contain one or two pure black rats and four or five others of a blackish tone which show a variable mixture of brown hairs; but one cannot find, when dealing with hundreds, every shade between a black rat and a light brown one. Similarly, one cannot arrange a satisfactory series between the white-bellied type and the commoner brown-bellied type, although some of the former have coloured breast stripes of variable breadth and some of the latter are very light in colour.

The collection is truly heterogeneous in appearance, although, in a broad sense, it consists of animals of one species. The individuals composing it have been brought in batches of two or three together, by the townsfolk. It is often noticeable that the individuals of any one batch very closely resemble one another. Thus the melanotic and semi-melanotic rats would probably all be brought in by one man. Another man would bring unusually large rats, a third would bring four or five white-bellied rats with relatively short tails, some with breast stripes, others without. The members of the separate batches often show a likeness to one another. This can only be explained by the fact that the members of each batch were usually taken together from a single house, the likeness being a true "family likeness." By the word "family" is meant a small localized group whose members are given to inbreeding. These observations point to the conclusion that the rats of one species in a town are divided into a number of groups which hold little intercourse with one another.

Experimental evidence of a more certain nature could be obtained by successively capturing, marking, releasing, and after an interval recapturing a large number of rats. It might be predicted that the recapture would take place in all cases in the same house that the capture and marking was effected. Such experiments could probably be carried out without much difficulty. The rats should be caught in a trap, anæsthetized lightly by placing the traps in a closed box containing chloroform, and removed from the trap while unconscious. They might be marked by branding the tail or piercing the ears. Recovery from chloroform in rats takes place with certainty, and often with most disconcerting quickness. The accidental scars which are present on so many rats might lead to some confusion, but a system of marking by metal rings and number plates would probably prove unsatisfactory. To recapture the rats it would be probably necessary to use spring jaw traps of which there are many effective patterns. Such experiments would give direct evidence of the movements of rats in a town or village which would be of value in any consideration of the means of plague dissemination.

APPENDIX II.

QUESTIONS OF BIOLOGICAL INTEREST.

The Government's measures against rats have afforded a unique opportunity of studying large numbers of closely related

and widely distributed animals. During the enquiry several matters of general biological interest have made themselves felt.

The chief interest lies in the large number of sports which have been met with; that is to say of individuals which differ widely in some character or characters from the race in community with which they were found, although otherwise closely resembling that race. The differences which characterise these sports are of colour for the most part; they are, however, in some cases, of a wider degree than the slight differences which are used at the present day to separate species. It is unusual to examine any race of animals in large numbers without meeting with sports both of colour and of form, but the peculiar interest of this enquiry lies in the several instances in which such sports have appeared in groups. Some of them have been met with singly, others as pairs caught together in the same trap, others in "litters" all the members of which agree in differing from the normal race in the same way and nearly to the same extent. Finally, two cases have been met with of rats, which can hardly be considered as other than sports, occurring in groups large enough to occupy two adjacent houses to the exclusion of other species of rats. The members of such groups must be of close blood relationship,—in fact, "family groups" prone to inbreeding.

Moreover, there are two examples of what appear to be the same kind of sport having arisen independently in two far distant localities. These similar sports are in one case from Bombay and Madras, and in the other from Rangoon and Naini Tal. The former places resemble one another in climate. The latter places are utterly different from one another.

Although many examples of sports have been already described, the most important ones will be reviewed here.

Cases of single sports.

Case 1.—The rat "Mds. 2" is a *Mus rattus*; its ventral surface is dark brown, and in the middle line of the breast is a pure white streak. It was selected from among about 600 freshly killed rats of the *rattus* type, which were received during two days.

Case 2.—A black example of the *rattus* type caught in the Museum of the Bombay Natural History Society where it attracted attention owing to the pure white line on its breast. Although this line is not quite so long as in the last case, it seems to be essentially the same variation. A large proportion of the Bombay rats are of the black type of *rattus*. The same variation has also been noticed in Calcutta and at Nowgong.

Cases 1 and 2 are shown side by side in plate i.

