two Gold Pheasants (*Thaumalea picta*) from China, a Pheasant (*Phasianus colchicus*), five Barn Owls (*Strix flammea*), British, purchased; a Japanese Deer (*Cervus sika*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

COMET BORRELLY-BROOKS (1900 *b*).—Several observations of this comet are announced. The comet is at present easily seen with a small telescope, but is becoming fainter.

Ephemeris for 12h. Berlin Mean Time.

1900.	R.A. h. m. s.	Decl. ° ′	Br.
Aug. 9	3 11 45	+61 11·9	0·91
10	15 14	63 37·6	87
11	19 12	65 56·8	83
12	23 41	68 9·4	79
13	28 47	70 15·6	75
14	34 46	72 15·3	71
15	41 48	74 8·6	67
16	3 50 8	+75 55·7	0·63

During the week the comet passes rapidly northwards from α Persei, across into Camelopardus, and then near the boundary of this constellation and Cassiopeia. Its path is at present so nearly linear that it may be found by sweeping along the direction formed by the stars π, κ and α Persei.

EPHEMERIS OF COMET 1894 IV. (SWIFT).—Mr. F. H. Seares sends the following search ephemeris for the assistance of interested observers:—

Ephemeris for 12h. Berlin Mean Time.

1900.	R.A. h. m. s.	Decl. ° ′
Aug. 8	15 57 20	−24 32·8
12	15 59 31	36·0
16	16 2 10	40·2
20	16 5 17	45·4
24	16 8 50	51·4
28	16 12 50	−24 58·1

VARIABLE STARS IN CLUSTERS.—*Harvard College Observatory Circular* (No. 52) contains the results of the measures of a set of photographs of the star cluster Messier 3 (N.G.C., 5272). This object is so low in the sky at Arequipa, and the stars so faint, that satisfactory photographs of it could not be obtained with the 13-inch Boyden refractor with exposures less than 90m. The rate of increase of the light of many of these stars is extremely rapid, and in order to determine such change with the greatest precision, it is necessary to have photographs taken with short exposures. Accordingly, at Prof. E. C. Pickering's request, Prof. J. E. Keeler has taken a series of excellent pictures of the cluster with the 3-foot Crossley reflector of the Lick Observatory The first of these had an exposure of 60m., while twenty-four others were obtained with exposures of 10m. each. Prof. Bailey has examined these photographs very carefully, devoting attention specially to three of the variable stars. It has previously been stated (*Circular* No. 33) that the proportion of variable stars is greater in this cluster than in any other object of the same class.

The periods of the three variables were found to be: No. 11, 12h. 12m. 25s.; No. 96, 12h. 0m. 15s.; No. 119, 12h. 24m. 31s. The variations were recorded for intervals of 5m., and are given in a table. From this it appears that the total increase of light takes place in the case of No. 11, within 70m.; No. 96, within 60m.; and No. 119, within 80m. The greatest rapidity of increase of light occurs in the star No. 96, which increases during 5m. at the rate of at least 2·5 magnitudes per hour, and during 30m. at the rate of more than 2·0 magnitudes per hour. This rate of change appears to be the most rapid of any known variable. The Algol variable U Cephei, which perhaps undergoes the most rapid change of any variable *not* found in clusters, changes at the rate of about 1·5 magnitudes per hour during about 30m. of its period. In all these stars the rate of change is relatively slow near the beginning and end of the period of increase. In No. 96 the increase is about *ten* times as rapid as the decrease. Generally speaking, the lengths of period and form of light curves of these three stars are similar to those of the variables in the clusters Messier 5 and ω Centauri (*Astrophysical Journal*, vol. x. p. 255).

RECENT INVESTIGATIONS ON RUST OF WHEAT.

RUST, or mildew, is familiar to the agriculturist as a disease destructive to wheat and other cereals, and to the botanist as the subject of important researches relating to fungi. It was known in times of antiquity, as shown by numerous references indicating its destructiveness. Virgil says, "Soon, too, the corn gat sorrow's increase, that an evil blight ate up the stalks" ("Georgics," i. 150–1). In Britain, it is stated that "mildew of wheat-plants has been known for over 300 years, according to the records" ("Report on Mildew on Wheat Plants, 1892," Board of Agriculture, 1893, p. 25). Shakespeare ascribes it to "the foul fiend Flibbergibbet" (*King Lear*, Act iii. Scene 4). The works on husbandry of Hartlib (1655) and Jethro Tull (1731) refer to it. The connection of rust of cereals with a specific fungus is generally ascribed to Fontana (1767), and Persoon, after further investigation, in 1797 named the fungus *Puccinia graminis*. An account of rust, with illustrations of the *Puccinia*, by Sir J. Banks in 1805, is apparently the first important paper on the rust and its fungus in Britain. Since then the epidemic has been the subject of many papers, and of, at least, three organised inquiries. The historical side of the subject is conveniently summarised by Worthington G. Smith ("Diseases of Crops," London, 1884, Chapter xxv.), by C. B. Plowright ("British Uredineæ and Ustilagineæ," London, 1889, p. 46), and in the Board of Agriculture report ("Report on Mildew on Wheat Plants, 1892," Board of Agriculture, 1893, p. 25).

Rust of wheat occurs throughout Britain, especially in the wheat-growing districts, and forms of it are found on oat, barley, rye, and almost all grasses The losses from the form on wheat, reported to the Board of Agriculture in 1892, vary from nine to sixteen bushels per acre of crop. Rust-epidemics have been the subject of special attention in Europe, more particularly in Sweden, Germany, France and Austria. A rust conference was formed in 1890 for Australasia, and still continues to meet. In the United States of America, the Department of Agriculture sanctions the statement that "the damage to wheat and oats from rust in this country probably exceeds that caused by any other fungous or insect pest, and in some localities is greater than that caused by all other enemies combined" (Carleton, M. A., "Cereal Rusts of the United States," U.S. Department of Agriculture, *Bulletin* 16, 1899). In India and Japan, substantial losses are ascribed to this disease.

The remedy for this epidemic is a difficult problem, and the aim of recent research has been, in the first place, to obtain a true conception of the fungus causing it. The facts leading up to recent investigations may be briefly reviewed. It is an old and deep-rooted belief amongst growers of wheat that the rust of their crops is influenced by the neighbourhood of barberry bushes. Evidence of this is seen in certain old enactments enforcing destruction of the barberry; for instance, that passed by a parliament at Rouen in 1660, and others included in the Province Law of Massachusetts (America) between 1738 and 1761. Sir Joseph Banks, in his paper (1805), holds the same opinion.

In 1841 Prof. J. S. Henslow (*Journal* of the Royal Agricultural Society, vol. ii. 1841) suggested that the yellow summer rust of wheat, and the black mildew which comes later, are stages in the life of one and the same fungus. Passing over many papers discussing these relationships, we come to one by De Bary published in 1865 ("Untersuchungen üb. Uredineæ." *Monatsber. d. Berlin Akad.*, 1865). From his experiments De Bary concludes, that the yellow summer rust (*Uredo linearis*, Persoon) on *Gramineae*, the black autumn rust (*Puccinia graminis*, Persoon) also on *Gramineae*, and the rust on barberry (*Aecidium berberidis*, Persoon) with its associated "spermogonia" stage, are phases in the life-history of the same fungus, for which the name *Puccinia graminis* is retained. In other words, that three (or four) recognised species of fungi are one and the same. At the same time a new phenomenon in the life of fungi was revealed, namely, that there existed parasitic fungi which required two host-plants in order to develop the forms of reproduction included in their life-cycle; this De Bary named metœcism or (as better known in Britain) heterœcism. The life-history of *Puccinia graminis*, as defined by De Bary, is given in all our text-books. Uredospores (see Fig. 1) are produced on wheat and other *Gramineae* throughout the summer, and infect the same group of host-plants; the teleutospores of the *Puccinia* stage hibernate and in the following spring germinate, producing secondary spores (also known as sporidia), which infect barberry foliage and give rise there to the *Aecidium* stage with its aecidiospores; aecidiospores do not infect barberry again, but on *Gramineae* produce the uredospore

