stadial Cape May formation in New Jersey, having quartz-to-feldspar ratios averaging 95 : 5, and 3 percent glauconite among the grains (*3*), indicates that an extensive reservoir of glauconitic quartzose sand existed on the continental shelf prior to the last Wisconsin glaciation. Concurrent with the lowering of sea level by 400 to 500 feet during the subsequent Wisconsin glaciation (*4*), it is probable that appreciable quantities of this quartzose sand were swept by longshore currents into the submarine canyons that cut the margin of the continental shelf, particularly the Hudson Canyon. The sand was transported, possibly by slumping and turbidity currents, onto the deep-sea floor.

Although most of the sand layers in the Hudson deep-sea fan, excluding the abyssal plains, are quartzose, a few are highly feldspathic with quartz to feldspar ratios as low as 72 : 28. Unlike the quartzose sands of the Hudson deep-sea fan which average 3 percent glauconite among the terrigenous grains, the feldspathic sands contain no glauconite or only traces of it. These feldspathic sands are derived from glacial sources and were probably transported by the Hudson River in the Hudson Channel across the continental shelf during lowered sea level and carried without appreciable modification directly into the Hudson Canyon and down to the Hudson deep-sea fan. Both the quartzose and feldspathic sands in the Hudson deep-sea fan come from mineralogically similar glacial detritus, but the contrast in abrasion history allows them to be differentiated on the basis of mineral composition. Rather surprisingly, the Wisconsin sands in the Hudson deep-sea fan are predominately glauconitic quartzose sands derived from the continental shelf, rather than feldspathic sands from the Hudson River, despite the obvious physical connection of the Hudson Channel, the Hudson Canyon, and the Hudson deep-sea fan.

In contrast to the feldspar-poor, glauconitic quartzose sands to the west derived from the continental shelf, the Wisconsin sands in the eastern and southern Sohm abyssal plain are highly feldspathic, very fine-grained to fine-grained, and poorly sorted (standard deviations of 1.00 to 2.00). These feldspathic sands have quartz to feldspar ratios from 85 : 16 to 71 : 29, and contain several percent distinctive carbonate rock fragments that are absent in the western and central Sohm abyssal plain, and only traces of glauconite. The feldspathic sands are probably derived without appreciable modification of the grains from glacial sources to the north of the Newfoundland abyssal gap. The sands were apparently transported through the Newfoundland abyssal gap and then southward down the regional gradient of the Sohm abyssal plain to ocean depths exceeding 5000 meters.

The association of the Mid-ocean Canyon with the dispersal pattern of feldspathic sands in the eastern and southern Sohm abyssal plain, and the Mid-ocean Canyon No. 2 with quartzose sands in the central Sohm abyssal plain, supports the idea that these little-understood mid-ocean canyons may be related to the transportation of sand to the deep-sea floor (*5*).

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1 December 1961

Cutaneous Sensory End Organs of Some Anthropoid Apes

Abstract. The organized end organs of nerves in glabrous skin of the chimpanzee, orangutan, and gibbon are similar to those of man in form and distribution but are more numerous on the soles of the feet than in man. I found cholinesterase in all the end organs of all these animals and, in the gibbon, alkaline phosphatase as well.

Cutaneous sensory end organs of man and monkey, as studied 100 years ago by Krause (*1*) and, more recently, with histochemical and silver techniques by me (*2*), differ greatly from those of mammals with paws, claws, or hoofs. The Meissner corpuscle and mucocutaneous end organs, the only specialized dermal endings in man and monkey, consist of masses or rolls of neurofibrils. The corresponding end organs of lower mammals are tubular, encapsulated structures containing a nerve within an enzyme-laden inner bulb. My study of gorilla skin (*3*) indicated that the nerve-ending pattern is simple and suggested that study of the great apes in more detail would provide a basis for future comparison with other primates and lower mammals.

Skin and mucous membrane were obtained from a 3-year-old orangutan, a 3-year-old chimpanzee, a 7-year-old chimpanzee (*4*), a white-handed gibbon (*Hylobates lar*), and a black gibbon (*Hylobates hoolock*). While the animals were under anesthesia, specimens for biopsy were obtained from mucocutaneous tissues, mucous membranes, and distal glabrous and hairy skin. Sites of sampling included the volar and dorsal surfaces of the digits, hands, feet, legs, and arms, the shoulder, back, genitalia, perianal region, lip, conjunctivae, nares, gingiva, palate, scalp, and face.

Portions of tissue were frozen for histochemical studies, and portions for silver preparations were placed in sucrose-ammonium formalin. Diazo coupling, alkaline phosphatase, thiocholine, cholinesterase, and silver techniques were used as outlined elsewhere (*3*).