Case 3.—One *Mus rattus* from the Punjab which shows a white-tipped tail, with some lengthening of the terminal hairs of that appendage. This case is specially mentioned because of the concomitant lengthening of the hairs. There are several examples of white-tipped tails among other species of *Gunomys*, *Bandicota*,

and *Mus*; in these, however, the occurrence is not associated with lengthening of the terminal hair.

Case 4.—One half-grown rat selected from some thousands of the mixed assembly of white-bellied *rattus* and *concolor* caught in Rangoon city, which differs in only one respect from many of the half-grown members of the white-bellied race. The under side of the tail of this rat is pure white. This is considered to be a most important variation, for on this peculiarity alone several species have been defined. This statement is open to criticism, but it cannot be denied that bicoloration of the tail is the most important feature in the definitions of those species of the genus *Mus* which have received the names of *niveiventer*, *vicerex*, *bukit*, *rapit*, etc., for the other less important details of the definition of these species seem to fall within the normal range of variability of the *Mus rattus* group, and the species have been defined from comparatively small numbers of specimens.

The fact that this young rat was only half grown is of importance; judging from its size it cannot be much more than two or three months old; this lessens the probability of its being brought to Rangoon by a foreign ship. Because of this and of the fact that it appeared to be unique among the large number examined, it is difficult to believe otherwise than that it was a sport, born of the white-bellied race of *Mus rattus* which is common in Rangoon. In case 8 we shall see another example of precisely this same variation, occurring in a group of rats found to be occupying two adjacent houses in Naini Tal.

Cases of more than one individual showing the same variation as sports which have been met at the same time and place.

Case 5.—An excellent example of this is from the Punjab. Captain Davys sent us from a village in the Amritsar district a pair of adult rats of almost exactly the same size and appearance. They are obviously of the *rattus* type, but can be distinguished at a glance from the others of that race among which they were found. They are much lighter in colour than the average Punjab *rattus*, though not lighter than certain exceptional individuals. They both have a pure white star on the forehead; the terminal third of their tails is white. The sender of these remarkable rats alluded to them tentatively as *Mus brahminicus*. There is very little doubt that if they had been sent together to any specialist, they would have been hailed as a new species. However, circumstances make it probable that in the capture of these two specimens, the new species would have become extinct before it was defined. They were almost certainly born of the same parents and were probably mates. The female was pregnant, carrying four embryos. They were caught in the village of Nowshera Dhala, in which over 800 of the normal *Mus rattus* had been taken. These

two specimens stand alone among 22,000 rats taken from the villages of the Amritsar district. In the remarkable character of their tails they exactly resemble a number of species which occur in the Eastern Archipelago.

Case 6.—A litter of five very young rats was brought to one of the collecting stations in Rangoon all of which were of a light buff colour and had unusually large feet. Two of them were subsequently reared to maturity by Captain Kelsall who found them to be typical examples of the Rangoon bandicoot, *Gunomys varius*, in everything but colour. On the same day that the writer first saw these rats, and at the same station, one adult specimen of exactly the same colour was received, the hind feet of which were 11 mm. longer than those of an equal sized specimen of the typical *G. varius*. Information was also obtained from the official in charge that at that particular station they had occasionally received such "sandy coloured bandicoots." It is clear that these interesting animals were to some extent established in that part of Rangoon, and they evidently breed true. Intermediate colour forms between them and the common blackish grey type were never met with. In Dr. Hossack's collection of Calcutta rats are two specimens of the smaller *Gunomys bengalensis* of exactly the same curious buff colour.

Cases in which a large group of sports was met with.

Case 7.—This is afforded by the ten black mole-rats described under Rng. 8 on page 76, where full details of the occurrence of these interesting animals will be found. They all resemble one another very closely indeed, and differ from the mean type of the race not only in colour but also in size and skull proportions. They seemed to be the only rats domiciled in two adjacent houses of a certain street in Rangoon. Black specimens of *G. bengalensis* are otherwise rare in Rangoon, and have never been recorded from any other place.

