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EXCRETION OF PHOSPHORUS

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Because of the great importance of phosphorus in the formation of bones and the functional significance of a great variety of phosphorus compounds the balance of phosphorus intake and excretion has been investigated in numerous cases. A vast literature on this subject is available in which often also the route of secretion is considered, that is the ratio in which the excreted phosphorus is to be found in the urine and faeces of the human subject or animal investigated. What percentage of the phosphorus excreted in the faeces is due to non-absorbed material and how much to phosphorus originating from the body proper is, however, not yet known. Neither is any statement to be found on the fate of the individual phosphorus atoms, for example the phosphorus taken up with the food on one certain day. By using radioactive phosphorus as indicator we can follow the circulation of the phosphorus taken up at a certain date with food, the route it takes, and the rate at which it leaves the body. Some information on this subject has already been given[1]). In this paper we are communicating the results of investigations in which the excreta of human subjects, produced in the course of few months, were investigated both by radioactive and by chemical methods. Data are also given on the phosphorus excretion of rats.

[1] O. Chiewitz and G. Hevesy, Nature **136**, 754, 1935; Kgl. Danske Vidensk. Selsk. Biol. Medd. XIII, 9, 1937; L. Hahn, G. Hevesy and E. Lundsgaard, Biochem. J. **31**, 1706, 1937. W. E. Cohn and O. M. Greenberg, J. Biol. Chem. **123**, 185, 1938.

General experience as to phosphorus excretion.

Ingested phosphates are excreted partly in the faeces and partly in the urine, the ordinary distribution in adult man being about two thirds in the urine and one third in the faeces. Conditions that diminish the solubility or promote the precipitation of phosphorus in the intestinal canal tend to reduce the amount excreted in the urine and to increase that in the faeces. Vice versa, anything that favours solubility of phosphate in the alimentary tract augments absorption and increases urinary phosphorus at the expense of the faeces. Thus, diets high in calcium and low in phosphorus lead to high fecal output and phosphorus deficiency, probably because the phosphate forms an insoluble precipitate of calcium phosphate in the intestine. It has often been observed that fatty acids, by diverting calcium from phosphoric acid, may release the latter for absorption. Anything which tends to produce a more acid medium in the intestine exerts a favourable influence on the phosphorus absorption. Thus the ingestion of hydrochloric acid increases the urinary phosphorus at the expense of the faeces. The daily excretion of phosphate in the urine of an adult in normal conditions varies from 0.3 to 2 gm. of P. A careful determination of the average daily phosphorus intake[1] of 25 college women has shown an intake of 1.40 gm., which is thus somewhat higher than required by the Sherman Standard (1.32 gm.). In experiments[2], in which the subjects used were students and an acid forming diet containing 780 gm. milk was administered, the daily phosphorus intake was found to be 1.98 gm. When as large an amount as 10.8 gm. P was ad-

[1] R. E. Havard and G. A. Reay, Biochem. J. **20**, 99, 1926.

[2] M. M. Kramer, M. T. Potter and J. Gillum, J. of Nutrition **4**. 105, 1931.

ministered to a human subject, an output of 8.9 gm. was found, 79 % of the latter being present in the urine and 21 % in the faeces. About one fourth of the phosphate fed was stored[1]. In the early hours of the day the rate of excretion in the urine is minimal[2], and then it rises during the course of the day, to reach a maximum at 4 or 5 in the afternoon. The level of excretion is then maintained for the remainder of the day and throughout the night. Within wide limits there is no relationship between the amount of urinary phosphate and urinary volume. The rate of phosphate excretion is independent of the rate of water elimination even when, owing to copious diuresis, the urinary phosphate is below the level of the plasma phosphate[3]. As to the phosphorus excretion in animals we wish only to mention the following data collected by us. Rats weighing about 230 gm. excreted daily 28.7 mgm. P; within 7 weeks the ratio urine P: faeces P varied between 1.3 and 2.4, the average being 1.6.

Excretion experiments.

The most suitable method of analysis of urine was found to be the following: Evaporate to dryness an aliquote preliminarily treated with fuming nitric acid and determine its activity. Another smaller known fraction is digested in a Kjeldahl flask and its P content determined by the method of Fiske and Subbarow. The method tried first, based on the precipitation of ammonium magnesium phosphate from the urine, was found to be unsatisfactory, as activity

[1] W. T. Salter, R. F. Farquharson and D. M. