tween 1828 and 1845, during which period 1,373,091 three-ruble pieces were minted, besides a few six-ruble and 12-ruble pieces. The three-ruble piece was worth $2.33 and it weighed 10.3 grams, for platinum was then worth but $7 an ounce; with platinum at $165 an ounce, the intrinsic value of such a coin to-day would be more than $54 of our money.

In view of the fact that the platinum output continues to be much smaller than some years ago, while the increasing demand for jewelry purposes offsets the falling off in the demand for munitions processes, it appears likely that the price will continue to go up, at least until the full resumption of platinum mining in Russia serves as a check. The search for the discovery of new sources is being diligently prosecuted, and Colombia seems the most hopeful of all the regions except Russia.

The newspaper notoriety given to platinum, because of the great legitimate demand for it and the consequent astonishing rise in value, before long excited the cupidity of dishonest persons. As a consequence of this there have been numerous thefts of the material. In several cases, valuable specimens of platinum have been purloined from museum collections, and chemical utensils made of platinum have been stolen from a number of chemical laboratories. Indeed, in one instance an entire university laboratory was burned down to hide the theft of platinum.

As to future prospects, an extensive development of the platinum resources in the republic of Colombia is in active progress. Possibly Canada may contribute somewhat with improved methods of refining the copper-nickel ores, and similar ores mined elsewhere may also furnish considerable platinum. However, the most encouraging sign is the reported determination of Soviet Russia to issue platinum certificates, that is to say, certificates secured by the platinum stock that has been accumulated in Russia and has not fallen into the hands of the Allies, or will be loaned now and in the future.

GEORGE F. KUNZ

SEXUALITY IN MUCORS. II

"NEUTRAL" RACES

As regards the intensity of sexual reaction, however, a gradation is clearly shown. A more detailed view of the complete table showing the combinations only where reactions might be expected, can be seen more clearly (Table I.). The higher grades of A and B predominate at the upper left-hand corner while at the opposite corner are only O's with C's and D's between. There is therefore in this species, varying degrees of sexual activity from the strongest down through the weakest to so-called "neutrals" which fail to show any sexual reaction under the conditions of the experiment. The word "neutral" is obviously only a relative term since, if the two races Nos. 811 and 367 had not been used as testers, No. 370 would have been classed as a neutral. It is possible that the 3 so-called neutrals would have taken part in zygospore formation if strong enough testers of the proper sex had been available or if more favorable environmental factors had been present. The fewer the number of tests made and the more unfavorable the environmental conditions, the larger will be the number of races listed as neutral from any collection of races of a given species.

A change in sexual activity tending toward neutrality may be brought about by environmental factors. Thus we have obtained a temporarily neutral condition in both the plus and minus races of *Mucor Mucedo* by growing them for several non-sexual generations at unfavorably high temperatures. The sexual activity can be regained in a few generations by cultivating them at low temperatures. In the same species the spores in a germ sporangium frequently are neutral in reaction but later become sexually active. One of my most active forms (*Mucor* V.) has become much reduced in sexual activity since its opposite races were first separated some sixteen years ago. A similar reduction in sexual vigor resulting in neutrality has been reported in a number of species by other investigators. In *Phycomyces* the plus and minus spores in a germ sporan-