Case 8, *the Ayapata race of Naini Tal.*—Eight rats were caught in a certain house and adjoining buildings in Naini Tal. They are very like the rats found in the bazaar and other buildings of the station, in all but the one respect that their tails are bicoloured. This bicoloration is very variable in degree, but not by a varying diminution of pigmentation from the lower surface, in the manner that our preconceived ideas would lead us to expect. The actual occurrence is fully described on page 40 and illustrated on plates i and iv. It is difficult to believe otherwise than that these eight rats are closely related as a family group. No rat with a unicoloured dark tail was caught in those particular houses. In all other respects they are so like the common rats of Naini Tal that one is compelled to regard them as an offshoot from the local race. It has been mentioned before that bicoloration of the tail is the all-important feature in the descriptions of many species of the *rattus* group.

The circumstances of case 8 are different from those of case 7. In case 7 the chief peculiarity, blackness, which marks off the ten rats from the race out of which they have presumably arisen, is remarkably constant in degree. In case 8 the feature, bicoloration of the tail, which marks off the group, is so variable that at least four distinct "types" are present among the eight. It appears that a parallel case to this has been recently published. In Hossack's "Account of the Rats of Calcutta" is an illustration which is

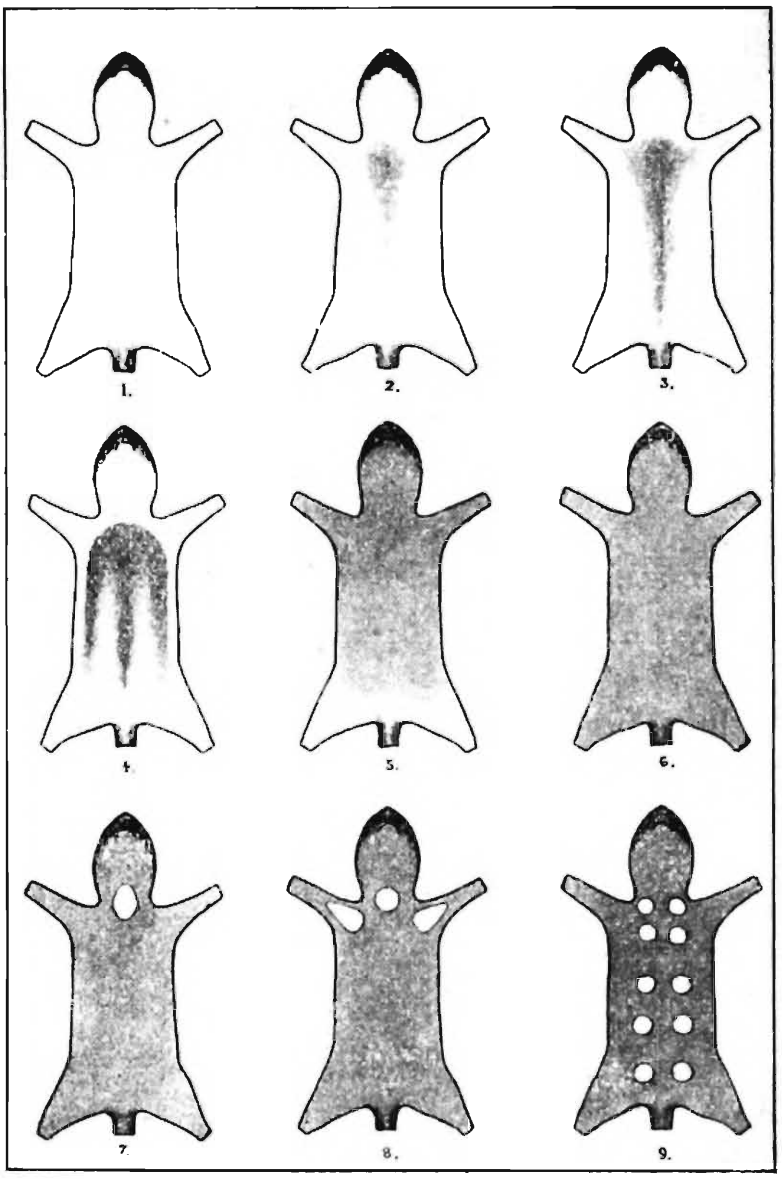

FIG. 9.—Illustration of variation in belly colouring in *Mus rattus* (after Hossack).

reproduced here (text-fig. 9); this is accompanied by the following statement: "As showing how endless are the combinations and variations of these different belly colourings, the figure in the text may be referred to, showing the different variations found in nine specimens of *M. rattus*, which represented the total bag for one day."

