low concentration of ammonia and high concentration of carbon monoxide—higher polymers of carbon monoxide may be formed.

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Dental Caries in Rats Fed a Diet Containing Processed Cereal Foods and a Low Content of Refined Sugar

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There has been slow progress in formulating dietary regimens on which laboratory animals develop dental caries, which may be regarded in all respects as a satisfactory analog of human dental caries. The coarse particle diets of Shibata (*1*) and Hoppert, Weber, and Canniff (*2*) and the refined diets containing an excessive amount of sugar (*3–5*) produce carious lesions which occur almost exclusively on occlusal surfaces and originate, with very few exceptions, only in the deep fissures. The identity of this type of caries with human dental caries has been questioned for numerous reasons (*6, 7*). One of the most disconcerting facts of such experimental caries is the general failure of caries to develop on buccal, lingual, or proximal surfaces, whereas these surfaces in human dentition are highly susceptible to caries. During the course of our present studies, however, Stephan (*8*) reported that low-fat, high-sugar diets, consisting chiefly of skimmed milk powder and cane sugar supplemented with cod liver oil, induced buccal and lingual surface caries as well as proximal and occlusal surface caries in white rats. It has been observed also that the Syrian hamster may develop a cervical type of surface caries in addition to buccal caries, on a finely powdered diet consisting chiefly of powdered corn meal and whole milk powder (*9*) and also on a diet of whole wheat flour, cornstarch, confectionary sugar, whole powdered milk, and alfalfa (*10*). In one other species (the cotton rat), caries is produced under a number of dietary regimens but presumably occurs only "deep in the occlusal fissures of the molars" (*11*).

The cariogenic properties of the following basal diet (586) are being studied:

Ingredients	Percentage
Cerelose (commercial glucose)	18.0
Enriched rye bread (dry)	25.0
Enriched white bread (dry)	25.0
Cooked rolled oats (dry)	15.0
Cooked yellow corn grits (dry)	15.0
Sodium chloride	2.0

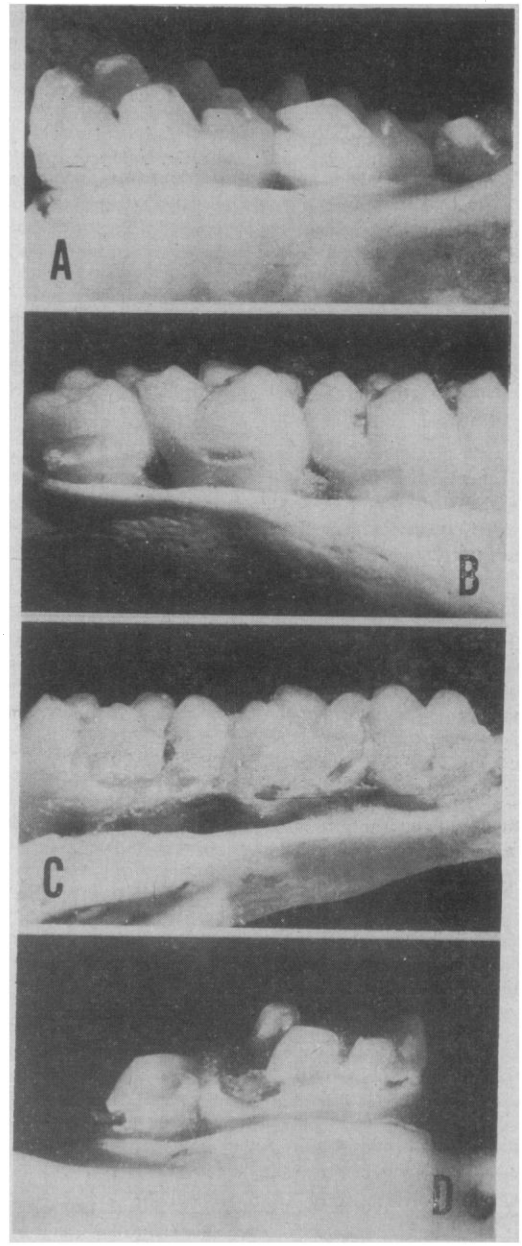

FIG. 1. *A*, lower buccal surfaces showing "orange peel" appearance of extensive white opaque area. At this stage, enamel will crumble easily on probing. Initial white areas may be smaller and more sharply defined. *B*, enamel is destroyed, exposing areas of dentin. *C*, further destruction on interproximal and distal areas. *D*, caries below gingival line and extensive destruction of occlusal areas.

