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A Study of Digital Variations of the Human Hand

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Introduction

The writer's interest in this study is a direct outgrowth of his teaching classes in Genetics for many years. Much has been written in the genetic literature about the inheritance of abnormalities in hands and fingers such as brachydactyly, clinodactyly, etc., and yet, relatively little has been done to study the normal occurrence of these inherited variations in the average population. Thus, the purpose of this study is to analyze in an average population sample, such as a college student body, some of the anatomical variations that normally occur in the digits of the hand. The study of these variations is limited to those which can be detected by a study of hand tracings or outlines. The study reveals certain information about the occurrence of tapered fingers, bent fingers, straight fingers, fingers with and without conspicuous joints, etc. Because of the method of collection of data, no information could be obtained about variations such as fingernail structure, absence of thumbnail, short finger tendons, etc., all of which are known to occur genetically. In no way is this an attempt to study the inheritance of the variations, although some information of that nature was obtained in the process of routine questioning. This is merely a study of the frequency of occurrence of specific digital variations in a non-selected group of college students.

Materials and Methods

The basis for this study consists of hand tracings or outlines made from 360 students at Grinnell College. These tracings were made by students of the writer's class in Genetics in the fall of 1952. Each set of outlines includes both hands; thus, 720 separate hand outlines were examined for various parts of this study. The students were instructed carefully on how to make the tracings so as to minimize the possibility of distortion. Outlines were made of the hands spread flat, palm down, on ordinary typewriting paper. In view of the fact that several students made the tracings, some variation was inevitable; however, the tracings on the whole were very good. Some outlines actually were thrown away. The entire idea was carried out, actually, as an incidental study not seriously expecting significant results. In view of the results obtained, however, the writer considers its publication desirable, even though the method of collecting the data is open to some criticism.

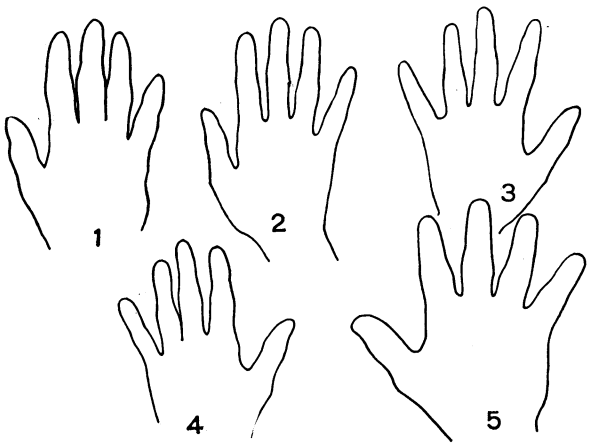
General Form of Hands and Fingers

The writer is greatly impressed with the normal variations that occur in the form of the hand and fingers. In general, the hand of the average college man and woman can be identified easily as to sex, yet there are hands of men and women that can easily pass for those of the opposite sex. Some of the girls' hands are as short, thick-set, and heavy as those of a typical man; similarly, some of the men's hands could pass for those of a woman. The writer almost hesitates to specify what constitutes a "typical" finger. Complete gradations occur between thick, short, powerful fingers and long, slender ones. Some fingers are fairly symmetrical and uniform throughout their length; others taper to a point in a very marked manner. Some fingers are lightly or heavily knobbed at the joints whereas others are virtually uniform in diameter from base to tip without any evidence of joint enlargement. Fingers may be bent to one side or the other or they may be straight, whereas others are partially and permanently flexed and cannot be straightened out completely. Since many of these characters exhibit continuous variation from hand to hand, it becomes quite difficult to make a classificatory study of the fingers. Certainly, it can be said that the typical hand of a man or woman has fingers that are fairly symmetrical, that is, that do not taper, that have some fingers bent to the radial or ulnar side, and that the fingers have average-sized joints. In general, this applies to the hands of both men and women. (See Plate I, Fig. 2 and Plate II, Fig. 1.)