TABLE I

"Dark" Absidia

← Grade		Grade →	2.55	2.39	2.33	2.06	2.06	1.78	1.61	1.56	1.56	1.50	1.44	1.44	1.39	1.33	1.33	1.33	1.28	1.00	0.11	0.00	0.00	0.00
			Plus (+) Strains																			Neutral Strains		
			369	203	345	359	366	348	202	347	353	716	350	364	201	351	356	357	355	714	370	354	360	368
2.53	Minus (−) Strains	571	B	A	B	C	B	A	C	B	B	C	B	C	B	B	C	C	C	C	O	O	O	O
2.21		713	C	B	A	B	C	B	C	C	C	B	C	C	C	C	C	C	C	C	O	O	O	O
2.16		811	B	B	B	C	B	C	C	C	C	B	D	C	C	C	C	C	C	C	D	O	O	O
2.10		365	A	A	B	B	A	A	C	C	C	C	C	C	D	D	C	D	O	D	O	O	O	O
2.10		711	A	B	C	B	C	C	C	C	C	C	C	C	C	C	C	C	C	C	O	O	O	O
2.05		362	B	C	B	C	C	C	C	C	C	C	C	C	B	C	C	C	C	C	O	O	O	O
1.84		349	C	D	B	C	C	C	C	C	C	B	C	C	D	C	C	C	C	D	O	O	O	O
1.84		352	B	C	C	C	C	C	C	C	C	C	C	D	D	C	C	C	C	C	O	O	O	O
1.68		363	B	B	B	D	C	C	C	C	O	C	O	C	C	O	C	C	C	C	O	O	O	O
1.58		572	B	B	C	C	C	C	C	C	C	C	D	D	C	O	D	D	C	O	O	O	O	O
1.58		715	C	C	B	C	C	C	C	D	C	O	C	C	C	C	D	C	D	O	O	O	O	O
1.42		346	B	C	D	A	C	D	C	D	C	O	C	D	D	D	C	D	D	O	O	O	O	O
1.42		367	C	C	C	D	C	D	D	C	D	C	D	D	D	D	D	C	C	D	D	O	O	O
1.42		712	B	C	C	B	C	C	D	D	D	O	D	C	D	C	D	D	D	D	O	O	O	O
1.11		371	C	C	C	D	D	D	C	D	C	D	C	D	D	D	O	O	O	O	O	O	O	O
0.68		358	D	C	D	D	C	O	D	D	D	D	D	D	O	O	O	O	O	O	O	O	O	O
0.53		717	C	C	D	C	C	O	O	O	O	O	O	O	O	D	O	O	O	O	O	O	O	O
0.26		638	D	D	C	D	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
0.00	Neutral Strains	354	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O
0.00		360	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O
0.00		368	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	

gium may produce mycelia, neutral toward each other, though reacting with the plus and minus parent stocks. Here again the neutrality or self-sterility is only temporary, since after a few spore generations their ability to take part in active zygospore formation *inter se* is completely established.

In nature the number of neutral strains appears to be large and many species have been studied, the races of which have never been induced to react, either *inter se* or with strong testers of other species. There is no evidence that even in these cases, the neutrality is absolute and the races completely devoid of sexual tendencies. Their apparent neutrality may mean merely that we have not yet happened to expose these forms to the peculiar environmental conditions necessary for an expression of the sex which is actually present.

SEXUAL DIMORPHISM

Similar tabulations of the sexual reactions between their races have been made for several species beside the "dark" Absidia and with similar results (Table II). All the races which were able to assist in zygospore formation appear to be sexually dimorphic, consistently either plus or minus. A few investigators have believed they have found evidence in certain species that would militate against sexual dimorphism in the diecious mucors. In a specific instance (8), however, where it was possible to retest the material upon which such conclusions were based, it was found that the dimorphism was in fact present but, for

