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The Canine Teeth---
Normal Functional Relation of the Natural Teeth of Man

ANGELO D'AMICO, D. D. S.

Foreword

It has been my privilege to review the manuscript of Dr. Angelo D'Amico, devoted to a new concept of the function of mastication in man. In reviewing this manuscript, one is impressed with the forthright honesty displayed by the author in presenting his thesis. He has presented his findings with the single intent that the truth may be learned. Not to the slightest degree has an attempt been made to prejudice the reader or to close his mind. The reader is left entirely free either to accept or to reject these theories as the functioning of his individual mind may dictate. Only one with a true concept of the scientific approach could have produced this manuscript.

Science dictates that a theory should be presented as a clear-cut entity. Evidence in its behalf should be presented to the fullest extent and, thereafter, the reader left free to draw his own conclusions. The road to acceptance or rejection is to be left entirely open. Time, and time alone, will make the decision. If a theory is founded on truth, it will ultimately be accepted as factual, and it will then gain general acceptance. Conversely, if a theory is not fundamentally sound, it will, in time be rejected and then be forgotten. Thus, time is both the judge and the jury; the judge, in that a theory may be evaluated, and the jury, in that the theory will be accepted or rejected in accordance with the evaluation.

Dr. D'Amico has spent years of study dedicated to the establishment of the truth. He has done his work well and has displayed great ability in the manner in which he has documented and presented his thesis. Not by any stretch of the imagination can a claim be made that an unsupported theory has been presented in which the reader is bludgeoned by bombast, half-truths, and palpable concealment of the truth, into unthinking acceptance. He has also shown rare courage, in that he possesses the temerity to present theories in direct opposition to others which have been generally accepted. That his theories will provoke controversy is a foregone conclusion. Such controversy, in some instances, may be motivated to suppress the truth and to furtherance of untenable and unsound thinking.

Our forbears in the field of general science and in the more specialized science of medicine, those fearless men who had a true concept of science and a burning desire that the truth might prevail, amply attest the fact that time will invariably come to the support of truth, although progress be ever so slow and the pathway difficult. Let us all remember and take heart by the examples presented by Christopher Columbus, Galileo, Copernicus, and Sir Isaac Newton, in the field of general science, and Semmelweis, Pasteur, and Lister, in the field of medical science. All of these great pioneers were subjected to persecution, ridicule, and contempt on the part of their confreres. They all stood steadfast, in that they championed what they believed to be right. Time has vindicated all of them. Will Dr. D'Amico's thesis be accepted? Here, again, time will be the judge and the jury. His case is well presented and the balance in his favor is well weighted with a vast amount of evidence. The writer is certainly not a seer, nor is he clairvoyant. In this instance, he has studied a thesis which has been honestly presented without fear or prejudice, and he has drawn his own conclusions.

George M. Hollenback, D.D.S.

PREFACE

It has been apparent to the writer that all contributors on the subject of occlusion are in agreement that the subject is the very foundation of dental science. It plays the most prominent role in all our specialized branches of dental practice, yet, being a general practitioner, it likewise has been apparent to me that the theories expounded by the various specialists have not coincided with each other, nor do their theories conform to what is natural or normal for man.

I wish to remind the reader that the author is not an anthropologist. I have tried to interpret and apply in dentistry certain aspects of physical changes in the natural teeth of man which I believe reveal the normal functional relation as nature has intended it to be. There is no doubt in my mind that the basic principles (forming the foundation) of past and present theories have been the outgrowth of what many have seen in primitive or prehistoric man, the edge-to-edge bite of the incisors, and the lateral movements of the mandible. I have tried to present sufficient evidence to prove that this phenomenon was the result of function and various usage of the natural teeth.

It will be apparent to the reader that I am quite critical of those expounding the "balanced occlusion" theory. If so, it is only to emphasize our past errors as seen by the author. I hope that my effort will encourage some group or individual to initiate a sound research program to prove my findings either right or wrong. It will be one way of seeking and obtaining the truth, for the truth will not be found in past or present dental literature.

The reader should not at any time interpret my findings and conclusions as being significant or related in any way to the theory on the origin of man. The sciences of Anthropology and Paleontology may some day give us the answer to this question. Their progress and findings to date are proving to be invaluable in the study of man and his place in life. Future research and findings in these two sciences no doubt will reveal more evidence on man's evolution and behavior.

I wish to acknowledge my indebtedness to the following:

To Professor Theodore D. McCown, Curator and Professor of Anthropology, University of California at Berkeley. His patience, tolerance and advice during our many personal discussions helped tremendously in keeping me within bounds. To Professor E. W. Gifford, Director and Professor of Anthropology, also of the University of California at Berkeley for his assistance and kind courtesies. I am deeply indebted also to Professor Wilton M. Krogman, University of Pennsylvania for his constructive criticism, suggestions and comments. I dare say that he is greatly responsible for this third revision of the original manuscript.

To John S. Shell, formerly Professor of Physics, Chemistry and Metallurgy, College of Dentistry at the University of California for his assistance in editing and for his collaboration in resolving the forces involved in the mechanics of the masticatory apparatus; to Dr. George M. Hollenback of Encino, California for his comments, suggestions and encouragement; to Miss Margaret Klausner, Stockton City Librarian, whose encouragement to write actually started this project, and to two of her very able assistants, Miss Patricia Clark and Frank Jones, for their research and untiring efforts to obtain suitable books and material related to my research efforts; to Walter Banbrock D.D.S. of Auburn, California, whose efforts and assistance made it possible to conduct our field work with the Maidu Indians of Placer County, California; to Charles M. Guss, Chairman, Communications Division, Stockton College, for his able assistance in editing this paper; to Victor Duran, Life Science Photographer, University of California at Berkeley, for most of the photography work; to my son Paul for his assistance in the photography work; to F. Raymond Garvey, D.D.S. of Saint Paul, Minnesota, for the loan of a number of scarce reprints of Dr. Monson's early work; to Mrs. Violet Rey spokeswoman of the Maidus of Placer County, California, for her courtesies and cooperation in the study of the natural teeth of her people.

ANGELO D'AMICO, D.D.S.

Accepted Theories On Normal Occlusion Of The Natural Teeth Of Man

RESTORATIVE DENTISTRY
ORTHODONTICS

The most interesting and controversial subject in dental science has been that of occlusion. Since the early days of modern dentistry, members of various specialties in the profession have given us their picture of what they deemed the normal relation of man's teeth. It is interesting to note that each specialist has seen the problem from his own point of view. The prosthodontist has seen it in stability of dentures, the orthodontist in growth and development, and the periodontist in pathological changes of the investing tissues. Although they all sought a "normal functional relation of the natural teeth of man," each wrote in the light in which he was trained or specializing.

Consciously or unconsciously, the profession has been influenced by two basic factors. First, G. V. Black's introduction to his "*Dental Anatomy*" wherein he classifies teeth into three types: the herbivorous, carnivorous and omnivorous, and said that man's teeth were omnivorous, so designed as to be able to masticate all types of food. But, are man's teeth omnivorous, or is man himself omnivorous due to his struggle for survival?

The second factor influencing the study of occlusion has been the spheroid theory. This idea has been attributed to Dr. George Monson. The accepted theory has been that in functional translatory movements of the mandible with the posterior teeth in contact, the mandible describes a section of an arc of an eight inch sphere, and that all cusps and ridges of the occlusal surfaces of premolars and molars of one jaw glide smoothly against those of the opposing jaw. From this theory the prosthodontists have evolved the "working" and "balancing bite." The question then is: does this theory apply to man's teeth, or is it more applicable to the teeth of the herbivores? Is the anatomy of man's teeth that of the ruminant type or is it that of the primate and similar to the anthropoid? I do not believe that Black classified man's teeth as being omnivorous because they were a distinct type of a species of mammal, but rather to designate man as a mammal capable of adapting himself to any kind of diet.