Meissner corpuscles were seen in all specimens of distal glabrous skin of all species studied. They were most prominent in the digits of the hands, but the contrast between the number of endings in the hands and feet was not as apparent as the corresponding difference between the number seen in the hands and feet of man. (The human foot contains only widely spaced endings, except on the digital surfaces.) These end organs consisted of neurofibrils layered and wound upon one another (Fig. 1*a*). Such nerve endings were found in all three types of primates. Only on rare occasions were end organs found with more than one simple lobe. No expanded or netlike terminations were seen.

At mucocutaneous junctions, end organs with a looser structure and more spheroidal shape were noted. They consisted of unencapsulated, rolled neurofibrils. They were supplied with heavily myelinated fibers. In some instances a degree of layering of the neurofibrils was apparent (Fig. 1*b*), but this was not universal. A more common structure is shown in Fig. 1*c*. No expanded nerve terminations or multilobular end organs were seen.

The nerve tissue of the hairy skin of

the orangutan, chimpanzee, and gibbon consists of hair-follicle nerve networks and dermal nerve networks. Tactile-hair disks were seen in the skin of all three genera, and typical sensory-hair formations with perifollicular vascular sinuses and heavy patterns of innervation were found in the skin from the brow and the lip of each animal. No sensory corpuscles were seen in such skin.

Nonspecific cholinesterase was found within the organized end organs of all the anthropoid apes studied, as illustrated in Fig. 2*a*. This demonstration of end-organ enzyme in perianal tissue is comparable to similar demonstrations in the end organs in all regions of the apes studied. The cholinesterase content in the end organs from the distal glabrous skin and mucocutaneous regions tends to minimize the significance of differences of structure seen with silver impregnation.

The Meissner corpuscles and other mucocutaneous end organs in the gibbons contained alkaline phosphatase as well as cholinesterase. This finding was pointed out to me by William Montagna and Richard A. Ellis after an initial study of gibbon tissue. I have since confirmed their observation (Fig. 2*b*). The gibbon is the only primate studied to date which has alkaline phosphatase in its specialized end organs. Other primates studied include lemurs, lorisoids, five species of New World monkeys, and seven species of Old World monkeys.

It seems more important to emphasize the similarities of these end organs than their minute morphologic differences. In all of the animals studied, including the gorilla, the endings tend to be monolobular, layered, and composed of neurofibrils. Expanded nerve terminations occur within Meissner corpuscles in man, and these corpuscles may be multilobular. These characteristics, expansion of nerve endings and multilobulation of the corpuscles, have been used to distinguish Meissner corpuscles from other mucocutaneous end organs. This study of the anthropoid apes has emphasized the morphologic similarities of the end organs in mucocutaneous regions and in distal glabrous skin from the same animal and from different species. The end organs in glabrous skin of monkeys are similar in type but usually smaller and less complicated.

This similarity is supported by the finding of nonspecific cholinesterase in the organized end organs of all regions in all three genera of anthropoid apes studied. The chemical similarity has no known functional significance.

The difficulty in relating enzyme content to function is emphasized by the presence of alkaline phosphatase in the gibbon's end organs. While all the felines and the cow have alkaline phosphatase in their cutaneous end organs (*5*), the gibbon is the only primate known to possess this characteristic. No known relationship exists between sensory or other nerve function and alka-

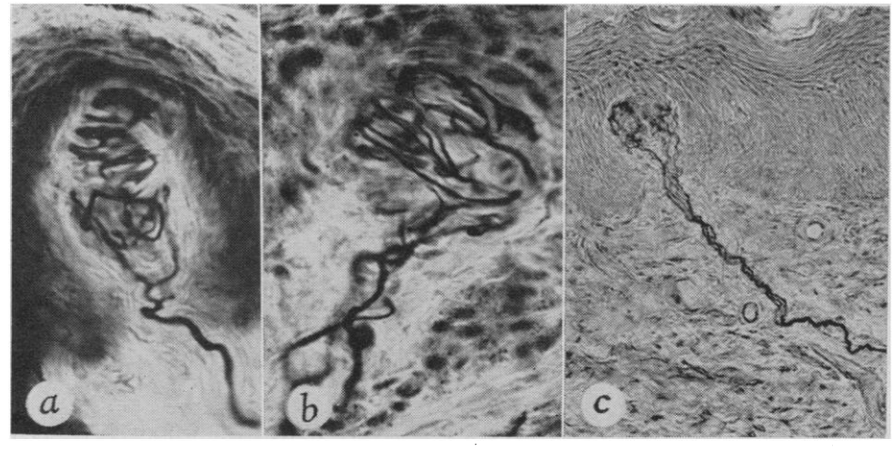

Fig. 1. *a*, Meissner corpuscle from the nailfold of the chimpanzee. Frozen section (silver, × 415). *b*, Meissner-form corpuscle from the lip of the chimpanzee. Frozen section (silver, × 415). *c*, Mucocutaneous end organ from the perianal skin of the chimpanzee. Frozen section (silver, × 186).