TABLE II

SUMMARY, DECEMBER 19, 1919

	No. Locations Represented	No. Gross Cultures	No. Races	No. Combinations Possible $\left[c = \frac{n(n-1)}{2}\right]$	No. Testers Used	No. Combinations Made	Plus (+)	Neutral (N)*	Minus (−)
Absidia cærulea	3	12	22	231	22	*231	4	5	13
A. glauca	5	5	10	45	10	*45	4	0	6
A. sp. (whorled)	11	15	34	561	34	*561	14	2	18
A. sp. (dark)	13	26	40	780	40	*780	19	3	18
Phycomyces			15	105	15	*105	11	3	1
Cunninghamella bertholettiae	18	36	92	4,186	14	1,183	13	8	71
C. elegans	1	16	42	861	12	426	25	1	16
C. echinulata	14	25	72	2,556	2	141	9	55	8
Syncephalastrum	18	35	80	3,160	18	1,269	37	4	39
Circinella spinosa	13	28	54	1,431	4	206	36	5	13
Rhizopus			236	27,730	20	1,574	89	85	62
Choanephora cucurbitarum	2	19	33	528	10	275	5	0	28
Total			730	42,174	201	6,796	266	171	293
Mated strains not listed above			34		4	102	16	0	18
Unmated strains			248		4	511	51	108	89
Total additions			282		8	613	67	108	107
Total			1,012		209	7,409	333	279	400
Zygospore Germinations									
Mucor Mucedo			512		514	1,280	46	432	34
Phycomyces			392		394	980	258	16	118
Zyg. Germ. totals			904		908	2,260	304	448	152
Grand totals			1,916		1,117	9,669	637	727	552

* All possible combinations made.

various reasons, has been misinterpreted by the investigator.

Burger, in a recent paper (11) concludes that sexual dimorphism does not exist in the mucor genus *Cunninghamella*. He reports finding certain races, among 25 or 26 of *C. bertholettiæ* studied, which will form zygospores with both plus and minus races. In other words a race A will conjugate with race B, B conjugates with C and C conjugates with A, and the family triangle is complete. In personal conversation, Dr. Burger has told me that he has found a similar condition in *Syncephalastrum*. It is not appropriate at the present time to enter into a discussion of Burger's paper. It will be sufficient to say that we have used some of the same strains that he worked with and, except for infections in an early series of contrasts before we discovered the great danger in *Cunninghamella* of contamination of a culture with spores of the opposite sex, we have never had results at all comparable with his. The negative results obtained by us do not, of course, prove that sex intergrades or hermaphrodites never occur in diecious species. He would be a rash philosopher who would deny to any protoplasm the possibility of reacting in an unexpected manner. They do indicate, we believe, that the occurrence of such sexual conditions must be, at best, a rare phenomenon. In view of the work tabulated in the accompanying table, it seems wisest therefore, to leave out of discussion, for the present, unconfirmed conflicting conclusions which are based on relatively meager material.

In the first 5 species of the table (those marked with a star) all the possible combina-

tions have been made. For the others it would obviously have been too enormous a task to have been profitable. The races from zygospore germinations have been added as being likely to show through segregation sexual abnormalities if such existed. Nearly 10,000 combinations have been made using nearly 2,000 different races of diverse types of mucors and no race of a diecious species has been found which, if it showed any sexuality at all, reacted other than as a plus or a minus.

We have just been discussing *intra*-specific sexual reactions. The next table shows *inter*-specific reactions previously discussed under the term "imperfect hybridization." In testing the reactions between the plus and minus races of two different species, all the four possible interspecific combinations have been made but, since the combinations between races with like signs have never given reactions, they have been omitted from the table. Only a part of the possible combinations have yet been tested, but sufficient to indicate that the same sexual dimorphism exists in all the species investigated.

We feel justified in concluding from our experience, that the forms in the tables are sexually dimorphic. From our experience with the diecious sporophytes of willows and poplars, such a strict dimorphism was hardly to have been expected. It would be a safe wager that one could not examine even a hundred individuals of either of these genera without finding sex intergrades. The apparent sharper differentiation of sex in the diecious mucors in comparison with higher plants is perhaps connected with the fact that in mucors we are dealing with sexually differentiated gametophytes instead of with sporophytes.

