applied to wireless telegraphy by Poulsen, and is therefore generally known as the Poulsen arc.

Among his many other electrical inventions should be noted his resistance electric furnace patented in 1894, and a dynamo-static machine (1900) by which it was possible to obtain high-frequency discharges suitable for vacuum-tube apparatus.

In the summer of 1858, when 5 years of age, Thomson had seen Donati's comet and in 1867 he witnessed spectacular meteor showers. These early observations prompted his abiding interest in astronomy. In later years he published nearly a score of papers on astronomical subjects ranging from discussions of zodiacal light to solar eclipses.

Still other scientific byways of Professor Thomson's interest were the earth sciences. He published on "The Nature and Origin of Volcanic Heat," and in his last appearance before the American Academy of Arts and Sciences in 1933, he read a paper on "The Krakatau Outbreak." The eruption of this volcano in Java occurred when he was a small boy in Philadelphia, and had incited the curiosity which he always exhibited. He had watched for evidences, in the brilliant sunsets, of the volcanic ash in the upper atmosphere and had, I am informed, recorded his observations. At a much later date he hired as a research assistant a survivor of the catastrophe and induced him to record his personal observations of the event.

With all this intensive activity, Professor Thomson lived a rich family life. He was married on May 1, 1884, to Mary L., daughter of Charles Peck of New Britain, Conn., and of this union there were four sons, Stuart, Roland D., Malcolm and Donald T. In 1916 Mrs. Thomson died, and on January 4, 1923, he was married to Clarissa, daughter of Theodore F. Hovey of Boston.

Behind all his astonishingly varied interests, stood a man who had complete faith in the efficacy of the scientific method, and who in all his activities, vocational and avocational, was a shining exemplar of the scientific spirit. Observation and experimental inquiry were his chief reliances; he apparently did not resort to the mathematical or analytical methods that most scientists and engineers use who tackle problems as complex as he solved. He was not, like Steinmetz, a gifted mathematician; he seemingly did not need to employ mathematical analysis because his teeming mind leapt to correct conclusions without it.

His powers of observation he carried into every walk of life, and no one could be with him for ten minutes without being impressed and stimulated by his perception and by his wide-ranging knowledge of natural phenomena. He could best be described by saying that he was a brilliant natural philosopher who was held in equally high esteem by practical engineers and by academic scientists.

I have spoken of his devotion to education. His long association with the Massachusetts Institute of Technology affords a specific example. He became a lecturer in electrical engineering at this institution in 1894, and from then until his death he maintained with it the closest sort of relationship. He was elected a life member of the corporation in 1898, was acting president from 1920 to 1923, and for many years was a member of the executive committee of the corporation. He likewise served Harvard University as a lecturer and as a member of several of its visiting committees.

In other ways he never ceased to teach. His friend, Dr. Richard C. Maclaurin, President of the Massachusetts Institute of Technology from 1909 to 1920, observed:

> Throughout his life he has not only done great things himself but shown an intense desire to help all who are struggling earnestly with scientific problems. He has proved an inspiration to an ever-widening circle of engineers and others who have intrusted him with their secrets and sought his help in overcoming their difficulties. They have done this, knowing that they had only to ask in order to get the full benefit of his imagination and his power, and that they need have no misgivings that he would take any advantage of their confidence or any credit for their work, for he has no touch of selfishness.

From my own association with him I can validate Dr. Maclaurin's tribute. He combined in a most remarkable way the constructive power of the inventor, the intuition and imagination of the great scientist and the kindly balance of the ideal philosopher, teacher and friend. His life encompassed the development of the electrical industry, and he will long be remembered as one of those who brilliantly extended and applied the primary discoveries of Faraday and the other pioneers in the science of electricity.

He died on March 13, 1937, in his eighty-fourth year.

GROUP ORGANIZATION AMONG VERTEBRATES[1]

By Professor W. C. ALLEE
THE UNIVERSITY OF CHICAGO

IN our laboratory and elsewhere, so far as we have found by gleaning through the literature, most stu-

[1] A shortened version of an illustrated lecture on this subject which was given as a part of the symposium on "Integration of Biological and Social Systems" at the recent Fiftieth Anniversary Celebration of the Univer-

dents of group organization in animals have been attracted to the subject primarily by the opportunity to study general and comparative sociology.