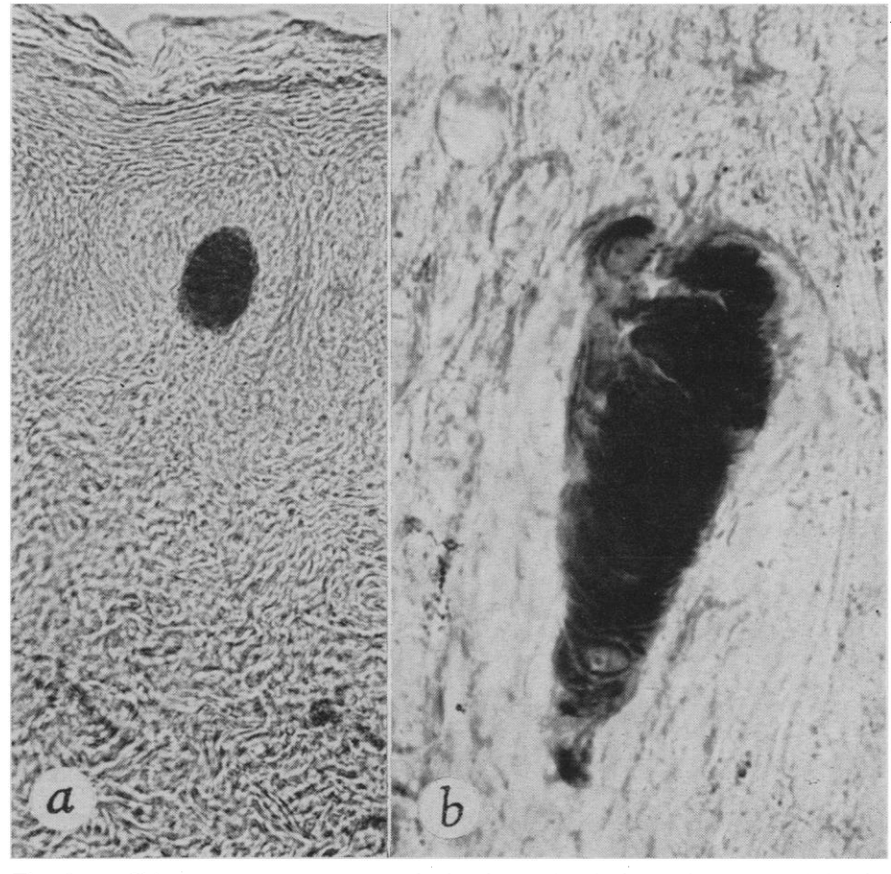

Fig. 2. *a*, Chimpanzee sensory corpuscle in the perianal tissue demonstrated by its cholinesterase reaction. Note the transverse striations (acetylthiocholine, × 225). *b*, Meissner corpuscle in the digit of the gibbon (*Hylobates lar*) demonstrated by the diazo blue B coupling technique for alkaline phosphatase. Prominent transverse striations indicate the path of the nerve in the corpuscle (× 1200).

line phosphatase. It should be observed that the enzyme is not within the nerve fibers nor does it appear to be clearly within the cells associated with these end organs. It may be associated with cell surfaces or with the nerve sheaths of the end organs (*6*).

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Separation of Aluminum Phosphate from Iron Phosphate in Soils

Abstract. Aluminum phosphate in the soil can be more discretely separated from iron phosphate by extracting 1 gram of soil with 50 milliliters of neutral 0.5*N* ammonium fluoride solution for 1 hour than by extracting with alkaline solution for a longer period of time.

Inorganic phosphates exist in soils in three main forms, namely, calcium phosphate, aluminum phosphate, and iron phosphate. Chang and Jackson reported a method of fractionation of soil phosphorus, in which the total amount of aluminum phosphate can be separated discretely from iron phosphate by extracting 1 g of soil with 50 ml of neutral ammonium fluoride in 1 hour (*1*). Fife suggested recently a modified procedure in which the *p*H of the ammonium fluoride solution was increased from 7 to 8.5 and the time of extraction was lengthened from 1 hour to 16 hours (*2, 3*). In order to evaluate Fife's procedure for a wide range of soil groups, 12 soil samples of different characteristics were investigated. Samples 1–4 listed in Table 1 are latosols with *p*H from 5.3 to 5.8, samples 5–7 are sandstone and shale alluvial soils with *p*H from 5.3 to 6.3, and samples 8–12 are slate, schist, and mudstone alluvial soils with *p*H from 6.5 to 7.5.