GAMETE DIFFERENTIATION

I should like to close our discussion by a consideration of gamete differentiation in mucors and other forms. As a general rule, all of the diecious mucors represented at the top of the chart (Fig. 4) have gametes equal in size. Of the hermaphrodites there are two types—those with equal gametes (isogamic), figure below, and those with a constant and marked difference in size (heterogamic), figures at right and left. We can conceive of the hermaphrodites as having been derived from the diecious types or the diecious types from the hermaphrodites. If the latter be the actual course of evolution, we may conceive a differentiation of sex to have taken place in two directions beginning with the isogamic hermaphrodites—first toward a differentiation, chiefly physiological, separating the sexes on separate plus and minus individuals in diecious forms; second toward a differentiation, conspicuously morphological, bringing about a constant difference in the size of the gametes in the heterogamic hermaphrodites. The prevalent biological distinction between males and females is based ultimately upon the relative size of the gametes which they produce. The smaller gamete is considered the male; the larger recognized in the left figure by the outgrowths behind it, is considered the female. The diagram (6) shows the reactions obtained in attempting, by use of this criterion of sex, to homologize the plus and minus signs with the terms male and female or vice versa. The hermaphrodite, which is heterogamic, is grown between the plus and minus races of *Mucor* V. On the right its smaller gamete reacts with the plus

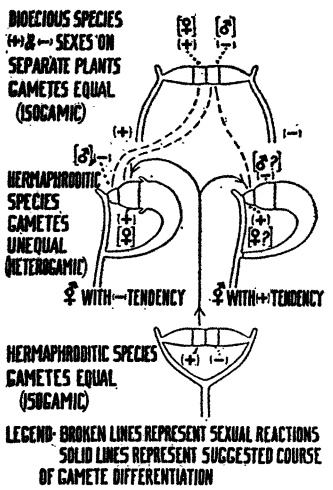

FIG. 4. Diagram illustrating sexual reactions and gamete differentiation.

race and on the left its larger gamete reacts, though but weakly, with the minus race. The smaller gamete is therefore minus and the larger plus. On the assumption that the smaller gamete is male and the larger female, the minus race must be considered male and the plus race female.

In our previous diagram (Figure 4) we recognize on the left the heterogamic species (*Absidia spinosa*) just discussed, by the outgrowths back of the larger gamete. That heterogamy has actually been derived from isogamy in this species is rendered probable by Lendner's report (12) of finding a race of the same species with equal gametes. The broken lines, connecting the unequal gametes on the left with the plus and minus diecious species above, represent the reactions which have taken place and indicate that the larger gamete is plus and the smaller gamete, minus. The isogamic hermaphroditic species below also reacts with the diecious form above and hence its gametes also may be labelled plus and minus. The plus gamete of the lower isogamic species may be considered, in the process of evolution, to have given rise to the larger gamete of the left-hand figure as indicated by the solid line. This is an orthodox interpretation and consistent with the facts so far discovered for this species. There are some facts, however, which indicate that such is not the necessary course of evolutionary development in all forms.

It has been shown that although the plus race is perhaps usually more vigorous than the minus, this condition is sometimes reversed. Some hermaphrodites have predominatingly plus and some predominatingly minus tendencies. Is there any intrinsic reason why, of two equal gametes, the plus should invariably become the larger in the process of size differentiation? I do not believe that there is. If not, we should expect to find forms like the one figured on the right where the plus gamete is represented as having given rise to the smaller of the heterogamic pair. In *Zygorhynchus heterogamus,* we have perhaps such an example. The evidence is not entirely conclusive since we have obtained reactions as yet only with one of the paired test races and the larger suspensor fails to show outgrowths which might help in distinguishing the unequal gametes when reacting with other forms. However, the appearance of the reactions between the right-hand figure and the minus race resembles that between the left-hand figure and the plus race. The figure on the left has a minus tendency, the same as its smaller gamete while the figure on the right has a plus tendency also the same apparently as its smaller gamete. No one realizes more strongly than the speaker that the specific case under discussion is in need of more thorough investigation. Whether or not my suggested interpretation of the right-hand figure proves to be the correct one, it will serve to call attention to the fact that those who define male and female in terms of size differentiation in the sex cells are making the gratuitous assumption that quantitative differences in the gametes are the fundamental peculiarities of the two sexes. I have used from preference, therefore, the terms plus and minus because I have wished to speak in terms of the physiological differentiation into sexually dimorphic races established in diecious species rather than in terms of male and female which are defined by differentiation in size of gametes and which conceivably may be secondary sex characters.