The concluding clause of this quotation is an important part of it. Having examined a certain number of the Calcutta *rattus*, the

writer does not think that Dr. Hossack could always select such a series of nine, as he has figured, from any 100 chance-taken rats of Calcutta. It is true that a similar series cannot be selected from nearly 2,000 specimens of *Mus rattus* from different parts of India. However, a similar series could be selected from 58 rats from Simla. And yet these nine are "the total bag for one day." The explanation seems obvious: this "bag" was made in one house or granary, and the contents of it represent a parallel case with the Ayapata family group.

Let us consider how similar these two cases are. Rats with dark (*i.e.*, any colour but pure white) under parts occur in vast majority throughout northern India, but white-bellied rats are common in certain places; Calcutta is one of these. It may be safely assumed that the white-bellied type was derived from the dark-bellied type, and that the Ayapata race with their bicoloured tails were derived from the rats which possessed unicoloured dark tails. It seems to the writer that in the groups of the eight Ayapata rats and of the nine Calcutta rats,—groups which cannot each represent more than two or at the most three generations,—we can see the change from one race to another actually in progress. In both cases the change is associated with a variation of much wider range than that which is spoken of as normal variation.

It is not claimed that this assumption is already far justified by facts. Such communities might be looked upon as groups of hybrids between two established species. These two cases, however, wonderfully resemble a case recently described from another part of the animal kingdom, which cannot be explained in this way.

In a certain part of the Arabian Sea a community of the crustacean *Squilla* [16] was found. This community shows an extraordinary variability in one respect. Species of the genus *Squilla* possess as a rule six-spined claws, the number of spines being very constant for each species. The members of this particular community, however, all possess a greater number of raptatorial spines, the number varying from 10 to 19, among the seventeen specimens obtained. The number of spines is so variable that there are eleven "types" among the seventeen, some of them being unsymmetrical, but the number of spines in every individual is well above the number found in any other species of the genus. Except for these spines the specimens resemble one another as closely as the members of a species usually do. It seems that there are certain definite resemblances between this crustacean community and the two communities of rats which have just been referred to. In all three cases there is a local community differing from the general group of which it is a part, in that it possesses a certain character (presumably a newly acquired one)—albiventralism and caudal bicoloration in the case of the rats, multispinity in the case of the crustacean; but in all three that character is in a most unstable condition, so that, as regards it, each community contains several types. At the same time there is little doubt that in each case the members of the community are of one stock and are not separated by more than two

or three generations. The variation in the character is, however, different in degree from that which is known as normal variation.

The "discontinuous distribution" of rats with white under parts, bicoloured tails, and of melanotic rats in the Oriental region is most interesting; it has been already dealt with, but some of the facts may be shortly reviewed. White-bellied rats form a pure race in Rangoon (Rng. 2); they are common in Calcutta. Out of sixty-nine villages in the Punjab it was found that only three contained them in small numbers. The rats of Simla bazaar and of several other places on the flanks of the Himalayas are nearly all of this type. A few were obtained from Cawnpore and other places; they form more than half of the rats received from Tellicherri. In many other places, however, they do not occur, and it cannot be doubted that the commonest type of *Mus rattus* in India is the dark-bellied one, and that the white-bellied type occurs sporadically (*vide antea*, pages 65, 80).