We have not been attempting an oblique attack upon group organizations of men; but while this is true, all of us who have worked with these problems have found our attention and curiosity caught by certain similarities between group organization in animals and some of the simpler phases of human society. Perhaps it will be such comparisons that will most interest the reader. I think it is wise for them to be made, providing that due restraint is exercised. In order to understand the integrations of human society we need to know how much is uniquely human and how much is, on the other hand, the specialized human development of a more generalized primate pattern, which derives from mammalian and lower vertebrate patterns which in turn are related to certain types of invertebrate social organization.

To be more specific, the social integrations of mice and hens, cattle, fish, frogs, lizards and turtles and many other animals have much in common with the organization of certain human groups. Without taking the comparisons too seriously, and leaving primary sex relations entirely aside, these similarities may help explain human social organizations; I would not say that the human social variant is justified either because it resembles or departs from the more generalized type.

The modern period in the study of social organization of groups of animals in which the individuals were in some way distinguished from each other was initiated by Schjelderup-Ebbe,[2] twenty years ago. A large descriptive literature has accumulated in this field and there has been a promising beginning of analytical work. Most of these studies have dealt with loosely caged flocks of various species of birds and the social order of the common domestic fowl has attracted particular attention. Reports of somewhat similar group organizations in nature are also beginning to appear.[3]

At Chicago we have been interested in these phenomena as one phase of the broad field of animal aggregations. We have studied the organization pattern in several different species of birds and in certain mammals, especially mice. The following discussion will be based mainly on the work at our own laboratory; not because it is most important, but because of our familiarity not alone with the results obtained but also with the observational and experimental errors and personal biases which may affect conclusions.

sity of Chicago. A more nearly complete account will be published, together with the other papers in that symposium, in a forthcoming volume of "Biological Symposia."

[2] *Zeitschr. f. Psychol.*, 88: 225–252, 1922.

[3] E. P. Odum, *Auk*, 58: 322–323, 1941.

One of the most regular social hierarchies which we have observed is summarized in Table 1.

TABLE 1

THE SOCIAL ORDER IN A FLOCK OF WHITE LEGHORN HENS

Individual	Number pecked	Individuals pecked							
BB	8	RG	RR	GG	BR	YY	BY	GY	RW
RW	7	RG	RR	GG	BR	YY	BY	GY	—
GY	6	RG	RR	GG	BR	YY	BY	—	—
BY	5	RG	RR	GG	BR	YY	—	—	—
YY	4	RG	RR	GG	BR	—	—	—	—
BR	3	RG	RR	GG	—	—	—	—	—
GG	2	RG	RR	—	—	—	—	—	—
RR	1	RG	—	—	—	—	—	—	—
RG	0	—	—	—	—	—	—	—	—

Such a social order among birds is based on what has come to be called peck-right. The higher ranking individuals are able to peck those of lower rank without themselves being pecked in return. This right is usually won at the first or at least during one of the early pair contacts between each two adult members of the flock either as a result of an active fight or by passive submission of one of the members of the contact pair.

Often the flock is not so simply and regularly organized. One of the most frequent irregularities comes when a low-ranking hen has the peck-right over some individual that outranks her in general social position. Another fairly common complication occurs when triangle situations arise in which *a* pecks *b*, *b* pecks *c* and *c* pecks *a*, and then all have the peck-right over those lower in the social scale. There is not space here to suggest all such variations or to discuss what is known about their causation.

The organization in a flock of hens represents a type of social pattern in which dominance, once won, is relatively permanent. At least one other type of social structure also exists among birds. With pigeons, doves, canaries and shell parrakeets, for example, although the flock organization is no less real, the outcome of any given pair contact is less predictable. Such flocks are organized on what may be called peck-dominance rather than on the more absolute peck-right relations that exist among hens and certain other birds. As was discovered several years ago[4] and confirmed more than once,[5,6] the peck-dominance type of social order is related in part to territoriality in that certain birds are dominant in one territory and subservient in another.

All group organizations among birds are apparently based on the ability of birds to recognize and remember their flockmates as individuals. When territory enters as a factor, recognition of the indi-

[4] R. H. Masure and W. C. Allee, *Auk*, 51: 306–325, 1934.