Table 1. Effect of *p*H of ammonium fluoride solution and extracting time on the amount of phosphorus extracted.

Soil No.	Amount extracted (ppm)					
	1 hr at *p*H			24 hr at *p*H		
	7	8	8.5	7	8	8.5
1	29	30	31	53	55	50
2	8	8	8	8	9	9
3	48	50	45	56	65	63
4	18	20	21	25	28	30
5	200	195	190	231	248	263
6	18	15	16	25	25	23
7	25	23	24	43	39	38
8	10	11	11	13	13	
9	11	10	13	14	16	19
10	18	16	19	23	24	24
11	33	31	33	50	48	53
12	9	9	9	13	15	14

Six 1-g samples of each soil, after removal of exchangeable calcium with 50 ml of neutral 1*N* ammonium chloride, were extracted with 50 ml of 0.5*N* ammonium fluoride solution of *p*H 7, 8.0, and 8.5 for 1 hour and 24 hours, respectively. The phosphorus in the extract was determined. The results (Table 1) indicate that, within the limits of experimental error, *p*H of ammonium fluoride solution in the range 7 to 8.5 does not affect the amount of phosphorus extracted. However, more phosphorus was extracted in 24 hours than in 1 hour. Chang and Jackson found that 50 ml of neutral ammonium fluoride in a single extraction for 1 hour can completely dissolve the aluminum phosphate in 1 g of common soil (*2*). Therefore the increased amount of phosphorus extracted in 24 hours was most possibly due to the dissolution of iron phosphate. It was found in this investigation that the increased amount of phosphorus (average at 3 *p*H values in Table 1) was positively proportional to the total amount of iron phosphate in the soil. The correlation coefficient between them is 0.965 (Fig. 1).

For ascertaining the possibility of hydrolysis of iron phosphate at *p*H above 7, samples of soils 1, 5, and 10 were used for study. Three 1-g samples of each soil, after removal of aluminum phosphate, were extracted each with 50 ml of 1*N* ammonium chloride solution of *p*H 7, 8, and 8.5, respectively. The phosphorus in the extract was determined. The amounts of phosphorus extracted at the three *p*H values were 0.5, 1.0, and 1.5 ppm for soil No. 1; 0, 0, and 1.0 ppm for soil No. 10; and 7, 17, and 34 ppm for soil No. 5, respectively. The results indicated that appreciable hydrolysis of iron phosphate occurs above *p*H 7 in the sandstone and shale alluvial soil (sample No. 5).

Since ammonium fluoride with *p*H from 7 to 8.5 will extract approximately the same amount of phosphorus, and since both prolonging the extraction time and using an alkaline reaction will cause a considerably large amount of iron phosphate to be included in the aluminum phosphate fraction, we conclude that extracting for 1 hour at *p*H 7 as originally suggested by Chang and Jackson (*1*) is better for obtaining complete separation of aluminum phosphate from iron phosphate than extracting for 16 hours at *p*H 8.5, as suggested by Fife (*2, 3*). However, in view of the fact that in the neutral ammonium fluoride solution, there occurs reprecipitation of phosphate released from aluminum phosphate by the ferric ions as demonstrated by Fife (*2*) on one hand, and dissolution of iron phosphate as found by Chang and Jackson (*1*) on the other, Chang and Jackson's original method (*1*) may be modified as follows: the phosphorus extracted by the neutral solution in 1 hour may represent the total amount of aluminum phosphate with no need for correction for the dissolved iron phosphate, assuming that these two amounts of phosphate are approximately counterbalanced.

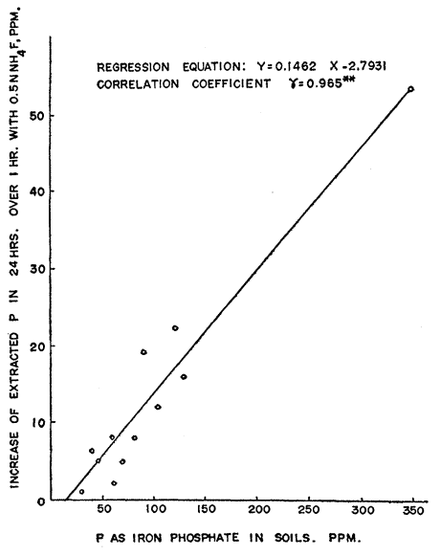

Fig. 1. Phosphorus as iron phosphate in soils as related to the increased amount of extracted P in 24 hours over 1 hour with ammonium fluoride solution.

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