For the past thirty-five or forty years we have been applying in practice certain theories in classification and function of the natural dentition of man without question. The writer believes that all theories should be open and subject to review from time to time until they have been proven true or false. The theory of the anatomy of man's teeth will be reviewed according to their morphology rather than according to function, while the theory of "occlusion" or functional contact of the teeth of one arch with their opponents will be reviewed from the standpoint of origin and evolution and the effect of function.

The writer hopes to present sufficient physical evidence to prove the accepted "balanced occlusion" theory to be false and contrary to the physical, biological and physiological factors involved in the process of mastication; also, that the overbite and interlocking relation of the canines determines the failure or, preservation of not only the periodontium but also all restorations supported by the natural teeth. However, before presenting such evidence pertinent to the subject, a general review and quotations concerning this subject as presented by a few of the many past and present writers is appropriate.

The writings of the prosthodontists, periodontists, crown and bridge and partial denture prosthetists, may be summed up as follows: movements of the mandible in all its excursions are controlled by the tempromandibular joint and its meniscus, capsular ligaments, muscles and ligaments; and in its functional excursions it describes a section of an arc of an eight inch sphere, and when the opposing teeth come in contact, all the cusps and ridges of the occlusal surfaces of premolars and molars of one jaw glide smoothly against those of the opposing jaw in all eccentric movements of the

mandible.

All the elaborations on the subject may be said to have been prompted by three basic observations of three individuals, Bonwill on the four inch triangle, Count von Spee on the curved occlusal plane of the premolars and molars, and George Monson on the eight inch sphere. Someone must have accused Monson of dressing up von Spees' work, for he devoted the better part of a special article defending his theory. (1)

As we analyze his articles, drawings and cuts we become aware that most of the cuts are an artist's attempt to illustrate a theory. (Figures 1 and 2). Other photos available cannot be said to show accuracy in recording or measuring actual conditions and dimensions. The specimens used to arrive at his conclusions do not present normal anatomy, but rather occlusal anatomy showing attrition not unlike specimens of primitive man with the edge-to-edge bite. But what we see in primitive man is not a normal condition; it is the result or effect due to adaption of the individual to an omnivorous diet and to many other uses to which primitive man put his teeth (Figures 3 and 4).

One observation of Monson's must be taken as a fact substantiated by evidence in evolution. Many writers on mandibular movements have taken the temporo-mandibular relation and condylar path as a fixed movement which can be recorded and reproduced on an articulator. Monson states otherwise, as follows :"Instead of studying the movements of the condyles independently to determine the relation of the two occluding surfaces of the teeth, we can,

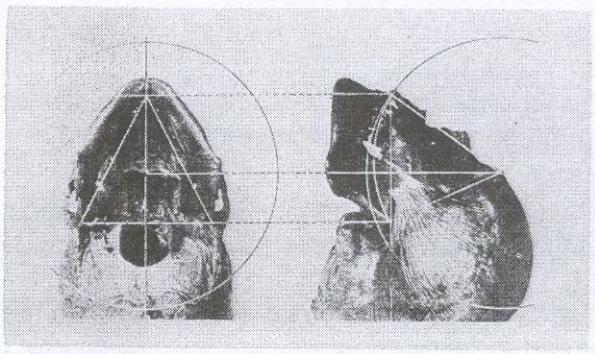

Figure 1. By Monson as shown in Dental Cosmos, November 1932.

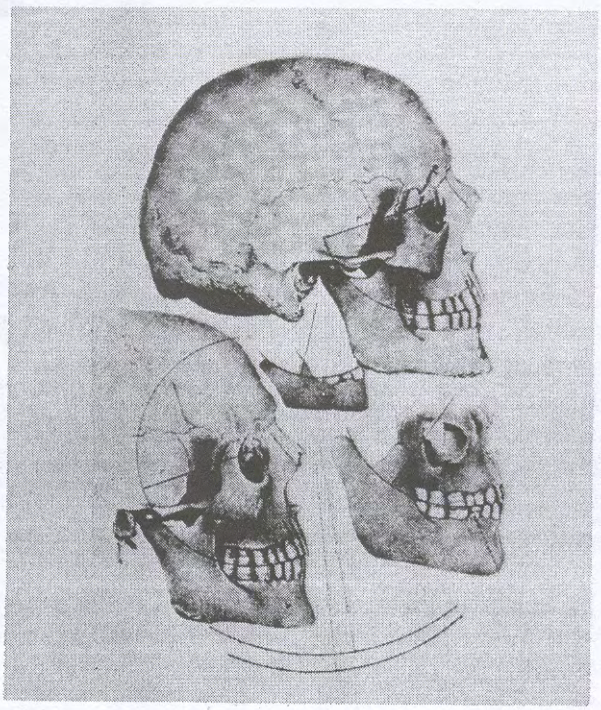

Figure 2. By Monson. As shown in Dental Cosmos, November 1932.

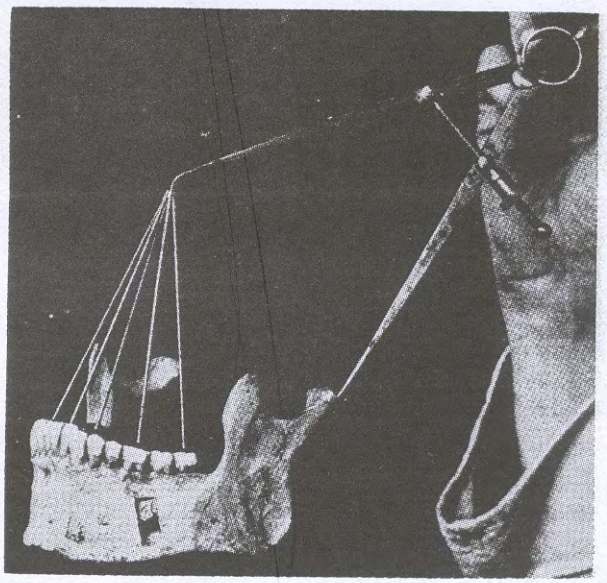

Figure 3. By Monson. As shown in Dental Cosmos, November 1932.

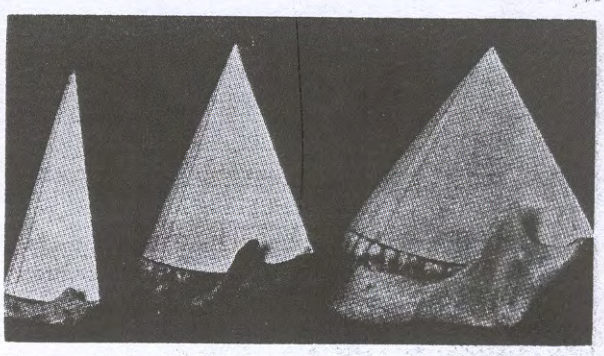

Figure 4. By Monson. As shown in Dental Cosmos, May 1927.

with check bites, go directly to the problem of occlusion. The movements of the condyles can be considered a result and not a guide. The guiding element in the mastication of food is the cusps of the teeth when the first contact is made with the opposing teeth. While the condyles guide the mandible to the first contact of the teeth, the major guidance is the teeth." (2)

The concept of the orthodontist as to what is the normal functional relation of man's natural teeth is of vital interest in the general practice of dentistry. It has been quite difficult to arrive at any conclusive concept as to what is normal. One of the most inclusive statements in this respect is attributed to A. LeRoy Johnson. Professor Samuel Hemley in his paper, "Occlusion—The Orthodontic Point of View," states that the works of Angle and Bonwill were hypothetical. (3) Also, he states that the first scientific approach to occlusion was by A. LeRoy Johnson in 1919. Hemley quotes Johnson as stating, "The concept of the normal dental arch is the foundation of modern dentistry. Although the dental arch is often referred to as being composed of the teeth and their supporting structures, a dogmatic definition of it does not convey a true idea of the nature of the conditions which surround all dental operations. The concept of the dental arch is not limited to a study of the morphologic characteristics of the teeth together with their supporting and surrounding structures. It is more comprehensive. It is a concept derived from a study of the action, reaction and interaction of different elements of the dental arch in the continual adjustment of life; it is a concept of the nature of living tissues as they stand in physiologic correlation."