I trust it will be granted that there is something fundamental, common to all the plus races that causes them to react sexually with minus races in the same or in different species and that this same fundamental something is present also in hermaphroditic forms whether possessed of equal or of unequal gametes. Dr. Gortner and I some years ago started an investigation based upon the assumption that the fundamental differences between the sexes might possibly be bound up with differences in sex proteins. The work was unfortunately interrupted before a definite conclusion could be reached with the delicate blood reactions employed. If we are able to imagine some fundamental biochemical constitution such as a sex protein, common to all the plus proto-

plasms in the mucors, we may be able to spur our imagination still further to conceive of this same constitution as existing in one of the two sexes in all organic forms. It might then be theoretically possible by proper technique to obtain reactions with our isogamic plus and minus races of the mucors and thus have males and females in different groups of plants and animals compared on a common and fundamental basis. If this highly imaginative proceedure were possible, is there any reason to believe that the so-called males in all groups of plants and animals would invariably be related to the same sex—plus or minus of the mucors? It might transpire that the so-called females of the moths and birds, to take an extreme example, would be found by their reactions with test mucors to bear the same sign—plus or minus—as the males of flies and mammals.

Sex has apparently developed independently many times in different groups of plants and animals. The term male and female are applied to the end products seen in visibly dimorphic gametes. There is no assurance that these terms have laid hold of the fundamental differences between the two sexes. Spines, superficially similar, are developed on the porcupine, jimsonweed and sea urchin, yet these have no close genetic relationship to one another. They are examples of parallel development in unrelated structures—in other words they are to be considered analogous rather than homologous organs. Is it not possible that visible differences in dimorphic gametes are also analogous rather than homologous; that the sperm in one form may be homologous to the egg in another form? It is suggestive in this connection that the males of mammals have this in common with the females of birds—that they produce two kinds of gametes. Moreover, it is the sex glands of the male of mammals and of the female of birds which form hormones influencing profoundly the expression of the secondary sex characters, albeit in a somewhat different manner. I do not suggest that in starting with human terminology, as we generally have done in describing lower organisms, we should call the rooster a female and the hen a male. I wish merely to call attention to inadequately explained sexual phenomena in higher forms in which similarities in the gross morphological differentiation of the so-called male gametes of two forms are not associated with certain physiological peculiarities which are common rather to the opposite sexes.

It seems reasonable to consider in mucors the physiological sexual differentiation into plus and minus races, more expressive of any fundamental peculiarities of sex, if such actually exist, than the size differences and associated phenomena in higher forms. Sperm cells, in addition to being gametes, are organs of locomotion and the egg cells, in addition to being gametes, are storage cells to supply nourishment to the developing zygote. Motility in the sperm and storage in the egg we can conceive of as secondary rather than primary sex characters. It is not alone the gametes of higher forms in which we find differences associated with the diverse functions of bringing the gametes together and nourishing the zygote formed by their union, but also the two sexual organisms themselves may have their sexual differences related directly or indirectly to these same somewhat conflicting functions.

The diecious mucors seem largely free from such secondary sexual characters which may tend to obscure more fundamental sexual differences. Their gametes are normally equal in size and nourishment for the developing zygote is supplied approximately in equal amounts from both sexes. Moreover, in those few forms in which the conjugative filaments seem to exercise attraction toward each other, such attractions seem to be mutual and equal.

It would carry us too far to attempt to meet the objections of cytologists or of others to our hypothesis of gamete differentiation or to attempt to show in what other ways the sexual differentiation in mucors may be of interest to students of higher forms. We will be satisfied, however, if we have shown that the simple bread mold may eventually be of some service in helping to solve the funda-

mental problems of sex, for we believe that many of these problems are to be solved only with the structurally simpler forms of life like the mucors.