Rats with bicoloured tails, although rarer, show the same sort of distribution. There is a pure race of them in Kashmir. There is a race in the Eastern Himálayas (*M jerdoni*). They have been recorded from Katmandu (*M niveiventer*) and from Simla (*M. vicerex*), but it is doubtful whether they persist as a race in these two places at the present day (see p. 6). This year a small colony of them was met with in Naini Tal (Ayapata race), and one specimen was found in Rangoon. They have been frequently met with in the southern part of the Oriental region, in the Malay States and Archipelago, chiefly from hilly districts. Wherever met with they have shown other slight peculiarities, for they have been described as different species. But the bicoloration of the tail is admitted to be the most important character in all of them. In the two places Rangoon and Naini Tal where the writer met with rats of this sort *they did not differ, except in the one respect, from the common local races of those places from which they are thought to have been derived.*

Passing now to the cases of melanism, we find that black rats are not uncommon in Bombay [17]. They occur rarely in Calcutta. We have received pure black rats from Cawnpore and Freemantle (Australia). There is an interesting semi-melanotic type among the Tellicherri collection. Ten pure black mole-rats were obtained from two adjacent houses in Rangoon. From the same town we have melanotic examples of *Mus concolor*, the miniature form of *Mus rattus*. It cannot be that the black *Mus rattus* gave rise to the black *Mus concolor*; and the brown *rattus* to the brown *concolor*. Melanism must have been acquired independently by these two races.

After considering their discontinuous distribution it seems difficult to believe otherwise than that these three characters, melanism, albi-ventralism and caudal bicoloration, have arisen independently in several places, and are continually arising unnoticed in thousands of other places. It is somewhat difficult to know how far this view is accepted at the present day. It appears that some

naturalists, having discovered an isolated group of melanotic rats, would speculate as to what part of the world they or their progenitors had wandered from. It seems to the writer that the discontinuous distribution of species (using the actual meaning of the word for "anything that has ever received a specific name") can often be explained without postulating means of emigration.

A list of sports or groups of sports has been drawn up, but other cases have been described which have perhaps an equal right to a place on the list; such cases are Pjb. 2, Qta. 2, Alh. 3, Mds. 4, Tci. 1, Rng. 1*b*, Rng. 7*b* and *c*, Rng. 8*a*. In some of these cases the differences which mark off the groups are smaller than in others.

We have also seen that all the rats living in a particular house (or set of burrows), although closely resembling one another, often show, in certain features, recognisable differences from the mean of the race, although these differences are so small that they fall within the range of normal variation of those particular features exhibited by the general population. The differences which mark off these groups are small, but the groups showing them are very common. These small differences seem to be equivalent to the "family likenesses" of mankind, heightened perhaps by inbreeding.

It is interesting to consider the commonness of sports and groups of sports. Within a week at least four were met with in Rangoon. The total number of sports mentioned in this paper was selected from among not very many thousands of rats. The number of rats present in India and Burma must be some thousands of millions. Four thousand rats a day were destroyed in Rangoon for some months without producing much effect on the rat population which in that city alone must be several millions; over a million have already been killed there. Sports, therefore, must exist in large numbers, each with a small chance of forming a "family group," each of which has a very small chance of forming a race. In the different magnitude of their chances lies an explanation of the well known fact that rare species are many and common species are few.

In the writer's opinion "family groups" of sports have been frequently met with by naturalists who have described them as new species. Such species can seldom be rediscovered; they become extinct after a fitful survival through a few generations. They remain in our literature, however, as rare species. The chances of a "family group" developing into a race seems to be very small indeed. For while among the rats of India the birth of sports seems to be of daily occurrence, the number of established races is very small, though from its superfluity a race is much more likely to meet the eye than either a family group or a single sport.

In India we have sure evidence of only four established races of the *Mus rattus* type.

Race 1 (*Mus vicerex* ?).—In Kashmir most of the house rats have white under parts and relatively short tails which are devoid of pigment below. It has been said that they are of the species

of *Mus vicerex*, because they resemble in their peculiarities certain rats which were caught in Simla in 1896. The common rats of Simla are to-day different from the common rats of Kashmir, which form a distinct race.

Race 2 (*Mus nitidus* ?).—Rats caught this year in six different parts of the Darjiling district all agree in possessing relatively short tails, thick, soft, greyish fur, dark under parts and feet pure white above with black soles. They are of course variable like all other rats, but their variability is about a mean other than that of the common rats of the plains. Hossack, who caught two of these rats, regarded them as *Mus nitidus*.

