restrictions on gene recombinations imposed by chromosomal rearrangements, form the basis for diversification both within and between species.

It might be well to compare some of these diverse characteristics as they appear in the different members of the species groups. In the *mulleri* group, two of the species live together in the same region and are much alike as to size and color pattern, but differ from each other in the color and size of eyes, in food habits and in length of life cycles, and are completely incapable of exchanging genes. In contrast to this, two other members of the group are separated geographically and differ widely in phenotype, but are readily capable of exchanging genes when brought together.

In the virilis group two distinct types are found, one of which lives in a domestic-type of habitat, the other in a wild-type habitat. The two types are therefore ecologically isolated and otherwise differ from each other in a number of morphological and physiological characters. The different strains of virilis, which represent the domestic-type, etherize very slowly, have clear crossveins, pupate on the sides of the container, have pupae which run the entire gamut of color variation from light-tan to deep black, and are fully cross fertile. The four wild-type species all etherize very quickly, have clouded crossveins, pupate in or at the edge of the food, have pupal color which is basically red, and are not fully cross fertile. Even within the wild-type group there are many character differences. Two of these species live in a region of severe winters in the high elevations of the Rocky Mountains and are readily distinguishable from the other two which live in a warmer climate in low wooded areas.

Some species groups are noteworthy for certain types of variation. For example, in the *pseudoobscura-affinis* complex of species extreme modifications of chromosome structure are common between related forms, but with little difference in phenotype. In the *mulleri* group modifications of phenotype are common, but differences in the chromosomes are absent between two of the genetically isolated species. The virilis group is remarkable among animal forms for having a clear case of hybrid origin of one of the species. The distinctness of the species in this group is in sharp contrast to the conditions found in the macrospina group. In the latter a series of genetic changes have accumulated so slowly across the distribution range that only the extreme ends may be regarded as distinct species.

The first of the fundamental problems propounded by Darwin was the question of the fact of evolution. This has been definitely established by a great variety of evidence from many fields of biology and geology. The second question as to how evolution actually operates is only now being elucidated, and toward the solution of this problem the contributions from the several investigations on the Drosophila species groups are playing an increasing role. It is no longer necessary to explain evolution by analogy, for the application of genetical and cytological techniques in this genus proves that it depends on experimentally measurable gene mutations.

STUDIES OF INFANT CHIMPANZEES

By HENRY W. NISSEN

YALE LABORATORIES OF PRIMATE BIOLOGY

ANNOUNCEMENT was made[1] in April, 1940, of an experimental chimpanzee nursery established at the Yale Laboratories of Primate Biology in Orange Park, Florida. The present report describes in greater detail the aims and methods of this program, and includes a brief account of progress to date.

Our primary general purpose in initiating this project was to provide and utilize infant chimpanzees in relatively large numbers as materials of psychobiological research. Heretofore very few specimens under one year of age have been available. Those few provided by dealers were invariably several months old and had limited scientific usefulness because of only approximately known age and ontogenetic history. Most of those born in captivity were, for obvious practical reasons, left with their mothers during the first year of life or longer and were therefore unavailable for anything but casual observation. The development in these laboratories, over the past decade, of a large and healthy breeding colony, gave the first opportunity, which may not soon be repeated, to undertake a relatively extensive study of young chimpanzees during the critical period starting at birth. Generous support by the Samuel S. Fels Fund, covering the special expenses of the project over a five-year period, made it financially possible to institute the program.

By making possible control and experiment, animal research has almost invariably pioneered in widening our biological horizons. The particular advantages of chimpanzees for investigations of characteristically human phenomena are fairly obvious. The extrapolation of discoveries by analogy and the examina-

[1] SCIENCE, 91: 336–337, 1940.

tion of relatively subtle differences (as contrasted to the search for broad principles of wider applicability), both demand a high degree of similarity in research materials. Use of the anthropoids opens the possibility of observing such phenomena in relatively uncomplicated form, tracing their more immediate origins or precursors, and of analyzing what is without doubt the most significant step in mental or behavioral progression to be found within the animal continuum.