[5] H. H. Shoemaker, *Auk*, 56: 381–406, 1939.

[6] E. Diebschlag, *Zeitschr. f. Tierpsychol.*, 4: 173–188, 1941.

vidual's territory also becomes a part of the group reactions system. Shoemaker[5] has shown that the space available for a flock of canaries is a matter of importance. When they are confined in a relatively small space, the social order becomes relatively simple and definite; it is little complicated by territoriality. Given more space, individual territories tend to become established in which the territory holder is usually supreme, even though it ranks low when in the neutral ground about bath bowls, feeding trays and in the other areas of the canary public service system. Even a socially low-ranking male normally dominates other males in some restricted space about his nest.

In connection with the intermingling of territoriality and social dominance, there are available many unpublished observations made locally by Mr. Dale Jenkins and Mrs. Barbara Hale Brainerd which show that a family of blue geese, as a family, dominated pairs and single individuals of ducks and geese during the winter months, and defended the territory about themselves wherever they might be, on land or in the water. The defended territory was not precisely located, but moved with the dominant family.

When there is a recognition both of individuals and of territory it is impossible as yet to separate the two. In such cases the question concerns the extent to which the individual plus his territory is the unit in the flock organization, as contrasted with either the individual or the territory as the basic unit.

What are the long-run biological effects of group organization at the level of which we are speaking? And what are the known factors that make for dominance? Our observations on flocks of chickens and other birds and on groups of other animals throw some light on these questions.

As to the first: The results of the fact that the highest-ranking hens lead the freest lives and low-ranking ones are harassed can be shown, among other ways, by studies on egg production. Hens from the lower half of the peck-order lay fewer eggs than their more dominant sisters, even when both come from the same genetic strains.[7] The egg-laying performance of the submissive hens can be much increased by segregating them from their domineering sisters. This is half of the story.

The other half is concerned with the relation between the peck-order among hens and mating behavior. Mr. Alphaeus Guhl, of the University of Chicago, has kindly allowed me to make a preliminary announcement concerning some of his unpublished work on this subject. He has had experience with several cocks placed successively or in groups of four with different flocks of hens, and has found practically no correlation between frequency of copulation and the social status of the hen.

Mr. Guhl also determined the peck-order in different groups of cocks; again there was no significant relationship between the social standing of the cock in relation to his fellows and the frequency of his mating when introduced alone into a flock of hens who were well accustomed to his presence.

When, however, the four cocks of a given flock were all placed together in an uncrowded pen of hens, there developed a type of psychological castration of the low-ranking males which, in some individuals, became practically complete. The details of the whole complicated story have much interest. I can take space for only one example.

The cock Y stood second to R in the peck-order of the males. Y was sexually aggressive and successful in a rough, forceful way when he was alone with the hens. When the four cocks and seven hens were placed together, the *alpha* cock R would charge at Y and drive him to the roosts whenever Y approached the hens. Meantime the hens would all scatter and fly to any available perch. Y soon learned to spend less and less time on the floor and the hens learned to run when he came down to feed. Y lost weight during this period and his food hunger increased. For practical purposes Y was no longer sexually effective.

Interestingly enough, these birds show what we can call favoritism as well as antagonism. Thus the dominant R did not similarly persecute cock G but even allowed him to interfere with R's own courting, and that without punishment.

When Y was placed with another flock of hens he was uninhibited sexually. Placing cocks with strange flocks is known to increase their sexual activity. However, later, when Y was again placed alone with the hens that he had been conditioned not to tread, not only did he attempt to copulate less frequently than before he was psychologically castrated, but it was also found that the hens had been conditioned against allowing him to tread them.

Conditions such as I have been reviewing indicate that social position in the flock may affect the opportunity of a given male or female for leaving numerous offspring. Those high in their respective peck-orders have the better opportunity for becoming parents of the next generation, as a result of the hen's greater freedom for egg production and of the cock's freedom for copulation.

So much for individual selection as a result of social status. There is a still more important problem in selection to be outlined. Is an organized group sufficiently different from an unorganized one at this level so that selection of the whole lot can occur?