This is all true, but, it is difficult to arrive at a conclusion as to what the "concept of the nature of living tissues as they stand in physiologic correlation" actually would be. The entire statement is meaningless to the general practitioner because the conclusion does not depict a normal functional relation of all the tissues involved. We cannot belittle the importance of the morphological characteristics of the teeth, their supporting structures, and their opposing functional relationship. The normal physiologic function and relation of all oral tissues is primarily dependent on such a relationship.

Hemley also presents his own definition of the science of Orthodontia as being "that branch of dentistry which treats of the forces controlling the form of the dental arch. The subject matter of the science of Orthodontia is derived from two phases of biology, heredity and environment, and is in the main a study of the fundamental truths and laws of science as they are expressed in the growth and development of the dental arch of the living human being; and the relation of these truths and laws to specific structural conditions. Orthodontia is essentially a science of form development." (3) Should form development of the individual arches be the sole goal of Orthodontia or should we not include the functional relation of the opposing arches including the functional relation of the opposing natural teeth?

Continuing in his paper, Hemley quotes Johnson again to mean "that normal occlusion is whatever condition of occlusal relation most effective in maintaining in its most stable form the equilibrium expressed in the life phenomena of the individual organism." This is broad enough to permit the orthodontist to exercise his own judgment as to what condition is most effective and select the most expedient means to obtain it.

One of the most severe critics of "expedient" practices in Orthodontia was the late Milo Hellman, former Professor of Dentistry in the School of Dental and Oral Surgery, Columbia University, and Research Associate in Physical Anthropology, American Museum of Natural History. One of his articles, "The Future of Orthodontia: A Present-Day Problem for the Orthodontist," edited by Professor William K. Gregory, Dr. B. W. Winberger, and Edith Hellman Bull, was enlightening to say the least in its candor and constructive criticism of his own specialty. To the general practitioner the following quotations should be of great significance: "At the Crossroads—What stands out clearly is that there is no unanimity in anything ortho-

dontic. There is no clear-cut mutual understanding of what is important, fundamental, and significant as there is none of what is immaterial, irrelative and unessential. As a consequence, all arguments are concerned with minor details in treatment of cases and desultory results attributed to faulty techniques. What constitutes success or failure is as little understood as the fundamental principles upon which technical principles rest. In the estimation of many, the crowding of lower incisor teeth, though occurring many years after a successful result in treatment, is considered as much of a failure as the dire result following incompetence and bungling. Resorting to extraction (the extraction of four teeth is now recommended) under such conditions may be a convenient way of covering over incompetence, but it does not justify mutilation of a complete dentition.

"The rationalization now rampant and used as a yard-stick is that the *end justifies the means*. But what is completely overlooked is the important demand that the end sought should conform to basic concepts in orthodontic aims, and that the means used should comply with fundamental principles in orthodontic practices. Progress is not made by preferences and expedients which violate both." (4)

The most significant statement in my opinion is that "what stands out clearly is that there is no unanimity in anything orthodontic. There is no clear-cut mutual understanding of what is important, fundamental, and significant as there is none of what is immaterial, irrelative, and unessential." This can well be applied in the field of restorative dentistry. The accepted theories of normal functional relation of the natural teeth (occlusion) have resulted in mutilation of many dentitions. Extraction of sound teeth for expediency in designing restorations is common practice. This is due to the effort being made to have man's natural dentition function in a manner that is not natural to the primate. The dental profession has been attempting to reproduce something that does not exist. In reference to normal occlusion, I. Louie Young expresses his observations in this manner: "Balanced occlusion of the human dental apparatus is that arrangement of the teeth of the maxilla and mandible which provides freedom from cuspal interference when the mandible is in centric, or any eccentric position, and which provides that all of the teeth in one jaw are in perfect co-ordination with all of the teeth in the opposing jaw—a condition which is *extremely rare* in the human apparatus." (5) Rare indeed: this relationship is *never seen* when we observe a natural dentition of an adult possessing a perfectly normal periodontium. Functional relationship of the opposing natural teeth cannot be said to be normal unless all supporting and adjacent tissues are in a normal state and physiologically correlated.

From the foregoing, we see that the Orthodontic view of normal occlusion is very flexible and subject to change. On the other hand, all other segments of dental practice have been following a fixed theory. An intensive review of dental literature on this subject indicates that the application of the theory has not produced the desired results. In other words, failure of restorations and periodontium has motivated these writers to try and find ways and means to justify its application. Were it not for failures, there would be no need to elaborate on any phase of the theory. Many have made intensive study of the temporomandibular articulation, believing that accurate registration and transfer of temporomandibular movements to an articulator would produce the desired results. (The tail wagging the dog approach.) Others have been attempting to equalize the forces of action and reaction. In this instance the guiding influence has undoubtedly been Maxwell's contribution in the field of dynamics. (6) This they refer to as equilibration. Splinting now seems to be the new thought; making use of a multiple number of teeth as abutments, all tied rigidly together. There is no doubt that every new approach to the solution of the problem stimulates thought and study, and this is quite desirable.

The approach to this problem by the writer may seem novel to most if not all members of the profession. It is a limited study of man and his place in life. The

study should be expanded and elaborated upon more fully. After all, man is our subject, and functions of the natural dentition is our specialty. We must take into consideration the physical and cultural changes that have taken place during his known existence and evolution, so as to better understand the changes and effects of function in the natural dentition and masticatory apparatus. The study of man alone, however, is not sufficient; it should also include a study of other members of the primate family.

The late Professor Earnest Hooton of Harvard referred to this subject as the study of primatology. He was of the opinion that the habits and behavior of man could better be understood if we make a close study of the living ape members of the primate family. He lauded the work of some anthropologists in this field, (Yerkes, et al) and deplored the declining interest in recent years. (7) With this advice in mind the physical evidence in paleontology and anthropology which will refute the "balanced occlusion" theory will include living and fossil specimens of man and ape.

Origin And Evolution Of The Natural Teeth Of The Primates Including Man

In the study of the Primates, we observe that the most dominating tooth of their natural dentitions, and the one which presents the greatest variation in dimension is the canine. However, its functional relation and position in the dental arch remains constant in all. Research in Paleontology and Anthropology as to the origin and evolution of the dentition of the Primates, including man, reveals sufficient evidence that the upper canines normally overlap and interlock between the lower canine and first premolar.

The most universally accepted theory on the origin and evolution of the natural dentition of the Primates is that which Dr. William K. Gregory compiled in book form in 1922, the title of which is "Origin and Evolution of the Human Dentition." (8) In this volume Dr. Gregory gives a comprehensive summary of the evolution of the locomotor apparatus and its general relation to the skull and dentition, from the primitive reptilian to the human stage. The seven stages he outlines start in the Carboniferous and end in the Midmiocene age. Expressed in geological time it covers a period from approximately 250,000,000 years to 25,000,000 years ago. Briefly summarized the seven stages including that for man are as follows:

Stage One: Primitive reptilian represented by lizard-like reptiles of the Carboniferous, Permian and later ages. The body is elongated, dragged or propelled near the ground. The limbs are held out at the elbows and knees and the extremeties are pentadactylate with spreading digits. The neck is short, the skull large and more or less like that of a lizard. It is slightly bent upon the vertibral column and the face is elongated. The teeth are numerous and food habits are carnivorous or insectivorous.

Stage Two: Advanced mammal - like reptiles of the Triassic. The body is well raised off the ground in walking, but the elbows and knees are still turned outward. The skull is opossum-like with carnivorous-insectivorous dentition.