The genetic method has proven its worth repeatedly in all fields of biological inquiry; its application in the present instance seems particularly indicated. An ontogenetic study of chimpanzee should not only add meaning to the phylogenetic comparison of the ultimate (adult) characteristics of man and the anthropoid apes, but should open up an entirely new dimension of comparison, that of the dynamics of developmental trends in the two species. It seems not unreasonable to expect that in the finer analysis of these diverging trends will be found essential clues to the critical differences which define the human and subhuman primate.

Two additional but definitely subordinate goals of the project may be mentioned: (1) The captured chimpanzee, purchased from a dealer, usually brings with him a host of intestinal parasites. Some of these parasites can be exterminated without much difficulty; others it is impossible or impracticable to eradicate, especially in larger specimens. Although it is conceivable that the wild chimpanzee does not suffer—perhaps even benefits—from the parasites, it is clear that in captive animals they constitute a hazard and probably affect, to an unknown degree, various life-functions. By removing infants from the adults at birth, infestation is prevented; with the institution of various precautions against subsequent contamination, it is hoped thus to build up gradually a parasite-free colony. (2) By eliminating the period of nursing, which in chimpanzees often persists for as long as two years, a speeding-up of the breeding rate is anticipated; instead of bearing one infant every two or three years, it may be that each breeding female can produce offspring at intervals half that long. This, together with better development and lower mortality of the laboratory-raised infants (as suggested by the record thus far), should increase significantly the number of laboratory-born chimpanzees available for research here and in other institutions.

Since it has been felt that the anthropoid apes could be employed most fruitfully in the investigation of phenomena which are distinctive of the highest primates, and since man is characterized most obviously and significantly by his behavior, the central focus of this program was clearly indicated. Our interest, accordingly, has been and is chiefly in experimental behavior analysis and in the correlation of behavior with underlying morphological and physiological factors. Our view-point, furthermore, dictates emphasis on the so-called higher mental functions (especially those seemingly mediated by symbolic processes), the secondary or derived forms of motivation and the more complicated expressions of emotion as seen especially in social behavior, rather than on relatively simple reactions which are perhaps essentially similar over a broad range of animal life.

It is clearly indicated, however, that approach to these most significant problems must be over the groundwork of preliminary information regarding basic growth phenomena in the species. After developing practicable and reasonably efficient routines for the care and feeding of infant chimpanzees, our first task, therefore, was to gather as large a body of facts as possible on the development of our subjects under these uniform conditions. No claim is made that these conditions have been "normal" or "natural"; doubtless they have fallen short of being optimal even for our purposes. In so far as considerations of health permitted, however, they have been essentially constant for all individuals. They were designed to promote healthy growth at not too great a cost in time and energy. During the first two years of life the animals are kept in individual cribs and cages. The problem of cleanliness has been solved by use of disposable diapers. Feedings are on a regular schedule decreasing in number from six at birth to four per day at age of thirteen weeks. The bottle formula is increased in strength, and new items of diet are added, at stated intervals. Except for special occasions, human contacts have been limited to four individuals: a female colored nurse, a white male assistant, Dr. Austin H. Riesen and the writer.

The schedule of tests, measurements and other records which have been made routinely, and with few exceptions[2] at the intervals indicated, of all members of the group, may be outlined as follows:

1. Body weight (daily at 10 A.M.).
2. Eruption of teeth (checked daily).
3. Fifty anthropometric measurements (monthly during first year of life, quarterly thereafter).
4. Physical description record of coat and skin characteristics (semi-annually during the first year, annually thereafter).
5. Photographic portraits in a standardized situation (monthly during the first year, bimonthly thereafter).
6. Radiographs (some parts monthly, others bimonthly, quarterly, semi-annually).
7. Food intake (each feeding).
8. Axillary temperature (three times weekly).
9. Pulse rate (three times weekly).