An excellent description of the typical variations of fingers due to congenital conditions is found in Bunnell's book The Surgery of the Hand. This describes the anatomy of such variations as syndactyly, brachydactyly, and others which are well known in the genetic literature. On the other hand, Holt and Hodges' book Significant Skeletal Irregularities of the Hands is a good source of information concerning digital variations due to disease. Although the average geneticist is not concerned with diseases that are expressed in the hand, we should remember that many conditions presumably inherited may also be caused by disease. Furthermore, we should be aware of the fact that many conditions such as arachnodactyly, though inherited, really are but an expression of very serious organic conditions seemingly unrelated to the conditions of the hand. Arachnodactyly is unquestionably related to serious ocular and cardio-vascular disturbances (Goyette and Palmer 1953). In this particular study, it is unlikely that diseases such as arthritis and others seriously alter the normal picture found in young people

PLATE I

Variations in Finger Outline.



Figures 1, 3, and 5 are hands with tapered fingers; 1 and 3 are girls' hands, 5 is a boy's hand. Fig. 2 is a normal hand of a girl. Fig. 4 is a girl's hand with "bottle" fingers.

of college age. Certainly, none of the very serious, extreme malformations of the hand and finger were found in this study, whether caused by heredity or disease.

Finger Form

It is very difficult to single out a particular finger type and call it typical, but it is true that by and far one of the most common forms of fingers is that shown in a girl's hand, Plate IV, Fig. 1. This hand is fairly typical and was included in these plates to illustrate that very point. This tracing shows fairly symmetrical fingers, decreasing slightly from base to tip and well-rounded at the end. Some enlargement occurs at the joints and the fingers are quite straight. This hand shows the more slender and delicate outline characteristic of the girls whereas Fig. 1, Plate II, shows the contrasting form of a typical boy's hand.

Tapered fingers

One of the inherited characteristics of finger form described in textbooks of genetics is that of tapered fingers (Plate I). This finger shape is not confined to delicate, elongated hands and fingers; note the tapered fingers in the man's extremely heavy and thick hand in Plate I, Fig. 5. The girl's hand in Fig. 1 shows an extreme case of thick, tapered fingers; she stated that the condition was very common in her family. A normal or typical hand is included in the same plate for comparison. One would imply from

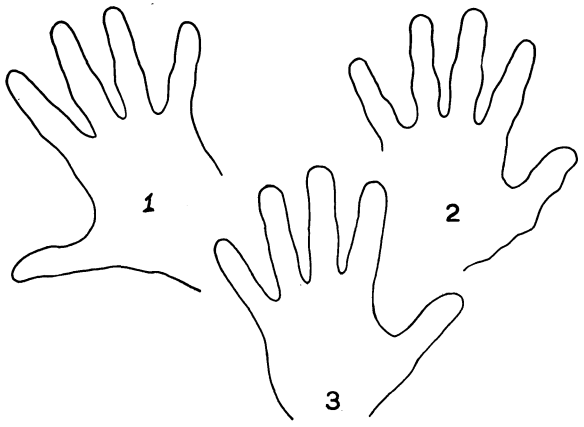
the textbooks that this condition is rather rare or, at least, not too common; the writer found that out of 360 students chosen at random approximately 30 students had well-defined hands with fingers of this type. When this finger form is present it tends to occur in both hands. Individual tapered fingers, however, do occur sporadically in many hands. There were no conspicuous sex differences in the distribution of these fingers since an equal number of men and women showed the trait. A clear-cut case of this finger form is easily distinguishable but transitions to the normal form occur abundantly. This finger form is described in Whitney's FAMILY TREASURES.

"Bottle" fingers

A second conspicuous variation encountered in finger form is one which is difficult to describe but for want of a better name is here called, not without misgivings, "bottle" fingers. Reference to this shape has not been found in the literature. This finger frequently shows a heavy or thick basal portion but the diameter decreases sharply at the first joint, then continues without further decrease in width to a rounded tip (Plate I, Fig. 4, the index, middle and ring fingers). Another example is found in the middle finger of Fig. 2, Plate I. Sometimes this finger shape is combined with a tapered finger as in the middle finger of Fig. 1, Plate I. As is true for other forms of fingers, intermediate variations between this form and others do exist; however, marked cases of this variation can

PLATE II

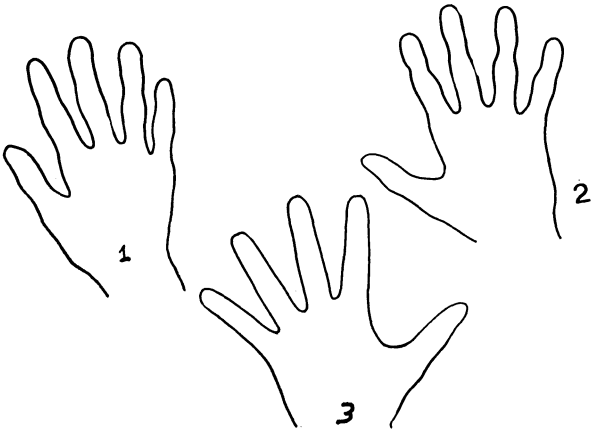
Enlarged Joints.



