G/H is locally shrinkable. This shows that G/H cannot have small finite groups and this contradiction proves the theorem.

[1] Gleason, "The Structure of Locally Compact Groups," *Duke Math. Journal*, **18**, 85–104 (1951) and Iwasawa, "On Some Types of Topological Groups," *Ann. Math.*, **50**, 507–557 (1949). The definition of Gleason's generalized Lie groups is more general than that of Iwasawa's L-groups but the difference is not great.

[2] Goto, "On Local Lie Groups in a Locally Compact Group," *Ann. Math.*, **54**, 94–95 (1951).

[3] Montgomery, "Connected One-Dimensional Groups," *Ibid.*, **49**, 110–117 (1948).

[4] Montgomery and Zippin, "Existence of Subgroups Isomorphic to the Real Numbers," *Ibid.*, **53**, 298–326 (1951).

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*A CASE OF "MATERNAL" INHERITANCE IN NEUROSPORA CRASSA**

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The inheritance of mutant characters of Neurospora has not previously been found to be influenced by the way in which crosses were made. Whether protoperithecia were furnished by one parent or the other, the result, in so far as the types of progeny recovered were concerned, was the same. In the case to be considered here, however, the inheritance of a slow-growth character, which has been designated as *poky*, appears to be dependent upon its being carried by the protoperithecial parent. If the strain which furnishes the protoperithecia is considered to correspond to the maternal parent on the basis that it also furnishes the greater part of the cytoplasm from which the ascospores are derived, then this case appears analogous to those which have been described in other organisms (reviewed by Sonneborn[1]). In its failure to be transmitted (when it is carried by the fertilizing parent and not by the protoperithecial parent) the *poky* character resembles in behavior the *petite* character in yeast, described by Ephrussi[2] and his collaborators. A simple comparison of the two cases probably cannot be made, however, since the yeast ascospores arise from a mixture of the cytoplasms of the two parents, whereas, in obligate heterothallic strains of Neurospora, it appears probable that such mixing does not occur.[3–5]

The growth rate of *poky* strains is as greatly reduced as that of many biochemical mutants on minimal medium, but, so far, normal growth of *poky* has not been observed on any type of medium which has been tested.

The Inheritance of Poky.—The character was first observed among the progeny of crosses of a standard wild type, 7A, to four different strains. From two of these crosses, in which 7A had been used as the protoperithecial parent, all spores from the 10 asci examined gave rise to strains which required 10 to 12 days to complete their growth on agar slants. (This is accomplished by wild strains and by many suitably supplemented biochemical mutants in 3 to 4 days.) The remaining two crosses had been made by simultaneous inoculations, but one of these gave only slow progeny from 13 asci derived from the 5 perithecia which were observed. Three perithecia were observed from the fourth cross and from two of these all spores of 11 asci produced slow strains, but from the third perithecium the 6 asci isolated contained only normal spores.

A *poky* strain, designated *po*-1437-3 (1437 = ascus number; 3 = spore pair number), from one of the above four crosses, was crossed to standard wild type as the fertilizing parent and as the protoperithecial parent. The manner in which crosses were made will henceforth be designated by placing the protoperithecial parent first. All spores of 5 asci from the cross, wild × *po*-1437-3A, gave rise to normal strains, but 5 asci from the reciprocal cross (*po*-1437-3A × wild) contained only spores which produced *poky* strains. Spores from these crosses were then plated on minimal agar and observed after about 15 hours' incubation at 25°C. Spores from *poky* × wild had produced the very short hyphae which had characterized those from the all *poky* asci. The plate was incubated for about 30 hours longer and examined from time to time so that it was quite clear that, although the mycelia could be seen to be growing slowly, none of the spores (approximately 2000) produced strains with the normal growth rate. Spores from wild × *poky*, on the other hand, showed the extent of mycelial growth which is characteristic of wild type under these conditions, and after about 24 hours' incubation the surface of the agar was well covered with mycelium. Although it could not be said with certainty that no *poky* spores were present, there were clearly very few. (Almost any wild × wild cross which has been examined in this fashion gave occasional strains whose growth on the agar plate was slower than that of most of the wild types.)