[2] The x-ray studies were not begun until fall, 1940.

10. Respiration rate (three times weekly).

11. Galvanic skin resistance (irregularly, under various conditions).

12. Activity records (usually continuous for 2 days or longer, at different ages).

13. Behavior tests—Gesell schedule with certain omissions and additions adapted to typically chimpanzee behavior (biweekly to the eighth week, every four weeks during the remainder of the first year, quarterly thereafter).

14. Records of behavior appearing in the nursery environment: locomotion of all kinds, vocalization, feeding habits, grooming activity, ticklishness, emotional expression, response to human contacts, ties and so on.

These "normative" data doubtless will have certain intrinsic interest and may be of value to various special branches of biological science. Our use of the results will be fourfold: (1) The data will provide base lines from which the effects of experimentally introduced variables can be measured. (2) They will be examined for intercorrelations of such "naturally" produced variations as weight and food-intake, health and bone "scars," behavioral and somatic development, parent and offspring characteristics, and so on. (3) The developmental trends manifested by the data will be compared to those of other species, particularly those of the human infant, and to the known characteristics of the adult chimpanzee. (4) Most importantly, perhaps, these results will raise questions for experimental investigation and will indicate the feasibility and significance of various lines of attack.

Since the program was initiated in July, 1939, there have been fourteen births at the laboratories, seven males and seven females. The infants were separated from their mothers soon (median, 17 hours) after parturition and were at once placed under the care of human attendants in the nursery. One male was returned to his mother 48 hours later, after the first series of tests, measurements and descriptions had been made; this animal will be the first of several "controls" who will serve to indicate the effects of our nursery environment as compared to the care given by the captive chimpanzee mother. One female was transferred to another laboratory at the age of two months. Another female died at the age of seven months; it seems highly probable that some innate weakness was primarily responsible for her death. The remaining eleven animals, the oldest ones now over two years old, are thriving in the nursery situation. The program is to include the first three years of life. The present members of the nursery will serve primarily as the "normative group," and with them the standard list of tests and measurements will be continued until they reach that age. Infants born hereafter are to be used experimentally, in accordance with the view-point and orientation presented above.

OBITUARY

HEBER D. CURTIS

THE scientific career of Heber D. Curtis began at a time when the old-line astronomy of position was being supplemented by the "new astronomy." His first important papers dealt with latitude work, eros observations, comet orbits; many of the papers after his ninth deal with astronomical spectroscopy. Dr. Curtis brought a broad and thorough training in fundamental astronomy to bear on the problems of the newer field, and the "new astronomy" has benefitted greatly, directly and indirectly, through his work and his counsel. His observations of stellar spectra extend over a decade and were accompanied by measurement and discussion, the system of Castor being one of the many interesting papers which he published in these years.

His work on comets was continued for several years, and the remarkable series of photographs of Halley's Comet secured by Curtis has yielded important results in the hands of himself and others.

The work which he himself rated most highly, and which has perhaps been of greatest usefulness, is the observation of nebulae. Curtis finished the survey begun by Keeler and discussed the results of the program in the Lick Observatory Publications. His general treatise on nebulae was published in the Handbuch der Astrophysik. This is an important document for any one who is interested in nebulae from any point of view.

From the beginning to near the end of his scientific activity, Curtis observed solar eclipses, taking part in the observation of eleven. In this work his mechanical genius and resourcefulness had room for full play. The discovery of the strong coronal lines in the infra-red is one of the important results of these many eclipses which has been ascribed to Curtis. Also any success which his party may have had was certainly due in part to his presence. The travel, visiting new places and meeting people of every race and culture were features of esclipse expeditions which he enjoyed and exploited to the full.

Heber D. Curtis was born on June 27, 1872, at Muskegon, Mich. At the University of Michigan he was granted the degrees of A.B. and A.M. in the years 1892 and 1893. The University of Virginia granted him the Ph.D. degree in 1902; and from the