All outlines are from mens' hands. Figs. 1 and 2 show conspicuous, enlarged finger joints. Fig. 3, inserted for comparison, is typical of fingers that have virtually no joint enlargement.

PLATE III

Enlarged Joints.



All outlines are from women's hands. Figs. 1 and 2 show conspicuous, enlarged finger joints. Fig. 3, inserted for comparison, is typical of fingers that have no joint enlargement.

be identified readily. These fingers occur sporadically among normal fingers or are found in most fingers of one or both hands. Whereas an accurate count is difficult to make, the writer did find at least some 75 persons out of 360 with conspicuous cases of this finger form in most fingers of one or both hands. For this condition, the women appear to outnumber the men approximately 2:1.

Enlarged Joints

One of the many inherited variations described in the genetic literature is the condition known as enlarged joints of the fingers, where the diameter of the fingers is greater at the joints than between the joints. The writer encountered many hands that unquestionably had excessively large joints. (See Plate II, Figs. 1 and 2; and Plate III, Figs. 1 and 2.)

In going over the 720 hands examined, the writer found continuous variations from fingers with extreme joint enlargement to those without any swelling. (Plate II, Fig. 3). In analyzing the occurrence of this trait, the writer arbitrarily classified the fingers into three categories: (1) those with slight or no joint enlargement, (2) those with average joints, and (3) those with marked or extreme enlargement. For obvious reasons, the first category was the least difficult to classify. Continuous variation between the other groups made their identification more difficult; nevertheless, all 720 hands were so classified. (See Table I).

From the observations made, few prudent generalizations can be

Table I

Occurrence of Fingers with Enlarged Joints

	Men	Women
1. No joint enlargement or very slight enlargement.	17	47
2. Average joint enlargement.	86	83
3. Large or extreme joint enlargement.	77	50

made. Large joints are not confined to one sex or the other. They may appear in heavy, muscular hands of men or in more slender hands of women. By no means are they confined to underweight or unusually slender persons. Average-size joints seem to appear with equal frequency in both sexes. Large joints, including the extreme form, appear abundantly in both sexes although men do outnumber the women in this category. Lastly, fingers with little or no joint enlargement tend to occur more frequently among women (Table I). Actually, out of the 360 students, with men and women approximately in equal number, only 7 men and 20 women were identified as having hands with no joint enlargement whatsoever (Plate II, Fig. 3 and Plate III, Fig. 3). It would appear on the basis of this study that the rare finger is not the one with the enlarged joints but rather the one without any joint enlargement.

The writer knows nothing about the inheritance of fingers without joint enlargement. On the other hand, during the survey, many students with large finger joints mentioned that the condition was present elsewhere in the family. After seeing such continuous variation between extreme joints and no visible joints, the writer raises a question in his own mind as to the ease of detecting the inheritance of enlarged joints in a family line. At one extreme of the variation, the maximum, identification would be simple, but where does one distinguish between an average joint and a large joint?

Bent Fingers

It should be understood clearly that all reference to bent fingers is restricted to fingers bent toward the radial or ulnar side. This does not include cases of flexed fingers (campodactyly and streblomicrodactyly) except where specifically stated. The writer cannot find in the literature a technical name for the condition described above. Gates (*Human Genetics*) and others restrict the use of clinodactyly to pathological bending of fingers to the radial or ulnar side but give no special name for simple bending of fingers, whether inherited or not.