Stage Three: Primitive amphitherium-like mammals of the Triassic age. The skeleton is unknown but very probably of primitive placental type of pentadactylate extremities including a more or less divergent first digit in hand and foot. The dentition is that of a primitive insectivorous type. The dental formula for this specimen is as follows:

$$I\ \frac{5}{4}\ C\ \frac{1}{1}\ P.M.\ \frac{4}{4}\ M\ \frac{7}{7}$$

Stage Four: A primitive lemuroid (nocturnal monkey-like mammal; arboreal) primate of the Eocene (45,00,000 to 70,-000,000 years ago). The habits were arboreal, skeleton adapted for leaping, climbing and perching in trees. The extremities were quadramanus (four hands), with strongly

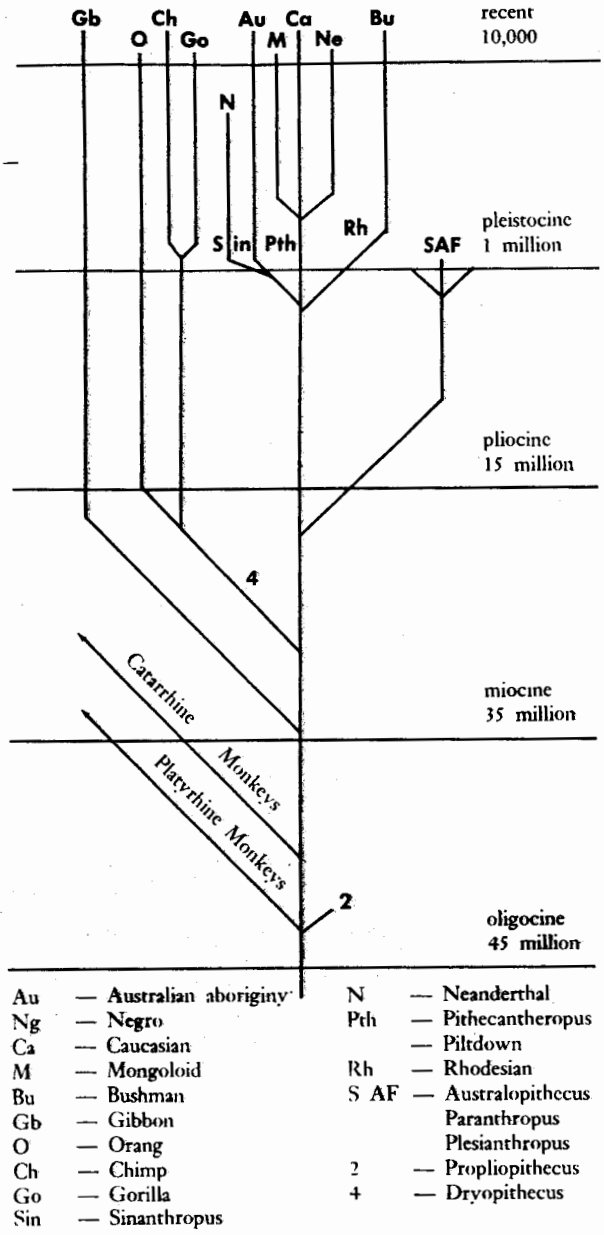

Figure 5. Redrawn from "Men and Apes: Four Family Trees," Hooton 1946, in Anthropology by A. L. Kroeber, copyright, 1933, 1948, by Harcourt, Brace and Company, Inc.

divergent first digit in the foot. The skull was like that of Notharctus and the dentition was adapted for a mixed diet of insects, fruits, eggs, small birds, etc. This species presents a definite dental formula of two incisors, one canine, four premolars and three molars

$$(I\ \frac{2}{2}\ C\ \frac{1}{1}\ P.M.\ \frac{4}{4}\ M\ \frac{3}{3})$$

(General Mammal)

STAGE FIVE: Ancestral catarrhine Primates (old world monkeys) of the lower Oligocene age (40 to 45,000,000 years ago). The fossil remains of the locomotor skeleton have not yet been discovered, but all their modern descendants have the important power of sitting more or less upright on the ischial tuberosities. This habit encourages the use of the hands to assist the lips, tongue and teeth in the manipulation of food. The cranium was carried at moderate angle to the vertebral column. The optic and auditory parts of the skull probably were well developed but not excessively enlarged. The muzzle was short and the dentition was much as in the Parapithecus with the dental formula of

$$I\ \frac{2}{2}\ C\ \frac{1}{1}\ P.M.\ \frac{2}{2}\ M\ \frac{3}{3}$$

(note that the dental formula is the same as in the primates of today). The incisors were simple with a lingual cingulum, the canines small and not enlarged for offense or defense. The premolars were more or less bicuspids and the molars had low rounded cusps . The upper molars were quadritubercular and the lower molars were quinque-tubercular. Diet was mixed: insects, fruits, eggs, etc.

STAGE SIX: Primitive Anthropoid Apes of the Miocene and Pliocine Age (20 to 35,000,000 years ago) of India, Egypt and Europe. Again, the locomotor skeleton remains to be discovered, the chief parts known being the jaws and isolated teeth, but there is strong indirect evidence afforded by the existing anthropoids and humans that their more primitive Miocene ancestors were already acquiring the enormously important ability to brachiate or swing from branch to branch with the body suspended from upraised arms. The foot probably had a grasping first digit. Erect progression on the ground and upright sitting posture were both more or less highly developed. The skull was sharply deflected on the vertebral column. The upper jaw deepened obliquely forward and downward beneath over-growing frontal portion of the skull. Diet was mixed with large fruits with tough rinds, insects and small animals. The central incisors, not much enlarged in primitive forms, were becoming very wide in orangs and chimpanzees. Teeth: both upper premolars are biscuspid; first lower pre-

molar with more or less sloping, enlarged antero external face and compressed cusps which shears behind enlarged upper canine. First and second upper molars quadrate with low cusps, becoming wrinkled in orangs and to a less extent in the chimpanzees. Lower molars with "Dryopithecus pattern" of five cusps.

In the modern anthropoids the head is supported on top of a more or less erect vertebral column, especially in the sitting or squatting posture. Locomotion, even on the ground is no longer quadrupedal in the primitive way, the chimpanzee and gorilla frequently balancing the body from the hips and touching the ground with more or less folded hands. Thus, the anthropoids, in acquiring the mode of locomotion called "branchiation," diverged from the primitive catarrhine mode of progression on all fours, and made possible the adoption of fully bipedal habits.

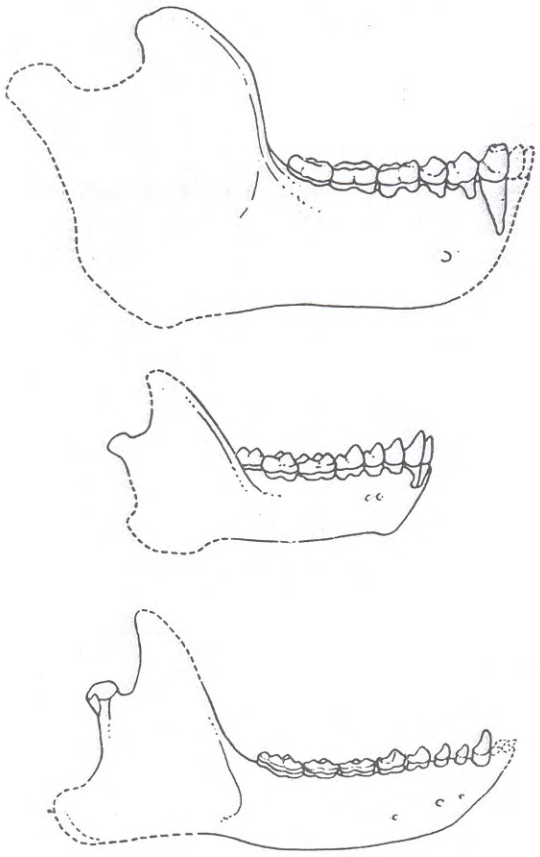

Figure 6. Evolution of the human mandible, lateral view. Lower: Northarctus osborni. Center: Parapithecus froasi. Lower Oligocene, Fayum, Egypt. Upper: Propliopithecus haeckeli. Lower Oligecene, Fayum, Egypt. As shown in "Origin and Evolution of the Human Dentition, 1922, Williams and Wilkins. Courtesy of Dr. Wm. K. Gregory.