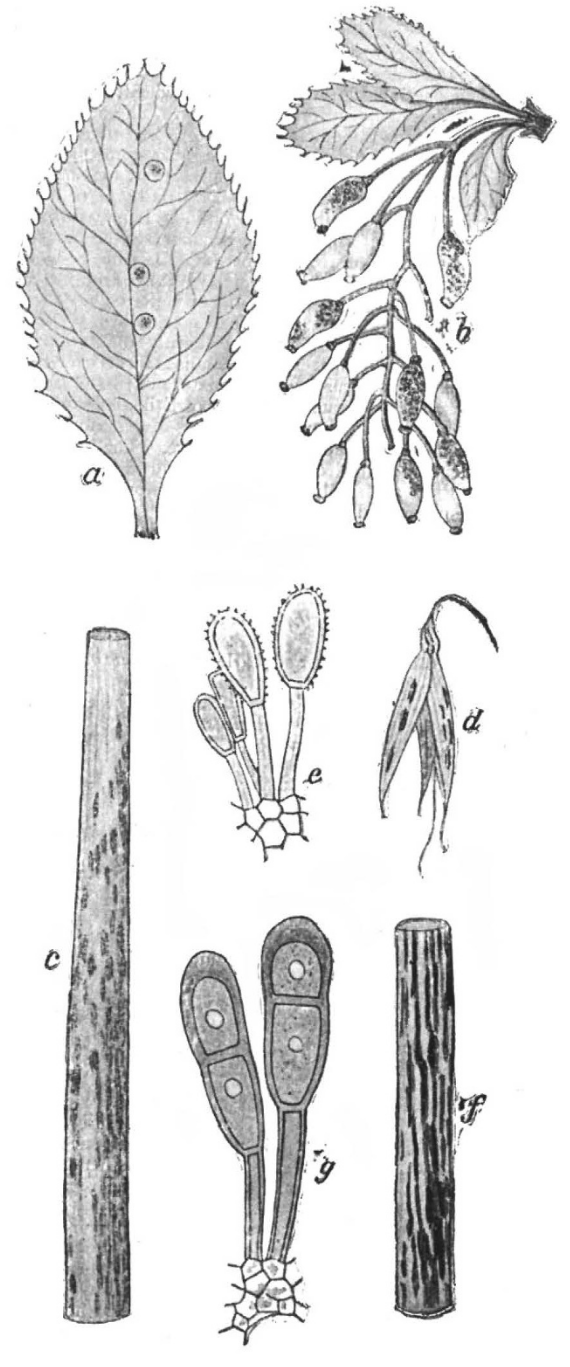

FIG. 1.—Black rust of oats (*Puccinia graminis*, spec. form *Avenae*). *a*, leaf, and *b*, cluster of fruits of barberry with *Aecidium berberidis* (nat. size); *c*, leaf, and *d*, a spikelet of oat with *Uredo* stage (nat. size); *e*, uredospores (× 500); *f*, sheath of oat with *Puccinia* stage (nat. size); *g*, teleutospores (× 500). (J. Eriksson.)

stage, thus completing the cycle. Accompanying the aecidium-cups there occurs constantly a form of reproduction, the spermogonia, which gives off spermatia or spore-bodies whose function neither De Bary, nor any one since, has been able to determine.

These results had an important and direct bearing on rust-epidemics of cereals, and they gave an impetus to further research on the biology of the whole group of rust-fungi or *Uredineae*, and, in fact, of all other parasitic fungi. In 1889, twenty-five years after De Bary's first results, both Plowright (*loc. cit.*, p. 56) and Rostrup published a list of fifty heterœcious rust-fungi. Recently, Dietel (Engler's "Pflanzenfamilien") gave about a hundred cases, including species outside the *Uredineae*. Works like Plowright's "British Uredineæ" are the evidence of this impulse, and a perusal of current botanical periodicals shows that the subject is by no means exhausted.

Ten years ago, three species of rusts occurring on crops of cereals were recognised:

(1) *Puccinia graminis*, with its *Aecidium* stage on barberry and mahonia; its uredospore and teleutospore stages on wheat, barley, oats, rye, and about a hundred species of grasses (see Fig. 1).

(2) *Puccinia rubigo-vera*, with *Aecidium* on many species of *Boragineae*; uredospores and teleutospores on wheat, rye, and a number of grasses (see Fig. 2). A variety, *simplex*, was distinguished on barley.

(3) *Puccinia coronata*, with *Aecidium* on species of buckthorn (*Rhamnus*); uredospores and teleutospores on oats and several grasses.

The four important European cereal-crops were thus known to have each two forms of rust-fungi, distinguished in their external characters, and with distinct *Aecidium* host-plants. Yet it was by no means certain that epidemics of rust were fully traced out. Fortunately the economic importance of rust-epidemics was enough to enforce attention from State departments, notably in Sweden, United States of America, Australasia, and in various parts of Europe and other countries. In Britain, while good work has been and is still done on rust-fungi, there has, in recent times, been no specially organised research relating to cereal rusts, probably because recent developments on the subject have rendered a research too extensive for the resources of any but workers specially retained and remunerated. The investigations on rusts of cereals reviewed here are mainly the outcome of State-aided research.

In Sweden, the Government in 1890 offered ten thousand kroner (about 560*l.*) to the Royal Swedish Academy of Agriculture for an investigation on rust of wheat, &c., intended, at first, to extend over three years, but which has been continued up till now. The grant was placed under the control of Jakob Eriksson, now professor of vegetable physiology at the experimental station of Albano, near Stockholm. The experiments were started in 1890; the first important results of Eriksson and his co-worker, E. Henning, appeared in 1894 (*Zeitsch. f. Pflanzenkrankheiten*, iv. 1894, pp. 66, &c.), and as a bulky volume in 1896 ("Die Getreiderost," Stockholm, 1896; 463 pp. and 14 plates). Other contributions, and re-statements of former work, have been made by Eriksson in almost every existing botanical periodical. The present summary is based chiefly on the latest re-statement (*Revue gén. d. Sciences*, ii. January 15, 1900, pp. 30–39), with aid from other papers.[1]

In Eriksson's experiments test-plants of cereals were grown from seed, or young plants from the open were transferred into pots. The soil used was generally sterilised. After inoculation with rust the plants were watered with distilled water, placed under large glass bell-jars moistened with distilled water, and left undisturbed for twenty-four hours in glass-houses specially constructed for the experiments. After this, observations were made at frequent intervals. The main lines of investigation were: (1) to define the species which cause rusts of cereals and grasses, and to trace their life-history; (2) the propagation of the rusts; (3) germination and vitality of the various forms of spores.