Judging from this study, it is established beyond doubt that bent fingers are extremely abundant in the human hand. Evidently all fingers can occur in a bent form, pointing to the radial side or the ulnar side; furthermore, the degree of bending varies greatly. In order to determine whether a finger was straight or bent, various techniques were tried. The method most used was that of drawing a straight line through two points, the center of the base of the finger and the center of the first joint. The center points were determined by actual measurement. The line then was projected throughout the length of the finger. This technique was chosen as the most desirable over several other methods. Final confirmation of the shape of the finger was made by actually sighting down the finger outline, with the paper held at a very flat angle. Surprisingly enough, this last check was extremely valuable and accurate.

For this study of bent fingers, a detailed finger by finger analysis was made of 75 pairs of hands (150 hands); each finger was ruled lengthwise as described above. In few cases, certain observations were extended to all 720 hands; such cases will be indicated appropriately. The following descriptions refer to all fingers of the hand except the thumb. It should be pointed out that although thumbs also occur in bent or straight form, little attention was paid to them in this study because in these hand tracings, the position of the thumb makes it impossible to study the degree and frequency of

PLATE IV

Typical Examples of Bent Fingers.

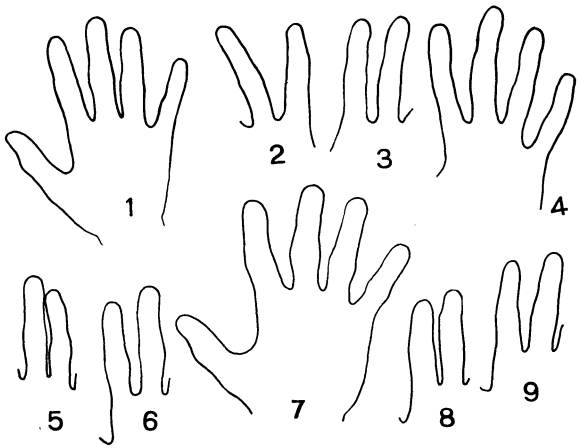


Fig. 1, girl's hand with straight fingers; Figs. 2, 3, 6, 8, and 9, index and middle fingers; Fig. 5, middle and ring fingers; Fig. 7, typical man's hand with strongly bent fingers.

bending. This is true because when a hand is placed palm down on a piece of paper, the thumb tends to roll over, more or less, on its radial side. Refer to Plate IV for typical examples of bent fingers. The readers should note that some fingers are bent at the terminal joint only (Fig. 2, right; Fig. 8, right); some are bent at the proximal or basal joint (Fig. 8, left; Fig. 9, left); others are bent at both joints, each bend in the same direction (Fig. 4, middle finger). The writer even found one case where the finger was bent radially at the basal joint and in the ulnar direction at the terminal joint. The right finger in Fig. 5 is not unique; many cases exist of fingers strongly bowed from the proximal joint terminally. Plate V shows some of the many variations of bent little fingers.

Direction of Bending

Although fingers appear to bend in a radial or ulnar direction at random, there is good indication of a preferential direction. The index or No. 2 finger was never seen to bend radially; this was true for all hands (720). The only case the writer has seen of this condition was in Greulich's book *Radiographic Atlas of Skeletal Development of the Hands and Wrist,* where the x-ray plate of a baby's hand at birth shows an index finger with the terminal joint bent in a radial direction. The writer cannot know whether this

PLATE V

Typical Examples of Bent Little Fingers.

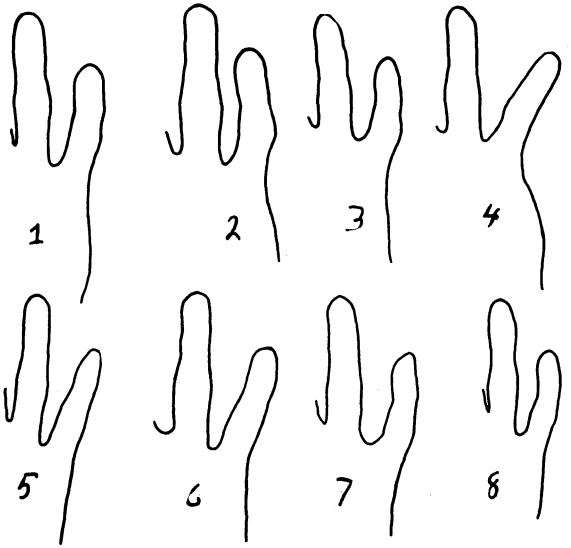


Fig. 5 shows a straight little finger. All other fingers show typical variations in manner and degree of bending. Fig. 4 shows a unique condition found only in 8 students out of 360 examined.