It will be noted that in this stage of evolution (Dryopithecus) the dental formula of two incisors, one canine, two bicuspids and three molars has been established. (Notes by Krogman called the attention of the writer to the fact that the number of

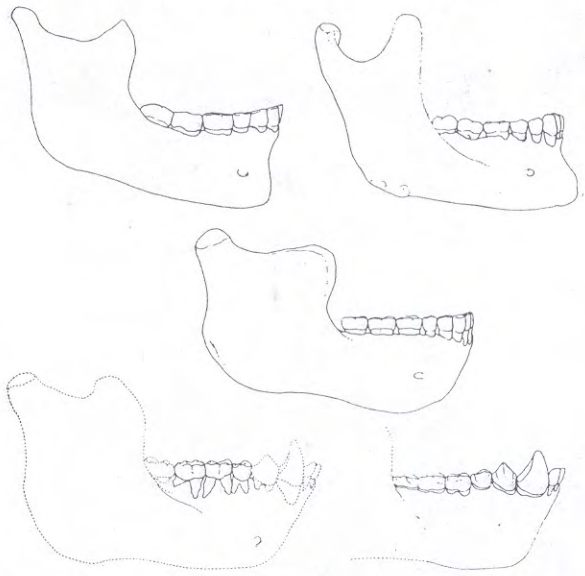

Figure 7. Evolution of the Human mandible. (Cont.) Lower Right: Dryopithecus. Miocene. Lower Left: Sivapithecus. Miocene. Center: Homo heidelbergensis. Lowest huma type, Pleistocene, Germany. Upper Left: Homo Sapiens australianus. Low human type. Upper Right: Modern man. As shown in Origin and Evolution of the Human Dentition 1922, Williams and Wilkins. Courtesy of Dr. Wm. K. Gregory.

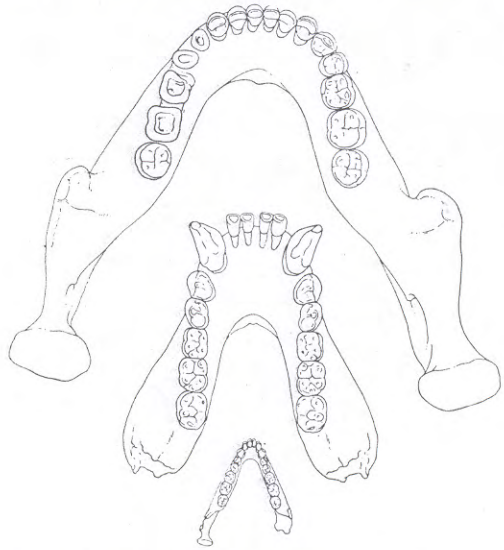

Figure 8. Evolution of the human mandible. (Cont.) Lower: Parapithecus. Super-tarsoid stage. Center: Dryopithecus fontani. By Smith Woodward, 1914. Upper: Homo heidelbergensis. As shown in "Origin and Evolution of the Human Dentition," 1922, Williams and Wilkins. Courtesy of Dr. Wm. K. Gregory.

canines has been constant. From the Triassic mammal-like reptiles to the present there has always been one canine tooth, whereas the incisors, premolars and molars have gradually diminished in number. He refers to the canine as the "guide tooth.") (9) Likewise, we note the enlarged and overlapping upper canine. Probably it was used more for the preparation of food for mastication rather than for offense and defense. The basic or fundamental anatomical forms of the teeth have been developed for an insectivorous, frugivorous and carnivorous diet, and are quite different from the herbivorous. Fundamentally, man's teeth still possess the specialized anatomical form for a frugivorous-carnivorous diet, even though some modifications in size and form have taken place since the Miocene period. Figures 6, 7, 8, 9 and 10.

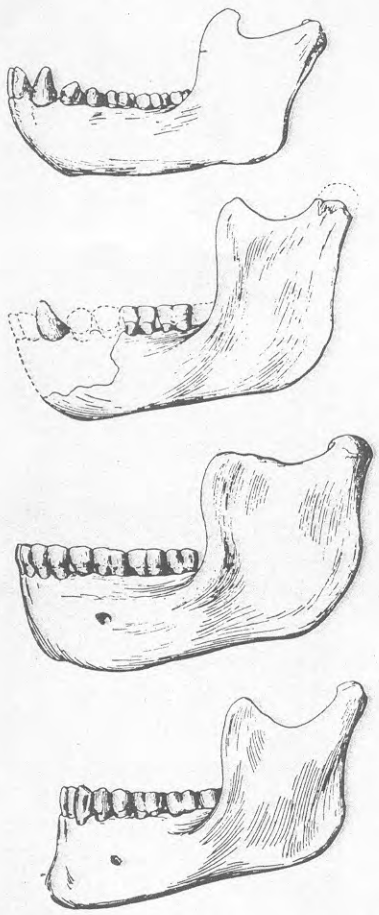

Figure 9. Evolution of the human mandible and teeth. (Cont.) Upper: Modern chimpanzee. Second: Piltdown. (This has been recently proved to be a hoax.) Third: Heidelberg jaw. Lower: Modern man. As shown in "Origin and Evolution of the Human Dentition," 1922, Williams and Wilkins. Courtesy of Dr. Wm. K. Gregory.

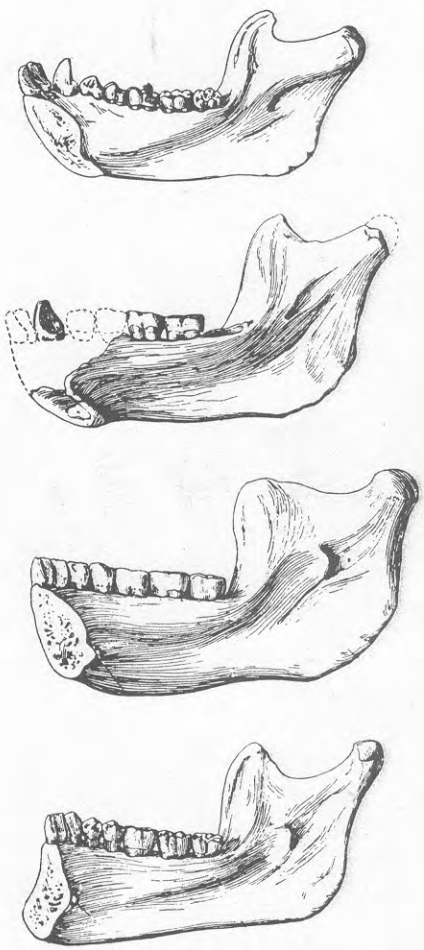

Figure 10. Same as Figure 9, Lingual view. Courtesy of Dr. Wm. K. Gregory.

The Living Apes: Dietary And Eating Habits

The teeth of the chimpanzee and gorilla of today have not changed a great deal from those of the Miocene. Figures 11 and 12. They still live in practically the same environment and the natural food of fruits, berries and tender shoots is readily available. In a comprehensive study of the chimpanzee of today (in captivity), Robert Yerkes makes some very interesting observations as to its eating habits and diet, which are quite pertinent to the study of function of the teeth of the Anthropoids,

such function being not unlike that of man. From his book "The Great Apes," I would like to quote a few excerpts from chapter nineteen, entitled: "Habits of Eating and Drinking, Hygiene and Care in Captivity of Chimpanzee." (10)

"Oftener perhaps than any other question, those who have chimpanzees in captivity are asked, "What do they eat?" Our reply is: "What they are taught to, as do we!" *This is an intimation of our conviction that the selection, acceptance, or rejection and manner of eating foods are chiefly matters of habit, and therefore, individually determined.* Our experience suggests that the chimpanzee may be taught to eat anything which is not positively injurious. ("Is this not like man?") With these remarks we preface our account of the foods and the feeding behavior of the animals, because it is so generally assumed or implied that choice and manner of taking foods are instinctive and characteristic for a species.