According to Eriksson's results, the three species and one variety of rusts attacking cereals and grasses as recognised in 1890 really represent twelve species and many subdivisions. His list is as follows, but the less important host-plants amongst the grasses are omitted:—

Species 1. *Puccinia graminis*, Pers. (Black Rust), with *Aecidium berberidis*. Specialised form (1) *Secalis*, on *Secale cereale* (Rye), *Hordeum vulgare* (Barley), *H. jubatum*, *Triticum repens*, *T. caninum*, &c., *Elymus arenarius*, and *Bromus secalinus*. (2) *Avenae*, on *Avena sativa* (Oat), *A. elatior*, &c., *Dactylis*

[1] J. Eriksson: *Ber. d. deutsch. botan. Gess.*, 1894, p. 292; 1897, p. 183. *Jahrbuch f. wiss. Botanik*, xxix. 1896. *Botan. Centralblatt*, lxxii. 1897, pp. 321–5 and 354–62. *Centralblatt f. Bakter. u. Parasitenkunde*, Abt. ii. 1897, pp. 291–308.

glomerata, *Alopecurus pratensis*, &c. (see Fig. 1). (3) *Tritici*, on *Triticum vulgare* (Wheat). (4) *Airae*, on *Aira caespitosa*. (5) *Agrostis*, on *Agrostis stolonifera*, &c. (6) *Poae*, on *Poa compressa* and *P. caesia*.

2. *Pucc. Phlei-pratensis*, Er. et Hen., *Aecidium* unknown. On *Phleum pratense* and *Festuca elatior*.

3. *Pucc. glumarum* (Schm.), Er et Hen. (Yellow Rust), *Aecidium* unknown. Sp. form (1) *Tritici*, on Wheat (see Fig. 2). (2) *Secalis*, on Rye. (3) *Hordei*, on Barley. (4) *Elymi*, on *Elymus arenarius*. (5) *Agropyri*, on *Triticum repens*.

4. *Pucc. dispera*, Er. (Brown Rust of Rye), with *Aecidium Anchusae*. On Rye.

5. *Pucc. triticina*, Er. (Brown Rust of Wheat), *Aecidium* unknown. On Wheats—*Triticum vulgare*, *compactum*, *spelta*, and *dicoccum*.

6. *Pucc. bromina*, Er., *Aecidium* unknown. On many species of *Bromus*.

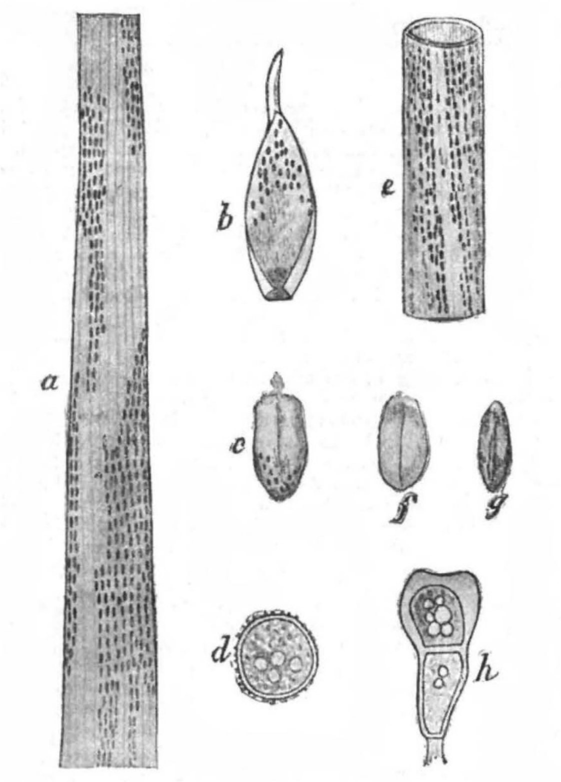

FIG. 2.—Yellow rust of wheat (*Puccinia glumarum*, spec. form *Tritici*), *a*, leaf (nat. size), *b*, outer glume (× 2), and *c*, a grain (× 2), bearing the *Uredo* stage; *d*, uredospore (× 375); *e*, sheath bearing *Puccinia* stage (× 2); *f*, a healthy grain, and *g*, a rusted grain (both × 2); *h*, teleutospore (× 500). (J. Eriksson.)

7. *Pucc. agropyrina*, Er., *Aecidium* unknown. On *Triticum repens*.

8. *Pucc. holcina*, Er., *Aecidium* unknown. On *Holcus lanatus*, and *H. mollis*.

9. *Pucc. Triseti*, Er., *Aecidium* unknown. On *Trisetum flavescens*.

10. *Pucc. simplex* (Kleb.), Er. et Hen., *Aecidium* unknown. On Barley.

11. *Pucc. coronifera*, Kleb., with *Aecidium Catharticae*. Sp. form (1) *Avenae*, on Oat. (2) *Alopecuri*, on *Alopecurus pratensis*, &c. (3) *Festucae*, on *Festuca elatior*. (4) *Lolii*, on *Lolium perenne*. (5) *Glyceriae*, on *Glyceria aquatica*. (6) *Holci*, on *Holcus lanatus* and *H. mollis*.