[7] W. C. Sanctuary, Master's thesis deposited in the library of Massachusetts State College, Amherst, Mass., 1932.

We are coming to realize that groups of animals and other more-or-less integrated population units can be selected somewhat as though they were individuals. In fact, some of us think that natural selection of such populations, rather than natural selection of individuals, is the important basis of evolution. There is no experimental evidence with regard to the selection of organized as contrasted with unorganized groups. I believe the problem is open to experimental attack and if we had had space available, such an attack would have been under way.

We shall turn from this to consider some of the factors that make for social dominance. Dominance-subordination patterns of behavior may be based on the recognition of other members of the flock as individuals to which a proper reaction must be made. This is the method which obtains in many social groups of men, and in all the flocks of birds which we have studied. Opposed to this is a type of impersonal behavior pattern such as is found in many of the groups of mice which have been studied in our laboratory, especially by Dr. Uhrich[8] and Mr. Benson Ginsburg. Impersonal group organization depends upon a kind of unoriented, generalized aggressiveness brought in contact with similarly unoriented lack of aggressiveness. This is a type of statistical relationship in which a very bellicose animal dominates its own or foreign groups as a result of his high degree of bellicosity. A dominance-subordination system of behavior with such a basis does not represent the same social mechanism as does one which depends on individual recognition, although the two systems may be related.

Small lots of male mice caged together develop a social order as just suggested which is based on relative aggressiveness and general fighting ability. The order is not as stable as that found among hens, but it is sufficiently stable to allow experimentation when this is carefully controlled.

In the work with hens and in early work with mice, there had been suggestions that a succession of victories tended to condition the individual to be victorious in the next contest, while a series of defeats had the opposite effect. Mr. Ginsburg and I turned to mice in order to make a direct test of this interesting lead.

The ease of experimentation was made greater by the discovery by Dr. J. P. Scott[9] of hereditary strains of highly inbred mice which differed decidedly in fighting tendencies and abilities.[10] Roughly speaking, we had available a belligerent strain which was black in color; a strain of pacific mice bearing white coats, and an intermediate agouti strain which generally lost to the blacks and usually won from the whites.

These differences in fighting prowess made it possible to expose a high-ranking mouse from the passive white strain to repeated defeats from the belligerent blacks, and then test the effects of such experiences by again staging intra-strain combats among the white mice. Or, on the other hand, an attempt could be made to "build up" a low-ranking brown or black mouse by repeated contacts with the submissive whites.

After some 60 fights among themselves, W 1 emerged as the dominant mouse of a group of five white males, and held that status during the next 140 fights. Since this order seemed to be stable, the time was ripe for experimentation. Accordingly, W 1 was matched with B 2, the *alpha* mouse of the aggressive blacks, twice a day for eight days. B 2 attacked aggressively even when W 1 was entirely passive. When again matched with his fellow whites, W 1 submitted to every opponent, including even the very passive *omega* white mouse. After some 180 fights among themselves, W 1 regained aggressiveness and again became dominant over the white mice. Even so, he remained passive when matched against even the least aggressive of the belligerent blacks.

Our experience with other mice indicates that if W 1 had met more active resistance from its own group, it would probably have been even slower to reassume aggressiveness. In fact, when W 2 was similarly conditioned downward and then returned to face the other white mice, it was attacked by the dominant W 1 and showed a submissive attitude toward all, until after a series of mild encounters with the *omega* mouse of these pacific whites it again became somewhat aggressive.

It is much easier to cause an intermediate mouse to lose social status by repeated defeats than it is to do the same with a dominant individual. Such an intermediate animal has already been partly conditioned toward submission as a result of losses to the more dominant members of its own group. When intermediate mice were conditioned downward and then kept from meeting dominant mice in their own group, they recovered social confidence just as a dominant individual does under similar conditions.

The dominant white mouse, W 1, was given a longer and more severe experience with repeated defeats. As a result he became so passive that he showed no resistance whatever, and throughout the ensuing two months, he was submissive to all the members of the group which he had formerly dominated. For a time he gave the submissive reaction whenever another mouse came near him; later, only when he was actively threatened. He continued, however, to give up immediately in the face of any show of aggressiveness

[8] J. Uhrich, *Jour. Comp. Psychol.*, 25: 373–413, 1938.
[9] J. P. Scott, *Anat. Rec.*, 78: No. 4. Supp., 1940.
[10] I am indebted to the Jackson Memorial Laboratory for the gift of these mice.

in another mouse. He regained aggressiveness after being isolated for four months.