ALBERT F. BLAKESLEE
CARNEGIE STATION FOR
EXPERIMENTAL EVOLUTION

BIBLIOGRAPHY

1. Blakeslee, A. F. '04. Sexual Reproduction in the Mucorineæ. *Proc. Am. Acad.*, 40: 205–319.
2 ———. '06a. Zygospore Germinations in the Mucorineæ. *Annales Mycol.*, 4: 1–28.
3. ———. '06b. Zygospores and Sexual Strains in the Bread Mold. SCIENCE, N. S., 24: 118–122.
4. ———. '07. The Nature and Significance of Sexual Differentiation in Plants. SCIENCE, N. S., 25: 366–371.
5. ———. '09. Papers on Mucors. *Bot. Gaz.*, 47: 418–423.
6. ———. '13. A Possible Means of Identifying the Sex of (+) and (—) Races in the Mucors. SCIENCE, N. S., 37: 880–881.
7. ———. '15. Sexual Reactions between Hermaphroditic and Diecious Mucors. *Biol. Bull.*, 29: 87–103.
8. ———. '07. Heterothallism in Bread Mold. *Bot. Gaz.*, 43: 415–418.
9. Baur, E., Jahn, E., Blakeslee, A. F. and Guilliermond, A. '07. Tabulæ Botanicæ, Mucorineæ, Tafel VI. and VII., Gebr. Borntraeger.
10. Burgeff, H. '14–'15. Untersuchungen ueber Variabilitaet, Sexualitaet u. Erblichkeit bei Phycomyces. I. Teil Flora N. F. 7: 259–316; II. Teil Flora N. F. 8: 353–448.
11. Burger, Owen F. '19. Sexuality in *Cunninghamella*. *Bot. Gaz.*, 68: 134–146.
12. Lendner, A. '10. Observations sur les Zygospores des Mucorinées. *Bull. Soc. bot. Genev.*, 2: 58.
13. Saito, Kendo und Naganishi, Hirosuke. '15. Bemerkungen zur Kreuzung zwischen verschiedenen Mucor-Arten. *The Botanical Magazine*, Tokio, 29: 149–154.

SCIENTIFIC EVENTS

THE DIVISION OF STATES RELATIONS OF THE NATIONAL RESEARCH COUNCIL

A STATEMENT concerning the work of the division has been issued by the council, in which the chairman, Professor John C. Merriam, of the University of California, writes:

The Division of States Relations is organized with special reference to the consideration of research interests related to organization of the states as political and economic units. In our commonwealth the state presents an important form of organization for the development of certain aspects of science. The function of science in such a unit is to direct the conservative use of the state's natural resources, to increase productivity, to improve sanitation, and in other ways to promote prosperity and the public welfare. The purposes of this division may be stated in simplest form as follows:

1. To obtain information as to the most effective types of organization for groups of departments concerned with research within state governments.

2. To become acquainted with the best methods of cooperation among the institutions within the state—educational, commercial and industrial—which are concerned with scientific research.

3. To study the wider outside relations of research in state organizations, including the contracts with activities of other states and with national agencies of the country.

However, much information upon the present situation is needed before steps can be suggested for the closer coordination of state scientific agencies. The division is, therefore, undertaking a study of the present relationships of the various scientific agencies in the government of a number of the states. Several systems for the organization of state scientific departments are in operation, some, presumably, with better effect than others. Relations have been variously developed between these state departments and the scientific groups in state educational institutions. The relation between research work in many state departments and the work of enforcing the regulations based upon scientific investigation has attracted attention from the point of view both of science and of political economy. Moreover, determination of the most satisfactory forms for central bodies which may be used to organize scientific effort within states, and of the auspices under which such bodies should act will require much careful study. The nature of the state organization must be adapted to the particular situation found in the state in which it may seem desirable to organize such a body. It is believed that careful review of present conditions and of means for improving them is warranted by the possible gains in the