12. *Pucc. coronata* (Corda), Kleb. (Crown Rust), with *Aecidium Frangulae*. Sp. form (1) *Calamagrostis*, on *Calamagrostis arundinacea*, &c. (2) *Phalaridis*, on *Phalaris arundinacea*. (3) *Agrostis*, on *Agrostis stolonifera*, &c. (4) *Agropyri*, on *Triticum repens*. (5) *Holci*, on *Holcus lanatus* and *H. mollis*.

Comparing these species with those known in 1890, *Puccinia graminis* is now divided into Eriksson's 1 and 2; *Puccinia rubigo-vera* into species 3 to 9: the variety *simplex* is now the species 10; and *Puccinia coronata* is divided into 11 and 12.

The species are distinguished by characters of uredospore and teleutospore, and by the host-plants of the *Aecidium*, where known. A species may be subdivided into "specialised forms," which agree in all external characters with the species, but form (1) is tied to one or more species of host, and its uredospores will not infect the hosts of forms (2), (3), &c. Thus *Puccinia graminis* has a specialised form confined to wheat, one to oat, and a third which attacks both rye and barley. The occurrence of the *Aecidium* on the same host, *e.g.* that of *Puccinia graminis* on barberry, might seem to afford a stepping-stone between specialised forms; yet Eriksson says definitely that, for example, in the form *Avenae* "the form of *Aecidium* on barberry which gives black rust on oat can infect oat only." It may be mentioned that specialised forms are not peculiar to the rusts of *Gramineae*. Klebahn in a recent paper (H. Klebahn, "Ueber den gegenwärtigen Stand der Biologie der Rostpilze," *Botan. Zeitung*, 1898, pp. 145-58) gives a list of heterœcious fungi, which show subdivision into "biological species" or "species sorores," forms identical with or only slightly different from those indicated by Eriksson's term of specialised forms. Klebahn has also an interesting discussion on the nature of these forms of parasitic fungi, and joins issue with many of Eriksson's results.

Carleton (*loc. cit.*) carried out a long series of experiments for the United States Department of Agriculture. The procedure was almost identical with that of Eriksson, and the results generally support the Swedish observations. Carleton distinguishes the following species and forms on cereals:—

Orange leaf rust of wheat, *Puccinia rubigo-vera tritici*; identical, or almost so, with Eriksson's *Puccinia triticina*.

Orange leaf rust of rye, *P. rubigo-vera secalis*; either Eriksson's *P. glumarum secalis* or *P. dispersa*.

Crown rust of oats, *P. coronata*, Corda; Eriksson's *P. coronifera*, Kleb.

Black stem rust of wheat and barley; *P. graminis tritici*, Er. et Hen.

" " " rye, *P. graminis secalis*, Er. et Hen.

" " " oats, *P. graminis avenae*, Er. et Hen.

The American results differ from the Swedish in two important points:—

(1) Whereas *Puccinia glumarum tritici* is the most destructive rust throughout Europe, it does not seem to occur in America, where the common rust on wheat is *Puccinia rubigo-vera tritici*.

(2) The specialised form *Puccinia graminis tritici* in America appears to infect, not only wheat, but also barley; this is not the case in Sweden.

These differences indicate that the rust of wheat or other cereal in one country may not be the same as that in another; and that specialised forms are variable. Eriksson distinguishes degrees of specialisation and classifies the forms thus: (1*a*) Forms restricted to one species of host, or to several species of a genus, *e.g.* species 4, 8, and 1 (5) in the above list. (1*b*) Forms occurring on hosts belonging to different genera, *e.g.* species 1 (1) and 1 (2) in list.

(2) Forms, which, under certain conditions of environment, are less fixed in regard to their hosts; thus, until recently, Eriksson included species 4, 5, 6, 7 as forms of one species, *Puccinia dispersa*, and it is still doubtful whether they are distinct enough in their external characters to be regarded as species

Further experiments are necessary to clear up many points regarding the distribution of species of rust. Yet the practical bearing of the results is evident. For example, wheat cannot now be regarded as subject to infection from any cereal or grass showing rust, but only from those which are host-plants of the species or specialised forms peculiar to wheat; thus a comparison from the above lists shows that no rust from oats has been found to infect wheat. The theoretical bearing of biological species or forms in relation to the classification and phylogeny of fungi is also of the deepest interest.

The propagation of the rusts of cereals has, in the hands of recent investigators, assumed new aspects. The life-cycle of *Puccinia graminis* as defined by De Bary, and already given above, is the one generally described in text-books. Many observers, however, have doubted whether this, the perfect life-history, is always followed entirely. Strong objections of this kind are given by Worthington G. Smith (*loc. cit.*), although at the time (1884) these were raised, the imperfect knowledge regarding the species of rust-fungi somewhat weakens the arguments at the present time. Yet Eriksson, Carleton, and other recent workers show even greater opposition. We are told that rust is a serious epidemic amongst wheat in Australia where there are no native barberries; in India an undoubted black rust (*Puccinia graminis*) occurs on wheat where there are no barberries nearer than 300 miles off in the Himalayas. More conclusive is Eriksson's observation of aecidium-cups on a barberry, yet the rust could only be traced on rye, barley, and couch-grass to a distance from 10 to 25 metres; or, again, tufts of *Festuca elatior* were found with uredospores of *Puccinia coronifera*, while across a road there was a hedge of *Rhamnus* almost free from the aecidial stage, yet easily infected by means of teleutospores from the grass transferred to it by hand. These observations appear to show, firstly, that the aecidial stage is not necessary in the life-history of rust of cereals; secondly, that the range of infection by aecidiospores, or the reverse, is not great. What then remains is one of the following possibilities: (1) The mycelium can hibernate and resume activity in the following spring; (2) the fungus is carried over to a new season by the seed-grain, either through adherent spores, or in some form internally; (3) the uredospores can hibernate; (4) the teleutospores can infect other *Gramineae*. In reviewing these we can only give a few of the leading points relating to cereals.