By repeating the cross, *po*-1437-3A × wild and other *poky* × wild crosses, using *poky* protoperithecial cultures of different ages, it was found, as would be expected, that the slow growth rate of *poky* complicates the problem of timing the cultures so that *poky* will act as the protoperithecial parent. Many strains may be seen to have formed numerous protoperithecia after 3 to 5 days growth, but in *poky* cultures they begin to appear later, in small numbers which increase slowly over a period of several days. If the wild-type conidia were added too soon, before the surface of the agar was well covered with mycelium from *poky*, then, apparently the wild strain grew and formed protoperithecia. Both wild and *poky* progeny

were usually recovered from such crosses. If the cultures were fertilized too late the crosses tended to give few mature perithecia and few spores, possibly because some of the protoperithecia had become too old to function.[6] In what follows, unless otherwise stated, cultures were fertilized only after some protoperithecia could be seen by microscopic examination. In a few cases this occurred after 7 days, but more frequently 10 to 15 days were required.

A *poky* ascus, *po*-1720, from *po*-1437-3A × wild 8a and a not-*poky* ascus, 1723, from the reciprocal cross were selected for further study. Reciprocal crosses of the strains derived from each of the four spore pairs of each ascus were made to standard wild type 1347-2a or 1400-4A. Crosses of the eight strains were also made to one or the other of two *poky* strains, *po*-1720-1A and *po*-1720-2a, from the same *poky* ascus. The spores were plated, heat treated, incubated for 12 to 20 hours, and counted. Results appear below.

	WILD	*poky*		WILD	*poky*?
po-1720-1A × wild	0	1749	wild × *po*-1720-1A	912	7
po-1720-2a × wild	0	3247	wild × *po*-1720-2a	1339	9
po-1720-3A × wild	0	1261	wild × *po*-1720-3A	1318	16
po-1720-4a × wild	0	1648	wild × *po*-1720-4a	1247	11
po-1720-1A × *po*	0	1750			
po-1720-2a × *po*	0	3224			
po-1720-3A × *po*	0	2482			
po-1720-4a × *po*	0	3135			
1723-1A × wild	1334	10?	wild × 1723-1A	1261	12
1723-2a × wild	1283	9?	wild × 1723-2a	1423	8
1723-3A × wild	1161	8?	wild × 1723-3A	1001	13
1723-4a × wild	1199	6?	wild × 1723-4a	1029	14
1723-1A × *po*	1128	3?			
1723-2a × *po*	1028	12?			
1723-3A × *po*	1212	16?			
1723-4a × *po*	1151	30?			

Crosses of strains from the not-*poky* ascus, 1723, to wild and to *poky* gave a few spores from which the mycelia grew too slowly on the agar plate for these spores to be classified as normal wild types. They are tabulated provisionally as *poky*, as indicated by the question marks. A few such spores from each cross were isolated and transferred to agar slants, upon which some of them grew more slowly than standard wild types, but none were nearly slow enough to be classified as *poky*.

Asci were isolated from the crosses, tabulated above, of *po*-1720 strains × wild, and one ascus from each of the four crosses was selected. These are designated *po*-1803, -1812, -1818 and -1827 and were derived from strains *po*-1720-1, -2, -3 and -4, respectively. Spore counts from reciprocal crosses of the 16 *poky* strains, from these asci, to wild type 1347-2a or 1400-4A are given below.