"Eating and drinking are as engaging for the chimpanzee as for man. Therefore, these patterns of behavior have peculiar importance in the life of the organisms and for approach to a variety of psychobiological problems. Neglecting historical perspective, since little was certainly known about the subject save from observation of captives prior to 1850, we note in quick transition to more recent work to observations recorded by Savage nearly a century ago. The dietary articles enumerated by this authority are: the tender foliage of certain trees when preferred fruits are scarce; fruits like the Elais Quiniensis, the Palm nut, various 'plums', only one of which is known botanically, the Parinarium excelsum, the Carica papaya, which is its favorite, the Murs Sapientium and paradisiaca, and three species of Amomura, A. azfellii, A. grandiflorum, and a third undescribed; and yet others which Savage did not identify.

"The strong development of the canine teeth in the adult would seem to indicate a carnivorous propensity; but, in no state save that of domestication do they manifest it. At first they reject flesh, but easily acquire a fondness for it. The canines are early developed, and evidently designed to act the important part of weapons of defense. When in contact with man, almost the first effort of the animal is to bite. (This paragraph was quoted by Yerkes from Savage and Wyman 1843-44 pp. 382-383).

"The dependence of the wild chimpanzee upon vegetable foods, affirmed by Savage, has been abundantly confirmed by direct observation of feeding animals and by the examination of the stomach contents of cadavers. The reader who desires an admirable review of the evidence, with citation of authorities, will find such in the

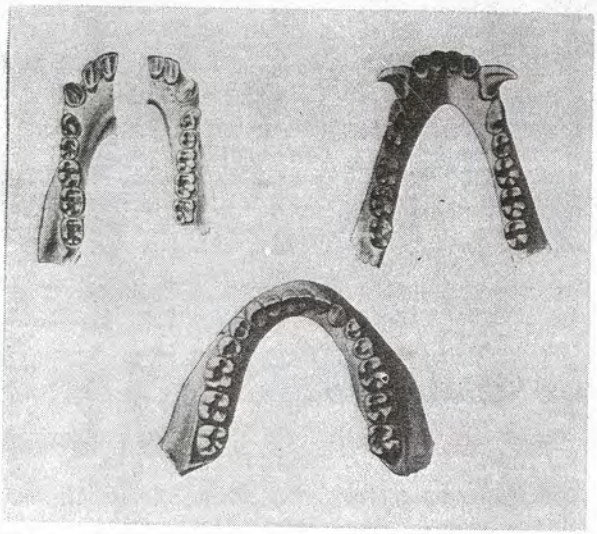

Figure 11. Upper left: Mandible of chimpanzee. Upper Right: Mandible of Gibbon. Lower: Mandible of Man. Courtesy of Dr. Wm. K. Gregory.

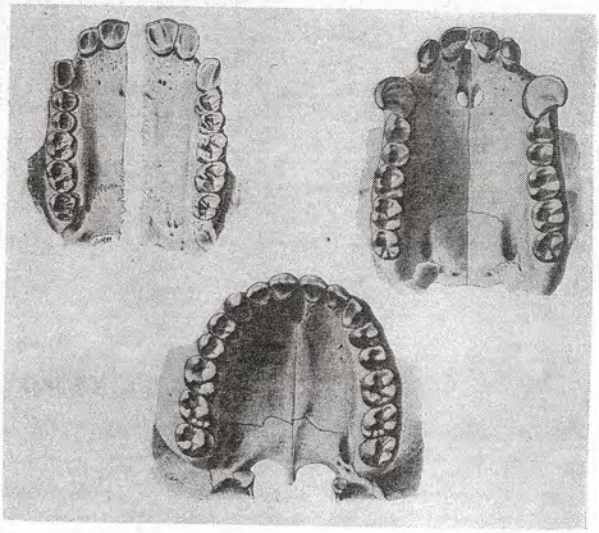

Figure 12. Upper Left: Maxillary teeth of chimpanzee. Upper Right: Maxillary teeth of Gibbon. Lower: Maxillary teeth of Man. Courtesy of Dr. Wm. K. Gregory.

paper of Reichenow, previously mentioned favorably because of its description of nest building. (Reichenow, 1920, pp. 23-27).

"Reichenow states as his conclusion that the chimpanzee is exclusively vegetarian (P. 23). We believe that the evidences necessitate qualification of this statement of substitution of such as the following: Although primarily a vegetarian, the chimpanzee does not necessarily reject animal products and may take and devour not only eggs but insects and small animals. The literature indeed proves that the only point on which serious disagreement has arisen is that of carnivorous habit. There are those who with Reichenow argue for strict vegetarianism, and others who accept as established fact the extreme partiality of certain individuals, and perhaps also species, to animal products. To the question, is the chimpanzee partially carnivorous in nature as in captivity, and do normal growth, health, and longevity demand animal as well as vegetable products, Savage, as indicated above, has given a negative reply. Meat eating, in the light of observations, is to be considered an accident of captivity. A similar position is maintained by von Oertzen (1913, p. 13) and other authorities. But von Koppenfels (1877, p. 418) on the contrary states that although the wild individual relies chiefly on vegetable products, it does not always reject eggs and small living animals. The case for the affirmative is presented strongly, although not in our judgment convincingly, by Falkenstein:

"In spite of the widespread prejudice one need not be concerned over giving flesh in any form to a species of ape. They teach us this themselves, if we have an opportunity to observe them in the open, since with eagerness they try to catch insects, especially spiders and grasshoppers, and also to obtain birds and eggs. Rats are a delicacy for chimpanzees which they energetically defend against the encroachment of companions, and equally the gorilla requires meat to keep him in good condition. If, in the forest the chase is unsuccessful, he must often content himself with fruits. In the stomachs of two chimpanzees which we killed I found only vegetable remains,

Figure 12A. Skull of the Gibbon with mandibular teeth in centric occlusion. Courtesy of Dr. T. D. McCown.

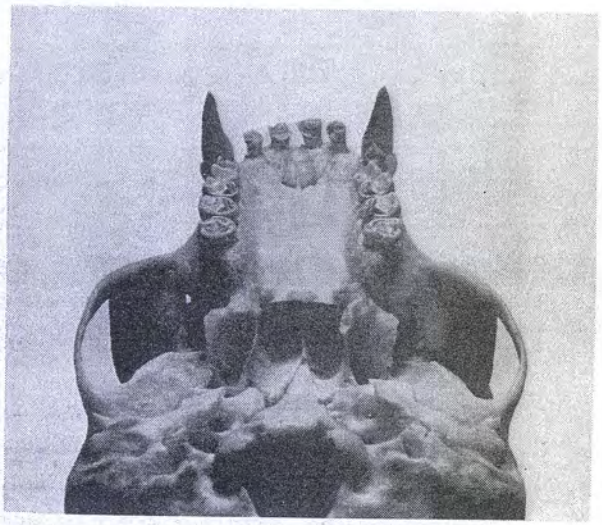

Figure 12B. Maxillary teeth of the Gibbon. Courtesy of Dr. T. D. McCown.

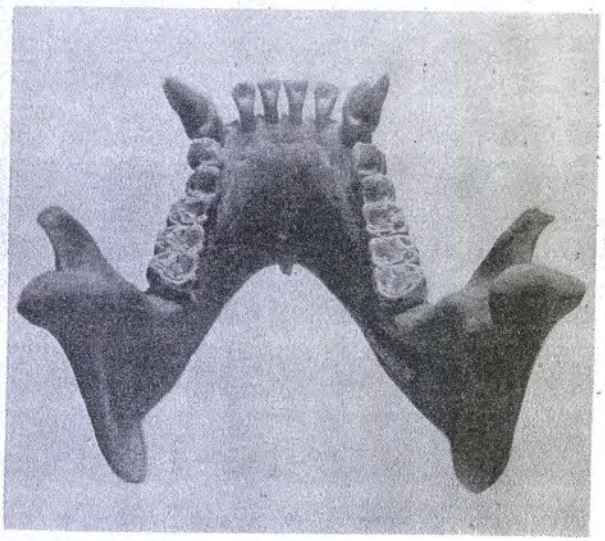

Figure 12C. Mandibular teeth of the Gibbon. Courtesy of Dr. T. D. McCown.

yet I am convinced that this was merely accidental and that under other circumstances one might readily find proof of animal food. (Falkenstein, 1879, p. 151).