It is unlikely that the mycelium hibernates in the dead remains of grasses, because it must then be capable of living as a saprophyte for a short time in spring when it awakens to activity; this has not yet been proved. If, however, one examines the undergrowth of an area of grass in winter, green shoots are generally present; the mycelium may winter here. Yet grain-crops are never sown except on ploughed land, and there is no good evidence to show that epidemics of rust, extending over whole acres, are propagated altogether from patches of wild grass. Uredospores adhere to the grain of rusted cereals, and there is a fair amount of evidence to show that these may assist the fungus through the winter. In the United States, Carleton believes that the uredospores of the orange leaf rust of wheat and rye are produced and can germinate late in the autumn, and so infect the sprouted autumn-sown crop for next year. Eriksson, on the other hand, has failed to discover that any one of the rusts of wheat lives all round the year in the *Uredo* stage in Sweden, although Sorauer states that in Germany the *Uredo* mycelium of *Puccinia rubigo-vera* hibernates without injury. There is thus a possibility that the uredospore stage may transmit a rust from year to year. This is more probable if the climate be suited to prolong the growth of grasses late into autumn or early winter, and if the specialised form of rust has more than one host-plant; if it occurs only on one cereal, it seems improbable that enough stray plants are present after harvest to account for a widespread re-appearance of rust in the succeeding year. Whether uredospores adhering to straw or grain can survive the winter and germinate has not yet been made quite clear. In laboratory experiments it has been observed that uredospores frequently exhibit deferred germination. After being soaked in water, only a small percentage may produce germ-tubes. Eriksson and others have observed that if the dormant spores are cooled in ice, a further proportion are induced to germinate. Klebahn states that the greater number of all forms of spore germinate if placed on a suitable host-plant; he believes that the proportion which do not germinate at once, do so gradually later on, and sees in this an adaptation for preservation of the race.

The teleutospores of the rusts of cereals have, as a rule, proved incapable of infecting cereals or grases, the aecidium stage must intervene. There is, however, the objection that observations can only be made under more or less artificial conditions in laboratory or green-house, and may not fulfil all the conditions of infection out-of-doors. Plowright recorded an instance of infection of cereals from the teleutospores of *Puccinia graminis* (*Gardeners' Chronicle*, August 19, 1882), but gives no special prominence to it in his "British Uredineæ" (1889). Indirectly certain facts lead one to suppose that teleutospores may have the power to reproduce other stages in the life-history than the aecidium. A rust-fungus of the group *Leptopuccinia* (e.g. *Puccinia malvacearum* on mallow and hollyhock) produces only teleutospores; these give rise to sporidia, which re-infect the mallow, and form the mycelium from which a new crop of teleutospores arises. Many forms of rust-fungi have only teleutospores and uredospores on the same host: for instance, in Eriksson's list many of the forms have no *Aecidium*; either the hosts of this stage remain to be discovered, or the teleutospore production is fruitless, or the teleutospores are capable of bringing about infection of the cereal or grass host. Species like *Puccinia suaveolens* on thistles have all the forms of spore on one host-plant except aecidiospores, which are unknown; here the teleutospores must, after hibernation, bring about re-infection of the host. The existence of rust-fungi producing all the forms of spore on one host, shows that two hosts are not necessary for the development of the aecidium stage, and suggests that heterœcism may be a later development in the history of the group. It is also noteworthy that the teleutospore is produced by all rust-fungi, with very few exceptions. It is therefore not improbable that the teleutospores of heterœcious rust-fungi may still, through their sporidia, retain the power of infecting the host on which they are produced; in other words, that heterœcism may be facultative.

In investigating the germinative power of teleutospores, Eriksson finds the general opinion, that teleutospores must hibernate, to be true only to a certain degree. As a rule, they do not germinate unless they have passed the winter exposed to all the changes of weather out-of-doors. Spores collected in autumn and kept indoors soon lose the power of germination; hence his conclusion that rusted straw housed in barns will not be in a condition to propagate the disease next spring. In the case of spores left out-of-doors, the germinative power decreases rapidly during the year after their formation, and in October they no longer germinate. There is one exception, teleutospores of *Puccinia graminis tritici* have a feeble power of germination after two winters. On the other hand, Eriksson finds that certain teleutospores (e.g. *Puccinia dispersa* and *P. glumarum tritici*) can germinate in the year of their formation; in the case of the former species, aecidia were produced on *Anchusa* in a short time; in the latter form the host of the aecidia is unknown. Plowright states that a bundle of rusted wheat straw laid near plants of *Anchusa* in August 1885 produced aecidia in September.

