as a sharp attack of vomiting and diarrhœa, recovery following emptying of the stomach and bowel of the irritating plant. Certain of the rank-smelling phalloideæ which exhale an offensive odor and are of course never eaten by man, are eagerly devoured by swine with uniformly fatal consequences. Gillot (*l. c.*) states that one or two species of *Volvaria* have caused death when eaten, but nothing is known of the nature of the intoxication or of the active principle. Finally the poisonous *Boletus luridus* or *Boletus satanus* may occasionally be the cause of transient disturbances in man, but the plants have such a rank, unpleasant taste as to forbid their consumption in any quantity. These species have been said to owe their toxicity to muscarine. The question as to whether the ordinary edible mushrooms, as distinguished from the poisonous toadstools, may not in certain localities or at certain periods of the year be the cause of fatal intoxication, may be answered, I am sure, in the negative. Old or badly decomposed specimens may cause transient illness, and I remember well an attack of cholera-morbus which I experienced in Paris from eating dried specimens of the meadow mushroom, purchased in the open market. There are, however, no authentic cases of *poisoning* from the black or brown spored agarics and when investigated in the laboratory, these species are found free from toxins. The three or four forms already mentioned are the only ones thus far *proved* to be poisonous and the only ones with which laboratory investigation has confirmed clinical observation.

In addition to *Amanita phalloides* and *Amanita verna,* I have also analyzed *Amanita rubescens* Persoon[27] collected at Woods Holl, Mass., and a species from the same place which I identified as *Amanita solitaria* Bulliard. It corresponded closely in its general appearance to the plates and descriptions given for this species. In *Amanita rubescens* I found a powerful blood-destroying substance like the amanita-hemolysin which could be freed from proteid and which gave the reactions for glucosides. *Amanita solitaria* had a peculiar action upon blood corpuscles, causing their agglomeration in densely adherent

[26] Boehm and Külz, *Arch. f. exp. Path. u. Pharm.*, 1885, 19, p. 403.

[27] Ford, *Jour. of Infect. Dis.*, Vol. 4, No. 3, June, 1907, pp. 434–439.

clumps, the phenomenon spoken of in bacteriology as *agglutination,* but in addition the corpuscles were slowly dissolved. Neither species contained any amanita-toxin. Both *Amanita solitaria* and *Amanita rubescens* are regarded by mycologists as edible. If they can be eaten by man, these substances acting "in vitro" upon the blood corpuscles must either be destroyed in cooking or be digested in the stomach and intestines, or the species must vary in their properties.

SPECIES COLLECTED IN 1908

For a long time I had been anxious to examine some of the rarer species of fungi which closely resemble the deadly poisonous forms, and also some of the species which are said to be *dangerous,* occasional intoxications from their use having been reported in the older literature. The opportunity of doing so was afforded me through the kindness of Mr. George E. Morris, of Waltham, Mass., who sent me last fall a number of fungi which he had himself procured, together with specimens collected by Mr. Simon Davis, of Brookline, Mass., and some from the general collection of the Boston Mycological Club. These mushrooms were accurately identified in the fresh state, carefully dried in a drying oven, wrapped in separate packages, labeled with the name of the finder and the place and date of finding. The specimens were analyzed "seriatim" in the laboratory. The results of this work will be reported in detail later, but to-night the principal conclusions drawn from the study of these forms may be briefly commented upon. It is essential, when looking into the properties of the rarer fungi, especially the amanitas, that the various species studied should have been identified by expert botanists, and I feel very fortunate in this respect in having material vouched for by such well-known mycologists. One species of *Amanita phalloides* obtained by Mr. Davis at Stow was found to contain the poisons typical of this species. Their strength was somewhat less than usual, but the action upon blood corpuscles and upon animals was identical with that usually found. Two lots of *Amanita virosa* Fries were examined: one obtained by Mr. Morris in Cohassett, and another by Mr. Davis in Stow. In both instances hæmolysin and toxin were present in maximum quantities. An extract of fungus in which the dried material was utilized in the proportion of six grams to fifty cubic centimeters of water gave a hemolysin active in a dilution of 1–200, and subcutaneous injection of the extract killed guinea pigs within twenty-four hours with the symptoms and lesions of an acute intoxication. *Amanita virosa* thus is identical with *Amanita phalloides.* Specimens of *Amanita spreta* Peck collected by Mr. Morris in Stow and by Mr. Davis in the same locality were identical in their action. In the proporton of six grams of dried fungi to sixty cubic centimeters of water a hemolysin was present in both instances, in a strength of 1–20 and the inoculation of animals with the heated extract produced a typical chronic intoxication. While the poisons are by no means as powerful as those in *Amanita virosa* they are of the same character. *Amanita spreta* is described by Atkinson[28] with the words "said to be poisonous." Although no cases of intoxication have thus far been reported in the literature, the species must be classed with the "deadly poisonous." *Amanita phalloides* Bulliard, *Amanita verna* Bulliard, *Amanita virosa* Fries and *Amanita spreta* Peck, may thus be grouped

[28] Atkinson, "Mushrooms," 1903, p. 69.

together in their toxicological properties. *Amanita rubescens* Persoon from the collection of Mr. Morris at Stow and a yellow form of *Amanita rubescens* from the Boston Mycological Club were examined by the routine method. The *rubescens* from Mr. Morris's collection was devoid of hemolysin and toxin alike, while the yellow form contained an active hemolysin but no toxin. A more careful study of the species *rubescens* must be made before a positive conclusion can be drawn concerning its properties. Four of the rarer species of *Amanita* may be described together because of their similarity, namely, *Amanita strobiliformis* Vittadini found by Mr. Morris in Ellis, *Amanita chlorinosma* Peck from the collection of the Boston Mycological Club, *Amanita radicata* Peck found by Mr. Morris in Ellis and *Amanita porphyria* Albertini and Sweinitz from the same place.