Table II

Direction of Bending of Fingers.

	Left Hand		Right Hand		Pairs of Hands
	Radial	Ulnar	Radial	Ulnar	Examined
Index finger (#2)	0†	71	0†	70	75
Middle finger (#3)	1	62	4	58	75
Ring finger (#4)	43	14	57	4	75
Little finger (#5)	*	2	*	8	360

†The figure of zero is true even for all 360 hands.
*The number of radially bent fingers and straight fingers was not determined for the total sample.

was a condition due to the age of the baby or whether it would have carried through to adulthood. The middle finger, No. 3, virtually always bends in an ulnar direction although in few cases it bends in a radial direction (See Table II).

The general symmetry or similarity between right and left hands is remarkable. The ring finger (No. 4) similarly has a preferential direction; in most cases it bends in a radial direction with a few cases to the ulnar side. Lastly, the little finger almost always bends in a radial direction; only 10 hands (out of 720) being found where it bends in the ulnar direction (Plate V, Fig. 4). This condition occurred in 8 students. In two students the condition was present in both hands; in all others it was present only on the right hand. Whether subtle anatomical causes can be given for this direction of bending or not, the writer does not know. Although bending of the fingers is supposed to be inherited, the writer does not know whether the direction of bending is subject to inheritance also.

Frenquency of Bending

Before the present study was started, the writer was of the opinion that hands with straight fingers were the normal condition and that bent fingers, though common enough, were definitely less abundant. Actually, the opposite is true; bent fingers are far more common than straight fingers. Using the data obtained from the 75 sets of tracings that served as a basis for the study of bent fingers, it was found that bent fingers do not occur at random throughout the hand; rather, there is an orderly pattern of distribution of bent and straight fingers on the hand. Table III shows the distribution of straight fingers in each finger position (except the thumbs) of both left and right hands. The resulting count, as shown in the table, appears too orderly to be acceptable without criticism; however, a trend is shown. With proper allowance for the size of the count involved, some generalizations appear to be justified. It

Table III

Occurrence of Straight Fingers According to Their Position

	Left Hand	Right Hand
Index finger (#2)	4	5
Middle finger (#3)	12	13
Ring finger (#4)	18	14
Little finger (#5)	27	21

seems that right and left hands tend to have a similar variation in the occurrence of bent and straight fingers for the different finger positions. It shows that bent fingers occur more abundantly in the index finger position and progressively decrease in number toward the little finger position. Or, stated in another manner, straight fingers occur in greatest number in the little finger position (No. 5) and progressively decrease in fingers 4, 3, and 2 respectively. This information, derived from a non-selected sample of the population, is not in agreement with the facts as reported by Stiles and Schalck (1945) in their study of one family line. They found that bent fingers occurred most frequently in the index and little finger positions. There are obvious reasons why data derived from the population at large might not agree with that derived from one family line. It is difficult to predict whether or not this particular distribution of bent and straight fingers in the different finger positions would be supported in a study based on more than 150 hands. No attempt was made to determine possible differences in distribution of this trait in men and women. In closing this section, it is interesting to note that the writer did not find one single person out of the entire number studied who had absolutely straight fingers in all finger positions in both hands. Actually, it is doubtful that there was one student in the entire number whose fingers were all absolutely straight even in one hand.

Degree of Bending

In collecting the data on bent fingers, an attempt was made not only to record the individual fingers which were bent and the direction of bending but also the degree to which each finger was bent. Each finger was evaluated as being absolutely straight or bent to one of three degrees, slight, average, or extreme. These evaluations were made by observation from the 75 ruled sets of hand outlines described previously. On the basis of this evidence it seems that there is no orderly plan as to the degree of bending of fingers. In any one hand, fingers may vary from straight to any one of the three degrees of bending. Uniformity of bending throughout one hand is virtually non-existent. There is, furthermore, no similarity