Eriksson, after all his experiments, professes to be at a loss to account for epidemics of rust on cereals year after year by external contagion alone, and he adopts the view that *infection is due to an internal germ.* He thus introduces an agent for the propagation of parasitic fungi which has hitherto been received very sceptically by the plant-pathologist. His conclusion is the result both of experiment and examination with the microscope. In the experiments, varieties of cereals were used which are known to be specially liable to rust. Vigorous shoots were taken out-of-doors in spring, and enclosed in long glass tubes with the open ends closed with cotton wool. Seeds were also germinated in sterilised soil and kept in culture boxes, with precautions against entrance of spores by stuffing the ventilators with cotton wool. At first the results were negative, but after (in some way) improving the methods, the test-plants showed rust, especially those shoots taken from out-of-doors. Examination with the microscope failed to reveal any mycelium or other traces of the fungus until a few days before appearance of the rust externally. At this time, however, with the aid of staining reagents, certain protoplasmic bodies were observed in the green cells near the margin of a rust-patch. These plastids occur solitary or in masses in a cell; they are oblong or slightly curved, simple or somewhat branched, and recall the form of bacteroids found in root-tubercles of the *Leguminosae*. In a short time the branch-processes pierce the cell-wall of the host, and develop outside the cell into an intercellular mycelium, part of the original plastid remaining inside the cell as the first haustorium or sucker. Soon after this a rust-pustule appears on the exterior of the host. The plastid is regarded as having passed a period mingled with the cytoplasm of the host "in a kind of symbiosis," till in response to external conditions—nutrition, moisture, heat and light—the "mycoplasm" becomes separated from the cytoplasm, and assumes the form of a plastid. The mycoplasm has its origin from the rust-fungus in the parent host-plant, it becomes located in the embryo of the grain, develops apace with the young plant, and so bridges the period between one crop and the next. The following general facts are said to support this mycoplasm theory: (1) The appearance of rust on plants carefully isolated from contagion; (2) the disease in a field appears regularly four to five weeks after sowing the grain of certain varieties of wheat and barley known to be very liable to yellow rust; (3) this rust is always more prevalent in sunny parts of the field.

A hypothesis so revolutionary is not likely to be adopted by a cautious fungologist without further evidence. At present, as far as we know, no figures illustrating the development of the mycelium have been published, nor can we obtain details of the staining methods adopted. Klebahn (*loc. cit.*) has entered his protest to the theory, chiefly, however, in general terms. In regard to the prevalence of rust in sunny parts of a field, he points out that Eriksson's own results confirm the fact that dormant spores are induced to germinate by alternate cooling and heating, drought and moisture; just the conditions to be expected in early summer in sunny parts rather than in shaded parts of a field. Klebahn also supports the view that spores of rusts are capable of wider distribution than Eriksson's results show; for instance, they have been found in analyses of air. We may recall, in support of this, Robert Hartig's observation in the Tyrol, when, after showers of rain, a yellow dust, coating objects in the neighbourhood, was found to consist almost entirely of the yellow spores of a rust-fungus, *Chrysomyxa* ("Diseases of Plants," Tubeuf and Smith, London, 1897, p. 54). If it be the case, as Eriksson says, that certain rusts of cereals appear regularly in four or five weeks, it seems quite as likely to indicate external infection of young plants at a certain stage in their existence, as to support the theory of an internal germ. The Swedish experiments in isolating test-plants from contagion have been repeated in America by Bolley.[1] Young plants of cereals growing amongst others in a field were enclosed in rust-proof cases; they grew to maturity without showing any rust, although plants left unenclosed were much attacked. The results are quite negative.

Recent investigations have been directed towards advancing our knowledge regarding the varieties of cereals suited to resist the various forms of rust. Carleton,[2] whose work was aimed in this direction, summarises our general knowledge thus: "as yet there is but little certainty concerning rust resistance, which varies continually under different conditions. Heretofore, in testing varieties for rust resistance, little attention has been paid to the species of rust concerned." For our own part, we feel that our ability in combating the diseases of plants would be greatly strengthened by searching investigations towards attaining disease-proof varieties. A certain amount has been done, much more must yet be done. The results hold good for only small areas of the earth, and there must be thorough and systematic research in many countries before any definite conclusion be arrived at. From a practical point of view the combating of rusts of cereals, and diseases of plants generally, seems likely to be solved sooner in this way than by investigations on the complex conditions of life amongst the rust-fungi. One cannot but feel that the long recent researches have added to what we knew only minor details of practical importance, although they have opened new vistas of the deepest interest to the fungologist; the outstanding lesson is the close dependence of the fungi on their environment, and the complexity thereby introduced into the study of diseases of plants.

WILLIAM G. SMITH.