Race 3 (*Mus blanfordi*).—In 1881 a peculiar rat was found at Kadapa in the Nilgiri Hills of Madras, and a little later another resembling it was found at the same place; both of these rats were distinguishable from the common type by the following features. The fur was thick and soft, greyish fawn above, white below, the ears were large; their tails were most peculiar, they were relatively long, and pure white in the distal half, the hair on the tail was unusually long and formed a terminal tuft. There are in the Indian Museum four other precisely similar specimens from the Shevaroy Hills which are nearly 200 miles from Kadapa, to the east of the Nilgiris. The peculiarities which were originally described in the skull of the "type" specimen are not constantly found among the four from the Shevaroys, which do not seem to differ in this respect from many of the common *rattus* type. There can, however, be no doubt that *M. blanfordi* is an established race in the Nilgiris.

Race 4 (*Mus jerdoni*).—Rats have been frequently obtained from the Himalayas of Sikhim and Assam which are peculiar in being bright rufous above, white below, and in possessing remarkably long bicoloured tails. In 1881 a close observer noticed that of five of these rats, all possessed a minute accessory palatal ridge between the two posterior ridges (4th and 5th) [2]. There are in the Indian Museum several similar rats; among them are three litters of young ones, two from Darjiling of two each, and one of three from Cherrapunji (Assam). Every member of each litter shows some irregularity of the posterior palatal ridges tending towards the interpolation of an extra one.

The number and form of the palatal ridges is most constant among rats. Besides the cases just referred to, the writer has only once found an abnormality in these structures although he has examined large numbers of them both in *Gunomys* and *Mus*.

The skulls of the *Mus jerdoni* in the Indian Museum could be distinguished from hundreds of the common *rattus* type owing to their remarkably small auditory bullæ. This point was discovered in other specimens in 1881. *Mus jerdoni* is therefore a distinct race in the Eastern Himalayas. It is said to occur in Java.

These are the only four special races of the *Mus rattus* type in the Peninsula of India of which we have sure evidence, although there must be many others. Local races showing albiventralism seem to be established in several places. One cannot assign a local

habitation to either *Mus fulvescens* or *Mus niveiventer*. Such forms as *Goalunda*, *Vandaleuria* and *Mus mettada* are considered to be quite distinct from the *Mus rattus* type.

If we consider in succession the numerous single sports, the small family groups of such sports (exampled by cases 5, 6 and 7), the larger groups (case 8), and the established races 1—4, they seem together to illustrate the process by which a new race arises from an old one.

During one week at least four well-marked sports were met with in Rangoon alone, whereas the established races of rats in India are very limited in number. Few sports can establish a family group, very few family groups can establish a race. One cannot do more than guess at the nature of the "fitness" which renders one sport successful and eliminates a dozen others. However, one can deny that all successful sports are so by virtue of the characteristic features which are obvious to our eyes. A short bicoloured tail, a long bicoloured tail, a sixth palatal ridge, a tufted tail are merely the marks of successful races, they are surely not the features which determine the success. The factors which determine the success of a group of rats may be a greater pugnacity or cunning, a greater resistance to certain diseases; and a greater fertility, combined with that mysterious factor prepotence; or they may be inconceivable.

Hitherto we have been considering races which show comparatively small differences from one another. There are in the fields round Amritsar two races of mole-rats living side by side always in separate colonies or sets of burrows. These show such structural differences from one another that they have received different generic names; one of these, *Gunomys*, is a genus which occurs throughout the whole of India. The other, *Nesokia*, seems to be confined to the north-west. *Gunomys* has a tail percentage of 80, small incisor teeth, a long palatine foramen and a large number of mammæ; it produces 8—12 young at one birth. *Nesokia* has a tail percentage of 50, large incisor teeth, and concomitantly a very short palatine foramen; few mammæ, and it produces 2—4 young at a birth. The skulls of these two genera are shown on plate iii. It may be safely assumed that *Nesokia* was derived from *Gunomys*.