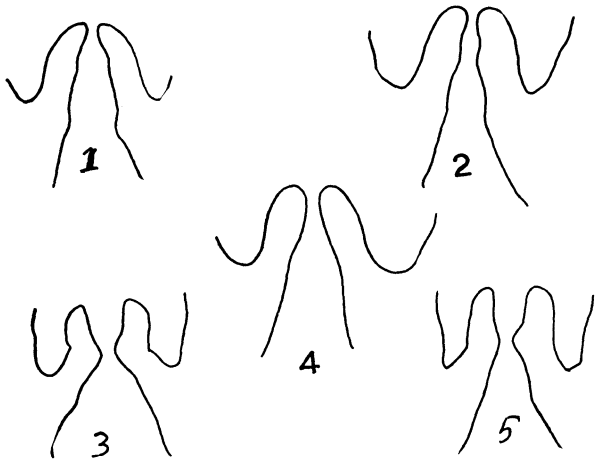
between right and left hands, as to the manner or degree of bending of fingers. However, one trend seems to be established; pronounced bending of the fingers appears more abundantly in the index fingers and decreases progressively toward the little finger. In the left hand (total of 75 hands), the number of strongly bent fingers decreases from 62 in the index finger to 50, 25, and 21 respectively in the different finger positions. In the right hand, the number decreases similarly, from 55 to 44, 41, and 21 respectively.

Campodactyly (permanently flexed fingers except little fingers).

Because of the nature of the hand outlines, the writer did not expect to find any true cases of campodactyly in this survey; however, quite by chance one true case was found in a girl where the middle finger in each hand was permanently flexed. Although not much attention was paid to the thumbs in this study for reasons stated previously, one unique condition did show up. This was found in four students, two girls and two boys. In each case the condition was found in both hands. In this case, illustrated in Plate VI, Figs. 3 and 4, the thumb rests in a sharply flexed position, a position that is distinctly and radically different from that of all other 356 pairs of hands. It was assumed immediately that here were four persons with permanently flexed thumbs (campodactyly). However, when the students were interviewed, it was found that

PLATE VI

Typical Examples of Thumb Positions.



Figs. 1 and 2 are typical or normal for women and men respectively. Figs. 3 and 5 are cases of simulated campodactyly (?) in a girl and boy respectively. Fig. 4 is a unique case where the thumb could be placed completely flat on the paper rather than in the usual position.

they could straighten their thumbs easily, a feat presumably impossible in true cases of campodactyly. Whereas the position of these thumbs could be purely a matter of chance, it is such an awkward position for the thumb that the writer doubts this is merely a chance position of the hand on the paper. It is possible that these might be mild cases of campodactyly or that some other minor anatomical variation makes this thumb position a normal one for these persons. The writer has no explanation for this condition.

Streblomicrodactyly (permanently flexed little fingers)

Only one true case of this abnormality was found; it was confined to the right hand only. According to the student, his finger had always been that way and he stated that his mother had a similar condition.

Summary

In conclusion, the writer wishes to restate certain broad observations which have become apparent in this study:

1. At least three major categories of finger shape or form can be identified: normal, tapered, and "bottle". These shapes can be identified easily when they appear in extreme form although many intermediate conditions occur. There is evidence that other finger shapes may be distinguishable.

2. Tapered and "bottle" fingers are not as rare as one might expect; frequency of occurrence of these conditions is given.

3. Fingers with enlarged joints are shown to be very common. As a matter of fact, fingers without joint enlargement are almost a rarity. They tend to occur somewhat more frequently in women.

4. Fingers bent in a radial or ulnar direction are described as being extremely common. Although most fingers tend to bend in either direction, a preferential direction for each finger position is given.

5. Maximum degree of bending tends to occur in the index and middle fingers most abundantly and less frequently in the fourth and fifth fingers.

6. Frequency of bending similarly occurs most abundantly in the index finger and decreases in fingers 3, 4, and 5, respectively.

7. None of the more extreme malformations of the hands such as polydactyly or syndactyly was found in this sample of the general population.

8. In view of the continuous variation that occurs in conditions such as tapered fingers, enlarged joints, and bent fingers, the

writer sees much difficulty in tracing the inheritance of these conditions unless the character is expressed in extreme form.

9. This introductory study should serve as an indication of the vast possibilities for study in this field.

ACKNOWLEDGEMENTS

The writer acknowledges with gratitude the interested cooperation of the students in his Genetics class of 1952 who participated in this survey and the valuable suggestions and advice given to him by Dr. S. D. Porter of Grinnell.

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