"Meat eating in captivity has several times been reported. We cite an instance, which already has repeatedly appeared in literature, concerning a bald-headed specimen named Sally, sometime resident in the London Zoological Gardens. Superintendent Bartlett from personal observation reports thus interestingly what would appear to be a dietary vagary with associated peculiarities of feeding behavior! 'Again the habits of this animal differ entirely from those of the well-known or Common Chimpanzee. She has always shown a disposition to live upon animal food. Soon after her arrival I found she would kill and eat small birds, seizing them by the neck, she would bite off the head and eat the bird—skin, feathers and all; for some months she killed and ate a small pigeon every night. After a time we supplied her with cooked mutton and beef-tea; upon this food she has done well. I have never found any ordinary chimpanzee that would eat any kind of flesh.

'Another singular habit was the producing pellets or "quids", resembling the castings thrown up by Raptorial birds; I have here a few of them, taken from her mouth. They are composed of feathers and other indigestible substances, that had been taken with her feed. Moreover, she is an expert rat catcher, and has caught and killed many rats that had entered her cage during the night! (Bartlett, 1885, p. 674).

"Dietary requirements in the chimpanzee, as in other animals, change radically with age. Similarly, there is adequate reason to maintain that the requirements of different species, type, and individuals vary with environmental conditions. It is not particularly surprising that certain captive specimens should take to meat eating, but this far from proves the prevalence of such habit in nature. However, the extension and improvement of naturalistic research should presently exhibit the facts. In the meantime, we present as tenable the statement that this animal is a vegetarian and only under exceptional conditions adds to its dietary animal products. Furthermore, the latter are unnecessary to normal growth, health and reproduction.

"Those who keep the animals for exhibition purposes as a rule rely on vegetables, fruits, eggs, and milk as dietary staples. Rarely they supplement these with cooked meats. Relatively few experienced observers or keepers consider the latter essential to growth and health. According to Rothmann and Feuber (1915, p. 11) the chimpanzees of the German Anthropoid Station at Tenerife, the Canary Islands, were maintained on vegetables and fruits. Especially mentioned are bananas, bread, potatoes, tomatoes, although undoubtedly a greater variety of vegetable products, including other parts of plants, was supplied. Marked individual preferences are reported by these observers, and also the fact that many articles were consistently refused by certain individuals, although eagerly taken by others. It is evident from records of this station, as from our own observations, that at the dinner table of the chimpanzee, as at our own, accidents of appetite and habit are commonplace."

From the preceding observations by Yerkes, we note that the natural diet of the Chimpanzee is non-abrasive and it is easily cut and crushed by the simple vertical action of the temporal and masseter muscles. However, we also note that the Chimpanzee in captivity can adapt itself to an omniverous diet just as can man. The enlarged canines of the Anthropoids serve to guide the Mandible into centric position, thus eliminating the exercise and development of the Internal and External Pterygoid muscles. Such lack of development is shown when comparing shape and size of the ramus and body of the mandible of the Anthropoids as compared with that of man.

The Fossil Apes (Man-Apes)

In the Seventh Stage of Evolution of the natural dentition of man, Gregory points out that certain evolutionary changes have taken place in the skeleton and skull which would indicate that it is quite possible that the forerunners of Hominid and

Homo-Sapiens could have been arboreal or semiarboreal primates. For instance, the gradual changes in shape and length of the bones of upper and lower extremities of Homo-Sapiens indicate a gradual change from the stooped posture to that of complete erectness as we see it in man today. The change in the shape of the skull from the ovoid to the round, and the change in the position of the foramen magnum at the base of the skull from the posterior position to the more or less central position also gives evidence of the gradual change in posture. We note also, gradual changes in the shape of the nares, maxillae, and mandible which affect the position of the teeth in the dental arches. Viewing the position of the teeth as seen in Hominid, we note a forward sloping direction of the upper and lower incisors with the upper incisors edge to edge with the lowers, with the possible exception of the teeth as seen in Pithecanthropus Robustus. (Fig. 13). Generally, Pithecanthropus Erectus and Pithecanthropus Robustus have been accepted as the first specimens of true man. However, in recent years, Dart's and Broom's discoveries in the Transvaal in South Africa, designated as the Australopithecinae specimens, may or may not shed some light in evolution which may or may not be associated with the evolution of Pithecanthropus. These South African specimens, so far, have not been accepted as being Hominidae but have been classed as being man apes.

Gregory and Hellman, in their report published in American Dental Association Journal V. 26 Pt 1—January-June, 1939, present an excellent comparison in the function of the teeth of Australopithicanae with that of the gorilla and apes, as follows: (11)

"The lower molars of apes and primitive men show various modifications of what we have called the Dryopithecus pattern, because this pattern is seen in its primitive form in the fossil ape of that name. On the outer side of each lower molar, there are three main cusps, numbered in our system 1, 3, 5. Number 3 is bounded on its inner slope by two grooves that form a V and the tip of the V is continued to the inner side of the crown, forming a Y. Cusp 2 lies in front of the stem of the Y; cusp 4, behind it. In primitive apes, cusp 3, of the outer row, is in contact on the inner side with cusp 2; in advanced specimens of modern man, cusp 3 loses its contact with cusp 2 and gains a broad contact with cusp 4. Cusp 5, which is prominent in apes, is often reduced or lost in modern man. By these changes, the Y pattern of Dryopithecus becomes transformed into the plus (+) pattern of modern human molars. Cusp 6, which is barely indicated in typical apes, becomes prominent in some men.

"In the lower molars of the South African man-apes the Dryopithecus pattern is still recognizable, but it is beginning to assume the appearance of the human plus pattern. Cusp 6 is very large, as in certain men. The chief difference from early man

Figure 13. Skull of Pithecanthropus Robustus. Reconstructed by Dr. F. Weidenreich. As shown by W. E. Le Gross Clark, History of the Primates 1950, British Museum of Natural Hist

is in the relatively enormous size of m_2 and m_3.

"The data for the reconstruction of the upper dental arch, within rather narrow limits of error, which, we believe, will withstand critical analysis, are given in our fuller report. Suffice it to say here that our reconstruction shows the upper dental arch of Plesianthropus transvaalensis as a structural link between those of the ancient Siwaliks stem-ape, Sivapethecus sivalensis, and primitive man, as represented by Professor McGregor's reconstruction of the upper dental arch of the Heidelberg man, which was made to fit the known lower dental arch.

"The crowns of the lower grinding teeth of the South African man-apes when well worn, present nearly flat surfaces, as in man; whereas those of apes show steep elevations, especially on the inner side. This means that in these structurally intermediate forms, the small size of the canines and the lowering of the cusps of the grinding teeth were making possible the hard-gripping, hard-grinding actions that are indicated in well-worn dentitions of Australians, Eskimos, American Indians and others that chew tough or gritty food. (Figures 14-15-37-38.)