If we suppose that it was derived from *Gunomys* by "natural selection" working on normal variation, we must assume that there were a number of steps linking together the two extremes. The steps—a series of hypothetical species now extinct—must have each shown, gradually and in turn, a reduction in the length of the tail and palatine foramen, fewer mammæ and young. Each of these hypothetical species must have fitted its environment and must have become changed in response to some slight alteration in that environment; although at the present day the two extremes are perfectly suited to what appears in our eyes to be the same environment.

The alternative view, that the first *Nesokiæ* were sports born from *Gunomys*, which established a family group and afterwards a widespread race, seems more in accordance with the evidence afforded by the present enquiry. The writer must confess that he has acquiesced in the generic distinction of *Gunomys* and *Nesokia* partly in order to heighten the effect of his argument. It must, however, be admitted that they are distinct animal forms, possessing characteristic features of more weight than those shown by some of the recently discovered species of *Mus*.

The writer has already expressed the opinion that the system of classification of animals now in vogue is unsatisfactory. The system seems unsatisfactory because it does not always offer a true picture of the way in which animal forms occur in nature. The systematist holds that every individual animal must be assignable to a particular species; and further, that species if properly defined, are elementary and indivisible, and approximately of equal value. This conception appears wholly true to those who examine small numbers of animals from many places. It must seem only partially true to those who examine large numbers of animals taken from a few places. It may be admitted that races such as those enumerated 1—4, which are regarded as elementary or true species, are approximately of equal value; but what is their relation to the heterogeneous mass of rats which extend through India and beyond, a race so definitely variable that three or more individual members of it living in Cawnpore in the heart of India, can be distinguished at a glance from one another, *while each one of them is indistinguishable from one of three individuals caught on a ship at Freemantle, Australia.* The members of this heterogeneous mass are bound together by the fact that they all possess the same type of skull, the same characteristic foot pads, and a tail variable in length, but seldom or never shorter than the head and body. Moreover, the races 1—4 also resemble the mass in these features but they are each clearly separated by their own special marks.

How can these various races be accurately represented by our nomenclature? It is surely absurd to name the heterogeneous mass *Mus rattus*, and to give the races 1—4 equivalent names. Systematists admit that *Mus rattus* is not a species equivalent to the others, but they seem to think that it will ultimately be possible to split it up into a number of equal groups, each a true indivisible species. Hossack's figures show that it is not possible, and the writer has met with the same impossibility.

One writer, in dealing with Siamese rats [18], simply excludes the common rats from his system. Another places the common rat of Borneo [19] in the group of the European house rats and describes them as "a group which has been the bane of workers on the Oriental Muridæ, and which at present owing to want of material is quite impossible to bring into any sort of order." The conviction is expressed here that it will ultimately be possible to place these rats in the Linnean system.

The conception which is in accordance with the Linnean nomenclature may be illustrated by text-fig. 10, in which the thick line represents the old species, the thin lines the new species into which it has been divided, the dotted lines representing the work of the future. This is pleasingly simple and hopeful of finality, but it does not seem to represent the way in which the animals occur in nature.

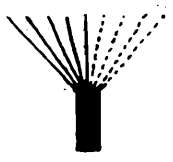

FIG. 10.

The diagram, text-fig. 11, is perhaps more in accordance with the actual occurrence. In this diagram the central thick line which represents the species *Mus rattus* is supposed to consist of a mass of tangled lines which are individually visible as the terminal twigs A. These represent the family groups, the members of which show very slight differences from one another, differences which are equivalent to the family likenesses of man. These twigs are represented because ten rats taken from any single house in a town will often resemble one another more closely than ten rats taken haphazard from different houses in the town. Some of these groups are slightly removed from the mean of the race, but all are not so to an equal extent. The mean of the race is represented by the vertical line XX. Those groups which in their characters diverge widely from the mean are represented at a wider angle from the parent stem. A well-marked sport will therefore come off almost at a right angle. The many sports and family groups which are unsuccessful are represented by short lines, the few successful ones which have established a race are indicated by longer and thicker lines, which themselves show side-lines like the parent stem. *A line which does not deviate much from the mean may be an old and powerful one*: for example, *Mus concolor* only differs in size from *M rattus*, but it is a well-established line; its members extend throughout Burma and far beyond to the south; it clearly shows its own side-lines, which are often of the same kind as those of the parent stem. On the other hand a line such as *Mus blanfordi* which deviates widely from the mean may also be well established.