The rolled oats and corn grits were cooked about 1 hr, dried at 100° C, and ground to a fine powder. The bread was dried at 100° C for a period of approximately 8 hr to a golden-brown color and ground fine. Vitamin B concentrates were added to provide thiamine 2.0 ppm, riboflavin 3.0 ppm, pyridoxine 2.5 ppm, calcium pantothenate 20.0 ppm, choline hydrochloride 1000 ppm, and inositol 25.0 ppm. Vitamin A and D concentrate (Natola) was given in separate feed cups (or directly by mouth) twice weekly to provide approximately 4000 units of A and 800 units of D weekly. The rats were housed, usually in pairs, in screen-bottomed cages, and the diet was started at weaning. In other experiments rats were given the diet from birth, and were on a sawdust surface prior to weaning. In this case the litters remained intact until the end of the experiment. All the rats were of the Holtzman strain and were obtained from the stock colony at the National Institutes of Health. This colony is maintained on a stock diet consisting of Purina lab chow and greens given twice weekly. Bread and milk are given daily during the first 2 weeks of life. The rats were sacrificed after about 90 days on the diet, the heads were autoclaved, and the flesh was removed. Prior to examining the teeth, the maxillae and mandibles (teeth *in situ*) were kept under water and in a refrigerator. The teeth were allowed to dry while being examined for caries under low power magnification. During this slow drying the initial white opaque areas, a characteristic effect of this diet, appeared easier to detect.

The gross appearance of the carious lesions produced by feeding Diet 586 is shown in Figs. 1 and 2. Initially, the carious process appeared as an opaque elongated area in the enamel, which progressed through various stages as shown in the photographs to an involvement of the dentin and loss of the entire tooth. The carious areas most frequently follow the gingival outline. Caries occurred mostly on buccal surfaces of lower molars, but was not limited to lower teeth or to buccal surfaces entirely. Lingual and mesial surfaces were sometimes involved. Occlusal caries was present but, unlike the occlusal caries previously referred to (*1–5*), did not appear to originate consistently deep in the sulci of the tooth.

Diet 586, which appears instrumental in producing this type of caries, is deficient in a number of dietary essentials. Growth is much below normal, and mortality may be high, particularly if the diet is started at birth. It should be noted, however, that this diet does not involve a coarse particle factor and that the content of sugar (18%) is relatively low. The obvious inadequacy of the cereal protein in the diet, particularly the lysine content, and the fact that the cereals have been heat-processed, have suggested a somewhat new approach to problems of nutrition in relation to dental caries. Much information has accumulated concerning the effects of heat-processing and storage on the nutritive properties, particularly the protein value, of foods (*12–15*). These effects are being investigated specifically in connection with the caries potential of Diet 586. The results with the diet are of special interest also because the initial appearance and general development of the carious process and the involvement of the lingual, buccal, and proximal molar tooth surfaces are strikingly similar to human dental caries.

Our past experiences in encountering unexplained variations in caries production among groups of rats have been duplicated in our current studies with Diet

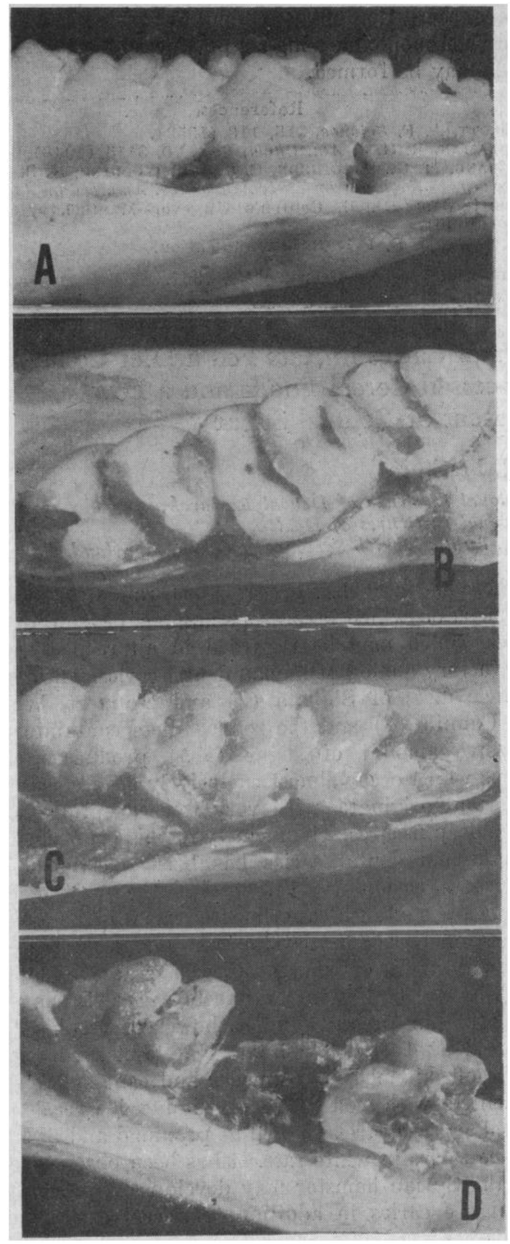

FIG. 2. *A*, upper buccal surfaces showing typical carious areas; *B*, destruction in mesial, interproximal and occlusal areas of lower molars; *C*, advanced caries in first and second lower molars; *D*, complete loss of second lower molar, advanced caries in first and second lower molars.