These four species were alike devoid of hemolysins, but contained in small quantities a poison which is practically identical with the amanita-toxin. It is resistant to heat, soluble in alcohol and kills animals slowly, but with many of the lesions found in phalloides poisoning. These fungi should all be considered "deadly poisonous," and future experience may even show that hemolysins are also present in other forms of the same species, in which case they would be practically identical with the "deadly amanita."

Two specimens of *Amanita muscaria* Linnæus were given me, one found by Mr. Morris and the other by Mr. Davis in Stow. The properties of these forms were identical with those of *Amanita muscaria* obtained for me six years ago by Dr. W. H. Lewis, in Woods Holl, Mass. The species thus seems very constant in its characteristics. All three samples contained muscarine, the aqueous and alcoholic extracts killing animals in two hours with the usual symptoms. The alcoholic extract contained in addition a peculiar hemolysin, the properties of which are still under investigation, while in the aqueous extract evaporated to a small bulk and precipitated by ethyl alcohol I found an *agglutinin* such as has been previously described for *Amanita solitaria*. The development of our methods of analyzing fungi enabled me to *isolate* this substance, which turned out to be a glucoside, but not one containing pentose. Although agglutinins are not uncommon in various plants, this is, I believe, the first time that one has been isolated by chemical methods, and the first time that a glucoside has been found to exert this action upon blood corpuscles.

Amanita frostiana Peck, three specimens of which were found by Mr. Morris in Stow and one at Cohasset were individually examined. They contained in all instances an hemolysin of low grade intensity, but the heated extracts were without action upon animals. Neither amanita-toxin nor muscarine could be demonstrated. The absence of resistant poisons from this species is particularly interesting since *Amanita frostiana* was first described by Peck as a minor variety of *Amanita muscaria*, and is put down by Atkinson[29] as "poisonous." The specimens sent me were certainly devoid of muscarine, a fact which suggests that the species may not be so closely related to *Amanita muscaria* as is indicated by its botanical characters. Further observations must be made with other forms of *Amanita frostiana* to determine whether it is uniformly free from the poison described by Schmiedeberg. Finally three specimens of *Amanita russuloides* Peck, one found at Natick by Mr. Morris, another at Stow by Mr. Morris, and a third at

[29] Atkinson, "Mushrooms," 1903, p. 54.

Stow by Mr. Davis proved to be quite free from poisons of any description. In one instance a slight hemolytic action was observed, but this was attributed to the acid reaction of the fungus. In all cases the heated extracts were without effect upon animals. This species is considered edible by most mycologists.

GENERAL CONCLUSIONS

The examination of these various species of fungi, representing now nearly twenty distinct forms, demonstrates one or two facts which should be particularly emphasized. In the first place, our methods of chemical analysis of mushrooms, and especially the methods of isolating their poisons are now so developed that a little material, two or three small specimens in fact, and even one good sized plant, may be studied and an opinion be given as to the properties of the species. In the second place, a more extended investigation should be carried out in regard to the properties of all the mushrooms believed on clinical grounds to be poisonous, but of which no laboratory study has thus far been made. Finally such a piece of work, to be of lasting value to science, can only be accomplished through the cooperation of trained mycologists who can identify with certainty the species of mushrooms selected for study.

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June 20, 1909

NOTES ON ELECTRICAL ENGINEERING AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The cause of electrical engineering research and the advanced instruction of graduate students in electrical engineering has been advanced by the appointment of Dr. Harold Pender to the professorship of theoretical and applied electricity which is connected with the department of electrical engineering at the Massachusetts Institute of Technology. Dr. Pender is a graduate of Johns Hopkins University and took the degree of Ph.D. at that university in 1901 under the direction of Professor Rowland. He thereafter taught for a year and a half, during which period he completed the classical experiments of Professor Rowland which demonstrated the magnetic effect of a moving charge of electricity. M. Poincaré having suggested the desirability of these experiments being performed in Paris, the Carnegie Institution of Washington arranged with Dr. Pender to go to France for the purpose. Upon returning from France Dr. Pender went into the employ of the Westinghouse Electric Company and he has since been in regular engineering employ. His teaching at the Institute of Technology will consist of a course for third-year undergraduate students and courses for graduate students in the more advanced theories of electric current flow and the electric transmission of power, in addition to the direction of experimental research by advanced students.

The advanced lectures on the organization and administration of public service companies, on the design of power stations and systems, and on electrical measurements heretofore carried on by Professor Jackson, Professor Shaad and Professor Laws will be continued by the same professors.

As indicating the trend of electrical engineering study at the present time, it is notable that forty per cent. of the students just graduated from the electrical engineering course at the Massachusetts Institute of Technology already bore degrees of bachelor of arts or science, conferred, as a rule, in classical or literary courses. These men are going into a wide variety of activities, from the manufacture of electric instruments and of incandescent lamps to electric transmission of power and heavy electric traction.

Mr. H. S. Osborne and Mr. W. S. Rodman, who are candidates for the degree of doctor of engineering in the electrical engineering department, have recently been appointed fellows by the faculty of the institute. Mr. R. L. Jones has been appointed graduate scholar in electrical engineering.