	WILD	*poky*		WILD	*poky*?
po-1803-1a × wild	25	1024	wild × *po*-1803-1a	1634	7
po-1803-2a × wild	0	1578	wild × *po*-1803-2a	1349	6
po-1803-3A × wild	4	1626	wild × *po*-1803-3A	1054	8
po-1803-4A × wild	0	1275	wild × *po*-1803-4A	885	4
po-1812-1a × wild	0	2265	wild × *po*-1812-1a	1787	3
po-1812-2A × wild	37	3012	wild × *po*-1812-2A	933	7
po-1812-3a × wild	51	2069	wild × *po*-1812-3a	1051	2
po-1812-4A × wild	119	1350	wild × *po*-1812-4A	909	7
po-1818-1A × wild	0	1723	wild × *po*-1818-1A	1146	8
po-1818-2a × wild	236	1532	wild × *po*-1818-2a	1094	1
po-1818-3a × wild	12	965	wild × *po*-1818-3a	1388	18
po-1818-4A × wild	0	1434	wild × *po*-1818-4A	1018	3
po-1827-1a × wild	14	2345	wild × *po*-1827-1a	1146	6
po-1827-2a × wild	20	1074	wild × *po*-1827-2a	1251	13
po-1827-3A × wild	36	1957	wild × *po*-1827-3A	1069	3
po-1827-4A × wild	0	1419	wild × *po*-1827-4A	1081	0

A summary of the crosses from which these strains were derived is as follows:

po-1437-3A—from 7A × 27947, 37301-1093-3a (27947, 37301-1093-3a is an arginineless, pyrimidineless double mutant—neither of the mutant genes is present in *po*-1437-3)
po-1720-1, -2, -3 and -4—from *po*-1437-3A × wild-8a
1723-1, -2, -3 and -4—from wild-8a × *po*-1437-3A
po-1803-1, -2, -3 and -4—from *po*-1720-1A × wild-1347-2a
po-1812-1, -2, -3 and -4—from *po*-1720-2a × wild-1400-4A
po-1818-1, -2, -3 and -4—from *po*-1720-3A × wild-1347-2a
po-1827-1, -2, -3 and -4—from *po*-1720-4a × wild-1400-4A

From the behavior of *poky* in these crosses it appears highly probable that the character is transmitted only when it is carried by the strain which functions as the protoperithecial parent. The difficulty encountered in attempting to ensure that *poky* strains function thus has already been mentioned. Protoperithecial cultures for the crosses *po*-1720-1, -2, -3 and -4 × wild, for which the counts are given, were allowed 15 days to develop, and, as the table shows, no wild-type progeny were observed. When these same crosses were made from 4-day protoperithecial cultures, however, both types of progeny were found among random spores from all four crosses. A small number of asci (10 to 15 from each of these crosses) were examined and all those from *po*-1720-1, -2 and -4 × wild contained only *poky* spores. From *po*-1720-3 × wild 10 asci from 2 perithecia contained *poky* spores but from a third perithecium 3 asci containing only wild-type spores were obtained. Whenever asci were examined from crosses which gave both types of progeny it was found that all spores of an ascus and all asci from the same perithecium were of one type. The observations of Dodge[3] and Sansome[4, 5] on cultures of *N. sitophila* and *N. crassa*, in which mycelia of strains of opposite mating type were growing,

have indicated that, in these species, each strain forms protoperithecia which are fertilized by the other, rather than that a bisexual mycelium is formed and the perithecia produced by it. If this is the case then the fact that only one type of progeny was obtained from a perithecium can be explained on the assumption that the progeny resemble the parent which produced the protoperithecium. The appearance of wild types among the progeny of *poky* × wild crosses would then depend upon the opportunity for wild type to act as protoperithecial parent. In agreement with this is the observation that their appearance seems to be favored by the