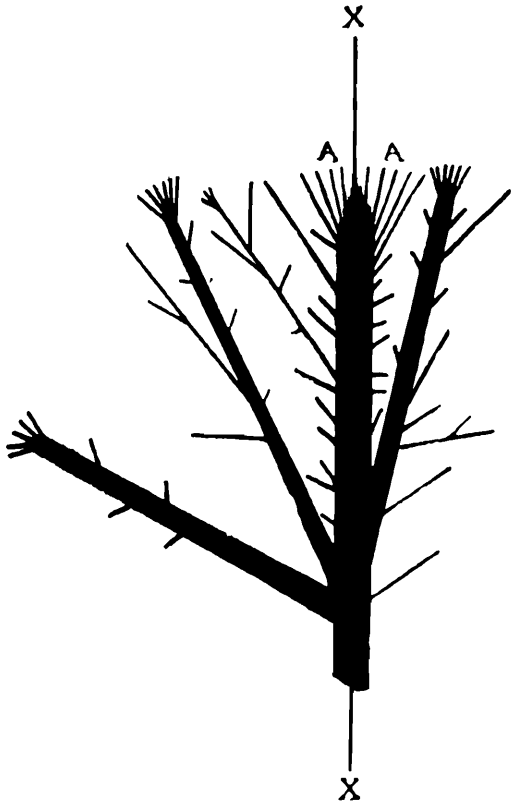

FIG. 11.

Not every species could be accurately represented by this diagram. The line of *Mus decumanus* would be shown with terminal twigs but without any established side-lines, for in India the race shows exactly the same fluctuating or normal variation as *Mus*

rattus, but never a sport. However, this assertion may at any moment be proved to be erroneous.

This idea of the relations of the many races of Oriental rats to one another has not the merit of simplicity, and is not in accordance with the Linnean system of nomenclature.

In concluding this appendix, I must acknowledge that as regards many of the ideas expressed in it I am much indebted to a book by R. K. Lock, entitled "Variation, Heredity and Evolution" (1907), which contains a clear exposition of the teachings of Mendel, Bateson and De Vries, teachings which seem more in accordance with nature than those usually expounded as Darwinism.

Lest it may seem that I have been unduly biassed by Mr. Lock's book I hasten to add that "Mutation, Mendelism and Natural Selection," by Professor E. B. Poulton (1908), has also been read. The author of this essay considers that a natural consequence of such ideas as those expressed in Lock's book is "a widespread belief among the ill-informed that the teaching of the founders of modern biology are abandoned."

These opinions, therefore, are put forward with diffidence, and I have felt the need of that criticism and discussion which are so necessary to temper fresh ideas.

APPENDIX III.

ENMITY BETWEEN THE VARIOUS RACES OF RATS.

The question of the cause of the ascendancy of particular races is important. It has been assumed that the absence of *Mus decumanus* from Madras is due to the fact that in its habits this rat resembles *Bandicota indica*, and that since the bandicoot is much the more powerful rat, it can secure the drains of the city for itself alone. This raises the question as to whether special enmity between particular races exists. Some evidence has been obtained and more might be the outcome of simple experiment.

The subject was first brought to my notice by Captain Davys, who found that if a living shrew were placed in a cage with a young living *Mus rattus*, the shrew seized the head of the rat with its powerful incisor teeth and after biting through the skull devoured the brains. I was subsequently reminded of this habit of the shrew when at Rangoon. It happened that a cage containing a living shrew (the grey "musk rat" *Crocidura cærulea*) was placed in contact with a pile of dead *Mus concolor*. The shrew dragged the foot of one of the rats through the bars of the cage and commenced devouring it. The dead body of the rat was placed inside the cage. The shrew continued to devour it, applying itself to the extremities, the snout, muzzle, ears and feet in succession. Six living *Mus concolor* were placed in a cage with one shrew; without a moment's delay they combined forces against the shrew. The fact that they