586. These variations relate both to the number of animals in a group which will develop caries, as well as the number of teeth involved and the extent of the carious process in each individual tooth. Under seemingly identical conditions, groups of rats given Diet 586 may show a disconcerting variability in caries production. However, over a period of 2 years, and in studies on approximately 500 rats, the above diet has continued to produce caries of the type described in relatively large numbers of animals.

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Weight and Body Temperature in Mammals

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In a recent paper Rodbard (*1*) proposed that the mean normal body temperature of various mammals bears a simple relation to the body weight: specifically, that the temperature is directly proportional to the logarithm of the body weight in animals smaller than 1 kg ($T = C + 1.5 \log W$), and inversely proportional in larger animals ($T = C' - 1.5 \log W$). Values for 30 species were selected from the literature to support this thesis, and these data as figured did indeed show close adherence to the postulated relation.

However, recent studies on body temperatures in smaller mammals, together with a general consideration of values in the literature, have convinced us that this relation is not valid, and that the apparent correlation (*1*) resulted from an inadequate representation of data. Further, even certain of the species there presented would not fit the postulated relation were it not for what appear to be errors of three- to thirtyfold in the average adult weights.

The data presented here are limited to two major sources, since it is not feasible to give a complete listing of mammalian temperatures from the literature and since such further values do not alter the conclusions. The two sources are Wislocki's review article (*2*), which principally relates to the larger mammals (2–2000 kg), and recent unpublished measurements[1] which cover a number of the smaller mammals (1–2000 g). All data available from these two sources are presented, with the exception of values on monotremes, marsupials, edentates, and bats, groups in which a low level and/or a considerable lability of temperature is found. Values for hibernators represent active, nonhibernating animals. Although some of these values represent less reliable or less extensive measurements than others, it was felt of paramount importance to avoid any selective bias that might be involved in eliminating individual species. Values for body weight represent either measurements on the animals in question or estimates of the average adult size taken from more general references (*3–5*).

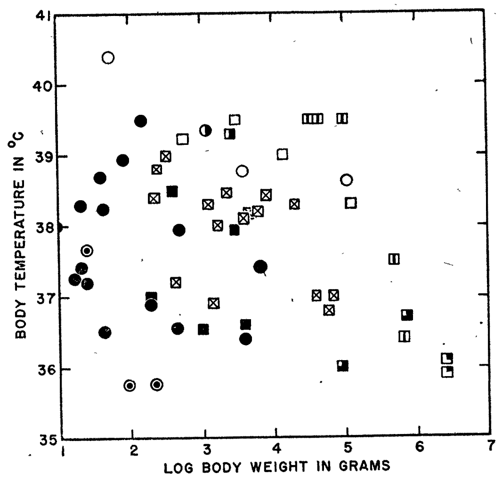

Fig. 1. Body temperature in various mammals as a function of body weight. Open symbols, Carnivores (*Mustela, Vulpes, Callorhinus, Leo*, dog, cat, ferret); point symbols, Insectivores (*Blarina, Scalopus, Erinaceus*); lined symbols, Ungulates (sheep, goat, camel, pig, horse); crossed symbols, Primates (*Perodicticus, Galago, Lemur, Cercocebus, Cynopithecus, Cercopithecus, Macacus, Aotus, Leontocebus, Callithrix, Ateles, Cebus, Papio, Pongo, Pan, Homo*); quarter-closed symbols, Proboscidians (*Elephas, Loxodonta*); half-closed symbols, Lagamorphs (*Sylvilagus*); three-quarter-closed symbols, Cetaceans (*Orca, Tursiops*); closed symbols, Rodents (*Microtus, Zapus, Clethrionomys, Perognathus, Reithrodontomys, Peromyscus, Dicrostonyx, Eutamias, Glaucomys, Citellus, Marmota, Tamiasciurus, Erethrizon, Coendou, Cynomys, Cavia*). Squares, after Wislocki (*2*), averages of individual measurements or midpoints of ranges: circles, unpublished data representing an average of 40 measurements/species on 1–30 individuals.

These data are presented in Fig. 1, where body temperatures are plotted as a function of the logarithm of the body weight. The points are distinguished according to source and order of mammal, to show the diversity of representation in the various weight

TABLE 1

Average Body Temperatures in Mammals by Weight Classes

Weight class (g)	Av values for species	Body temp in °C: Range	Body temp in °C: Mean
10^1–10^2	11	35.8–40.4	37.8
10^2–10^3	12	35.8–39.5	37.8
10^3–10^4	17	36.4–39.5	38.0
10^4–10^5	8	36.0–39.5	37.9
10^5–10^6	6	36.4–39.5	37.8
10^6–10^7	2	35.9–36.1	36.0
10 –10^6	56	35.8–40.4	37.8
10^7–10^8	4	36.5–37.5	37.1
1 –10	2	37.8–38.0	37.9

[1] These studies were supported in part by a research grant from the Wisconsin Alumni Research Foundation and by a contract between the University of Wisconsin and the Alaskan Air Command, Arctic Aeromedical Laboratory, Ladd AFB, Fairbanks. We are particularly indebted to Earl H. Herrick for the specimens of *Perognathus* and *Reithrodontomys*.