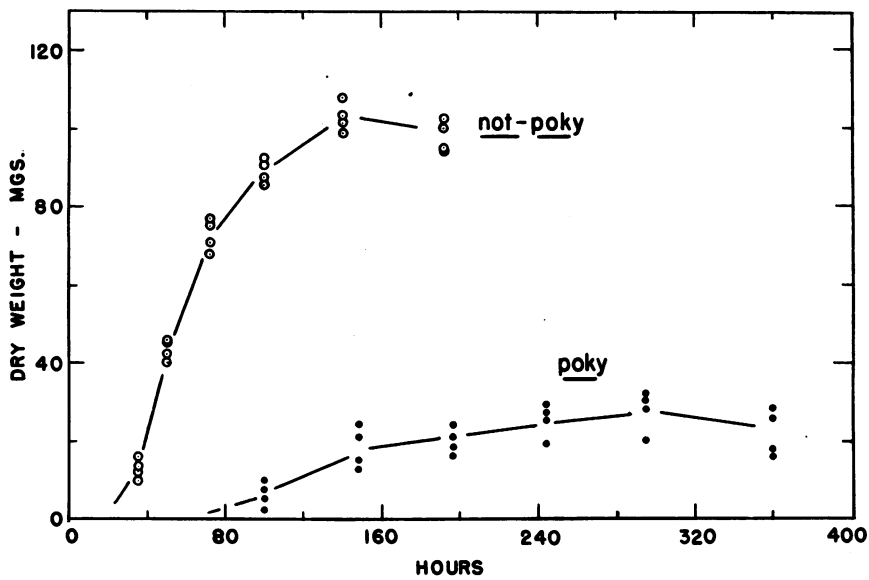

FIGURE 1

Growth curves for *poky* (solid dots) and *not-poky* (open circles) strains. The four points at each time interval represent dry weights for strains from spore pairs of the asci *po*-1852 and 1849.

use of very young *poky* protoperithecial cultures, in which, it appears likely, the wild type fertilizing strain would have a better chance of growing. The fact that wild-type progeny were not observed from *poky* × *poky* crosses (about 4000 spores from four crosses besides those tabulated were examined) suggests that wilds from *poky* × wild crosses did not arise from reversion of *poky*.

Wild Type 7A and the Occurrence of Poky.—At the time of preparation of the crosses from which *poky* was first obtained, 7A grew more slowly than wild type 8a but it clearly was not so slow as *poky*. Upon being subcultured several times, however, it became more slow-growing until it

resembled very closely *poky* strains from single ascospore isolations. In reciprocal crosses with wild-1347-2a it then behaved as a *poky* strain. The strains derived from two asci, *po*-1852 from 7A × wild and 1849 from wild × 7A behaved in crosses with wild as did those from *po*-1720 and 1723. There is no indication as to what was responsible for the conversion of the vigorous wild type, 7A, into *poky*. Isolates from the cross, wild × 7A, are being kept under observation to see whether they will become *poky*.

Mixed Cultures Involving Poky.—In connection with the question of whether the *poky* character may be due to infection, by, perhaps, a virus, the behavior of *poky* strains in mixed cultures has been studied, although, so far, in a limited fashion. Slants of Westergaard's minimal medium[7] were inoculated with dry conidia from one or the other of two *poky* strains, *po*-1720-1A and *po*-1720-2a and from one of the following strains of the same mating type: not-*poky*-1723-2; argininеless mutants,[8] 30300 and 34105 which grow slowly without arginine; the "colonial," 70007; a double mutant (kindly furnished by Dr. T. H. Pittenger of this laboratory) of albino 15300 and C102, a mutant which is phenotypically wild at 25°C. but "colonial" at temperatures above about 31°C. Cultures involving this double mutant were kept at 34°C., at which temperature the expression of the "colonial" character is extreme. Mixed cultures of *poky* with the phenotypically normal strain, 1723-2, were not distinguishable from the 1723-2 controls and in none of the four other cases was there any indication that a heterocaryon had been established. Growth in mixed cultures involving the two argininеless mutants kept pace with that in control cultures of the faster growing component, which was *poky* in one case and 34105 in the other. In the "colonial" + *poky* cultures both types of mycelium could be seen to be growing together with no indication of increased vigor or loss of the "colonial" character. The behavior of mixed cultures in which growth was more rapid than that of *poky* perhaps suggests that if *poky* carries an infective agent it is not readily transmissible by contact.