"Modern apes use their sharp canines to pierce and hold tough fruits, bamboo shoots, sugarcane, etc., which are cut into small bits by the more or less sharp-crested molars. *Primitive men use their small, almost incisor-like canines to grab and hold parts of the carcasses of animals, and their nearly flat-topped molars to grind flesh, small bones and grain.* The South African man-apes were in an intermediate structural stage. As they lived in open country which was much the same as it is today, they may have chased away the vultures and hyenas and filled themselves with the noisome remnants of the lions' feasts. From the abundance of broken baboon skulls in their caves, Dr. Dart long ago suggested that his Australopithecus killed the baboons and broke open their skulls to get at the brains. A gorilla's food habits are widely different from those of primitive man, the gorilla being nearly exclusively a fruit-eater. Nevertheless, the gorilla's digestive tract

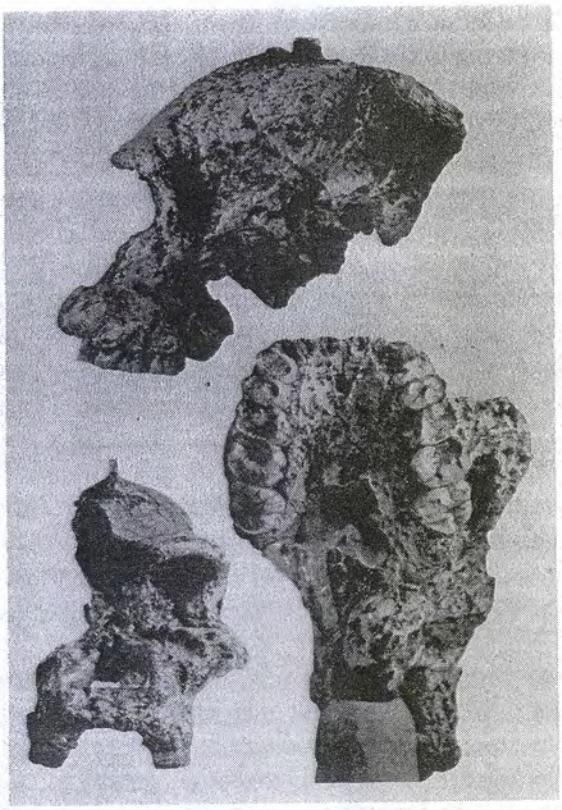

Figure 14. Paranthropus Crassidens. (Australopethicenae) Fossil man-ape of the Transvaal. By Broom. Transvaal Museum, Pretoria, Union of South Africa.

Figure 15. Paranthropus Corassideus. (Austratopethicenae) Fossil man-ape of the Transvaal. By Broom. Transvaal Museum, Pretoria, Union of South Africa.

and all its appendages are almost identical with the corresponding parts in man, except in proportions. *The transitional conditions in the dentition of the South African manapes suggest that there was a gradual shift from frugivorous to omnivorous food habits.*"

As to the geological time in evolution in which the Australopithecus existed, Dart, states: (12)

"Geologists are unable to inform us precisely that the Taungs deposit is Tertiary; but the bias of evidence is clearly in that direction. Both du Toit and Broom (Broom, '30) "have independently suggested that the deposit is quite likely to be Pliocene as Pleistocene." Until other evidence is forthcoming our inferences as to the age of the deposit must logically be based upon the paleontological evidence and its intrinsic consistency. All the forms of life found are primitive forms and those available in sufficient anatomical detail to enable us to speak with confidence: i. e. Australopithecus and Papio, are types related morphologically and in an ancestral way to living types.

"But even if the Pliocene age be regarded as tentative, the nature of the deposit is agreed. It is a brecciated cave deposit of creatures which were unquestioned "inhabitants of unforested regions." Australopithecus was terrestrial, troglodytic and predaceous in habit—a cave-dwelling, plains-frequenting, stream-searching, bird-nest-rifling and bone-cracking ape, who employed destructive implements in the chase and preparation of his carnivorous diet. The variety of the dietary: tortoises and lizards, fresh-water crabs, birds' eggs, rock rabbits, rodent moles, spring hares and antelopes, is witness to the untra-simian agility and cunning of the hunter.

"Only a methodical exploitation of every accessible source of food could render the existence of an ape in this untoward environment of Bechuanaland possible; it involved resourcefulness, agility and rapacious but social instincts, such as are evidence in minor degree by living South African baboons."

The study of Yerkes of the ape of today have a great bearing on the study of the natural dentition of man. Likewise, the studies of the teeth of the Australopithecinae specimens by Dart, Broom, Gregory, Hellman, et al., confirm the findings of Yerkes, that an ape can adapt himself to any variety of diet other than the natural diet for which the morphology of the teeth was intended to masticate. The study of the teeth of the Australopithecinae group, in the opinion of the writer, reveals the results or effects of adaption to an omnivorous diet. The attritition of their teeth is such that the writer is convinced that it could not have been brought about instantaneously. Such extensive attrition can only be the result of many thousands of years of struggle for survival in an environment which did not provide their natural diet of fruit, berries and vegetation.

In their effort to masticate the coarse, abrasive foods of the plains area in which they lived, it would appear to the writer that the extra effort to incise and cut such foods led to the exercise of the Pterygoid muscles producing a horizontal movement of the mandible in unison with the vertical pull of the temporal and masseter muscles. The result of such muscular stimulation was the extensive growth and development of the ramus and body of the mandible as shown in figures 14, 15, 37 and 38. Likewise, the exercise and development of the Pterygoids, producing the horizontal movements of the mandible, was responsible for the extensive attrition of the dentition. The horizontal movement of the mandible and early attrition of the dentition made it appear as though the canines had assumed incisor-like function.

Such attrition of the dentition of the Australophithecinae is common to all succeeding specimens of hominid and Homosapiens, with the possible exception of the dentition of Pithecanthropus robustus. (Fig. 13). Attrition of the dentition resulted in the edge-to-edge bite of the incisors and canines. This relationship of incisors and canines is the result of excessive or extra-ordinary function. The edge-to-edge bite has been interpreted by many writers as being a normal evolutionary change, rather than a change due to lack of specialization. Because of such lack of specializa-

tion, the interlocking and overbite relation of the canines has been obliterated but not eliminated as some writers believe. Le Gros Clark in his book entitled "History of the Primates" apparently has written off the canines as casualties of evolution, quote: (13)

"Another striking contrast between man and ape is the great development in the latter of long and powerful canine teeth, used as weapons in attack and defense. *On the other hand, in man the canine teeth have no special functions—they form part of the same series with the front biting teeth or incisors, and are used in just the same way.* But, in this case, there is definite evidence that the human canine teeth have indeed undergone some reduction in their later evolutionary history. For example, even today they still retain long and powerful roots out of proportion to those of adjacent teeth, and out of proportion also to the requirements for strength in the functions which they now perform. *Also, in some people they are pointed and projecting in a manner which certainly suggests that they once had their own special functions.* But while it may thus be inferred that in common ancester of man and ape the canine teeth were definitely more powerful and projecting than they are in modern man, it seems probable that they were not so strongly developed as they are in the modern larger apes since, in the latter, their excessive development has led to specializations in the adjacent teeth, and in the skull and jaws, which have been avoided in man."

Comparing specialization of mammals in general since their origin Le Gros Clark states that: "It has been pointed out and emphasized by many comparative anatomists that the relative lack of specialization shown among the Primates is consequent upon the circumstances of their particular habitat for, with only a few exceptions, all the Primates are arboreal creatures and live in tropical or sub-tropical regions. Now there is considerable reason to believe that the proto-type of mammals as a whole was arboreal in its way of life. As far as the limbs are concerned, this sort of life necessarily requires those grasping functions which are clearly dependent on primitive features, such as pentadactyly, with a wide range of movement of the fingers and toes, a well-developed clavicle (which is used as a strut for sideways movements of the arms) and so forth. Therefore, since from the outset of their evolutionary origin from the arboreal mammalian prototype the Primates remained in the trees, they tended to preserve these advantages, though primitive, anatomical characters. In many other matters, also, an arboreal habitat favors the preservation of a generalized kind of body structure. As far as the dentition is concerned, an arboreal kind of life obviates the necessity for developing highly specialized grinding teeth, since the diet available to most tree living mammals in the tropics, consisting of leaves, shoots, soft fruits and insects, can be adequately masticated by molar teeth of relatively simple structure."

(*Continued in February Issue*)

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TABLE OF CONTENTS