Generalizing from a considerable extent of such experience, we have found that it is relatively easy to condition a mouse downward in its social scale, and that the longer and more severe the conditioning, the more lasting the results. We have found that it is also possible to so train a less aggressive mouse that it will become more dominant. This can be done even with low-ranking mice in the most pacific strain. But while it is possible, it is difficult to arrange social contacts such that a mouse at the very bottom of the group organization will show increased social aggressiveness. The training toward aggressiveness goes exceedingly slowly and must be modified to meet the nuances in the behavior of each individual. As in causing mice to lose social status, it is much easier to train intermediate mice to be aggressive than those which are low in the social scale.

One example must suffice. I choose this particular case since we have a motion picture record of the final battle of such a long conditioning series.

Br 6 was at the bottom of the social order among the agouti mice. He was almost completely non-aggressive. Finally Br 6 was mated; and low-ranking, passive white mice were introduced into his home cage. Br 6 had never before made an attack, but now, in the presence of his mate, he threatened and fought off the mild invaders. Even this show of aggressiveness did not carry over in the absence of a female, and it took six weeks of careful social manipulation combined with a judicious use of isolation, which in these mice helps to build aggressiveness, before Br 6 finally attacked one of the whites when the two were alone together in a neutral cage. After this he was made to encounter several low-ranking whites daily in the fighting cage, and as a result of the total build-up he became definitely aggressive.

The extent of his aggressiveness is indicated by the fact that within an hour after a defeat by B 1, the fightingest mouse we had, he vigorously counterattacked and defeated his immediate superior in the social scale among the agoutis. He also won from other superiors after we had taken the precaution to have these fights staged soon after the latter had been defeated.

Meantime we wanted a good hard fight for the motion picture record. B 2, the dominant black, had just suffered two of his rare defeats and was nursing a lacerated shoulder. Even so, he was an aggressive, hard-fighting mouse. Somewhat optimistically we matched Br 6 against him. It is fortunate that we have a visual record of one of the most decisive inter-strain combats seen in this laboratory. Br 6 lost but only after fighting so hard that he died a few minutes later. There can be little question of the efficiency of the upward conditioning in this case.

And now a few final paragraphs. The socially dominant animals we have been discussing may or may not be the leaders in their groups. The *alpha* hen in a penned flock does not necessarily lead in foraging expeditions when the hens are turned out into an open lot. In fact, in such a foraging flock leadership changes frequently and the bird at the apex seems always more or less dependent on her followers. With certain other birds, in the flying flocks of which the different individuals can be recognized, the one in front is at times merely the fastest bird in the flock. So far as true leadership is concerned, it is only following along ahead of the main flock. A somewhat similar relationship between leader and followers has been observed among other animals, notably with ants and with men.

In the female herd of cows the dominant animal is the leader. With certain species of deer the female also leads, even when males are present; with other species the male is the leader.

The final point I have to make is a disappointingly negative one: I have said that group organization with a dominance-subordination pattern occurs among a wide variety of vertebrate animals, but the bearing of these patterns on leadership is another matter. While we now know how to study the problem of leadership in an objective and comprehensive way, actually very little progress has been made in such studies upon non-primate animals.

We do know, from experimental analysis, that the dominance-subordination pattern of group behavior may be influenced by environmental factors and may have its foundations in (a) heredity, as shown by different degrees of aggressiveness in different genetic strains; (b) in the physiological state of the individual, one phase of which is illustrated by studies on the hormonal control of dominance; and (c) on experience which with hens and mice may be recent, or remembered from the relatively remote past.

OBITUARY

JOHN ALEXANDER McGEOCH

IN the prime of his career, occupying a position of leadership in American psychology, the life of Professor McGeoch was cut short by his untimely death in Iowa City on March 3, 1942. He died of a cerebral hemorrhage after a short illness.

Professor McGeoch was born in Argyle, New York, October 9, 1897. He received his A.B. degree from