Growth Responses of Poky.—Growth rates of *poky* and wild type were compared at 25°C. in growth tubes[10] containing minimal agar medium. The average rate for three 24-hour periods was, for *po*-1437-3, 1.6 mm. per hour and for wild-1400-4, 3.1 mm. per hour. It was clear that this did not indicate the real difference in the rates at which mycelium was being produced by the two strains, since growth of *poky* was less dense than that of wild type. A much greater difference was apparent when growth rates were measured by the increase in dry weight with increasing length of growth period. Dry weights from cultures in 125-ml. flasks containing 20 ml. of unsupplemented liquid medium were measured for the four strains from ascus *po*-1852 from 7A × wild-1347-2a and for those from the not-*poky* ascus, 1849 from the reciprocal cross. Growth rates of the not-*poky* strains were not significantly different from those of standard wild

types, and, as figure 1 shows, were about 8 times as high as those of the *poky* strains.

The growth rate of *poky* has not been restored to normal by any supplement which has been tested. Some mixtures of growth factors are stimulatory, but they are also stimulatory to wild type. The following are some dry weights in mg. obtained after 91 and 144 hours' growth of wild-1400-4 and *po*-1720-2, respectively. The supplements given were added to 20 ml. of medium in which the carbon source was 300 mg. of sucrose, except when otherwise stated.

	WILD (91 HOURS)	*poky* (144 HOURS)
Supplement		
None	72	13.5
Casein, acid hydrolyzed, 40 mg.	89	20
Bacto-yeast extract, 40 mg.	91	29
Bacto-peptone, 40 mg.	86	24
Lederplex B-complex capsule in 10 ml. H_2O, 0.2 ml.	80	19
Carbon source		
Glucose, 300 mg.	74	12
Fructose, 300 mg.	78	5
Molasses (Grandma's), 500 mg.	99	23

The reduced growth of *poky* with fructose as the carbon source is reproducible if cultures of this age, or younger, are observed, but in older cultures, the difference in dry weight on glucose and fructose disappears. Since wild-type strains tested gave, on fructose, lower dry weights from very young cultures, a real difference between *poky* and wild type does not appear to be indicated.

Biochemical Differences.—A number of preliminary observations have been made concerning biochemical similarities and differences between *poky* and not-*poky* strains. Activities of the enzymes, acid and alkaline phosphatase (*p*-nitrophenylphosphate substrate) pyrophosphatase, metaphosphatase, tryptophan desmolase and succinic acid dehydrogenase, in cell-free preparations, are from 0 to 40% higher in the *poky* strain than in the wild strain studied. The differences, based on dry weight of mycelium, are not considered significant at the present time.

With regard to other chemical constituents the *poky* and wild strains studied do not differ significantly in their content of polysaccharide but *poky* is relatively low in protein, nucleic acid and uncombined glucose. These observations were made on only a few strains, and not on all strains from an ascus. It is not yet certain, therefore, that the differences are associated with the *poky* character since they may be due to the actions of segregating genes.

Discussion.—Since the observations reported appear to support the view that the *poky* character is inherited only when it is carried by the proto-

perithecial parent, the possibility that something is being transmitted through the cytoplasm is immediately suggested. However, with so little information available as to the possible nature of the defect which produces the *poky* phenotype, conclusions regarding the mechanism of its transmission would necessarily be highly speculative in nature. It seems preferable, for the present, to look upon the phenomenon as the perpetuation, through the protoperithecial parent, of a certain "physiological state." It is to be hoped that further investigations on the physiology of *poky* strains will throw some light on this mechanism, but it should perhaps be kept in mind that a strain which is so different in growth rate would be expected to show many physiological differences from normal strains and it may be very difficult to distinguish between differences which result from the slow rate of growth and those which cause it.

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*ON THE LAW OF CONSERVATION OF HEAVY PARTICLES**

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The purpose of this note is to trace in more detail the consequences of treating the conservation law for heavy particles[1] on a par with the conservation law for electric charges. It is thus an attempt to guess at the properties of particles as yet unknown and their interactions, and therefore speculative. However, it does not attempt a classification of elementary particles similar to that proposed recently by several writers, in particular, A. Pais.[2] In this regard it is somewhat more conservative.

We do not know the deeper cause of the conservation law of charges in the same sense as we know, for instance, the cause for the conservation of angular momentum.[3] Perhaps the clearest sign hereof is that the