MEDICINE AS A SCIENCE AND MEDICINE AS AN ART.[3]

IT has sometimes been disputed whether medicine should be regarded as a science or an art, but there is no doubt that the original meaning of the term medicine, in English and in other languages, is the Art of Healing. Medicine is so defined by Aristotle, and it has all the characters of an art. It depends upon experience and skill; it deals with individual cases; and the perfection it aims at is practical, not speculative: the knowledge how to do, not the knowledge how things happen.

Nevertheless, as practical navigation is founded on astronomy, meteorology and physics; as the art of agriculture rests on botany, geology and vegetable physiology, so the art of medicine depends on the science of pathology, the practice of physic on the principles of physic.

On the one hand, then, we must never forget that we practice an art; we must never allow theories, or even what appears to be logical deduction, or explanations, however ingenious, or statistics, however apparently conclusive, or authority, however venerable, to take the place of the one touchstone of practical medicine, observation and experience. We must never treat the disease without considering the patient, for the art of healing is the art of healing individually; nor need we wonder if profound learning and the best scientific training sometimes fail to make a successful practitioner. For beside adequate knowledge to save us from gross blunders, and a strenuous endeavour to do your best for each individual patient, however uninteresting the case or however irksome and unrewarded our toil—beside these first requisites for our art, there is ample room for those personal qualities which ensure success in every department of life; for power of observation and insight, for the personal influence by which a strong character will secure obedience and inspire hope, for the judgment which divines what kind of remedies are suited to each patient, what kind and of what strength, and for the sympathy which puts one in the patient's place, and not only meets, but anticipates his wants.

On the other hand, however, if medical science without art is inefficient, medical art without science is not only unprogressive, but almost inevitably becomes quackery. As soon as we treat our patients by rule of thumb, by tradition, by dogmas, or by metaphysical axioms, we do injury to ourselves as well as to them. The bone-setter who is ignorant of anatomy; the wise woman, who cures by charm, are not more irrational or less successful than was the physician of the seventeenth century who, in obedience to the doctrine of signatures, advised an infusion of roses for hæmorrhage, and saffron for jaundice. and lung-wort for consumption; or the astrologer who prescribed salts of silver, of iron, copper, lead, or mercury in accordance with the horoscope of the patient and the planet under which he was born.[1] Not less mischievous, and in the true sense of the word unscientific, were the systems of medicine known as the Iatromechanical and the Iatrochemical, which in their turn had their vogue. The Brunonian system, explaining all diseases as due to laxity of fibre, was no better; for indiscriminate use of "corroborants," or as they would now be called "tonics," is irrational. There is no such thing as a tonic or strengthening medicine, the only source of strength is oxidisable food, and bitter medicines only give strength indirectly by improving appetite. The last of the systems of medicine founded on a dogma is homœopathy, of which the theoretical absurdity is somewhat concealed by the more obvious nonsense of infinitesimal doses. It, like the other systems which preceded it, is not a rival to rational medicine; they are not mistaken answers to a legitimate question, but attempted solutions of a problem which does not exist, attempted answers to a riddle which has none.

Apart from these exploded systems of treatment, our profession has often suffered from lack of the scientific, inquiring, sceptical spirit, and has often been led too easily by authority, by tradition, and by fashion. The reckless abuse of venesection in the last century and the former half of this led to almost complete disuse of a valuable means of treatment; the misuse of mercury in the treatment of syphilis led to the denial of its unquestionable efficacy; have we not seen the value of stimulants with fever lead to their indiscriminate use in almost every ailment? Has not the immense value of careful and thorough nursing led to its absurd exaltation to an independent place, as if good nursing was anything more than an intelligent carrying out of the physician's directions? Has not the remarkable powers of electrical stimuli led to a blind, unscientific and mischievous employment of this remedy, as if it had some mystic power apart from its demonstrable physiological effects? May we not say the same of hydropathy, of massage and of hypnotism? It is significant that the irrational exaltation of any of these particular modes of treatment into a panacea, while it begins in want of scientific intelligence invariably ends in imposture and deceit. Our only safeguard against the spirit of quackery and the deserved loss of public confidence in the

[1] *Centralblatt f. Bakt. u. Parasitenkunde*, Abt. II., vol. iv., 1898, pp. 855–9, 889–96, 913–9 (6 figs.). Also *Proc.* Amer. Ass. Adv. Science, 1898, p. 408 (the limits of this paper prevent a longer reference to this research).

[2] *Loc. cit.*, p. 69.

[3] Abstract of the Address in Medicine delivered before the British Medical Association at Ipswich, on August 1, by Dr. P. H. Pye-Smith, F.R.S.

[1]

☉	☽	♂	☿	♃	♀	♄
Sol	Luna	Mars	Mecurius	Jupiter	Venus	Saturnus
Au	Ag	Fe	Hg	Sn	Cu	Pb
Sunday	Mon-day	Mardi	Mercredi	Thors-day	Vendredi	Saturday

These relations of metals to the planets, and also to the days of the week, are commemorated in the phrases:—*lunar* caustic, *martial* disposition, *mercurial* temperament, ℞ before a prescription, *Cuprum a Cypro* (*divapoteus Cypri*) and *saturnim* gout.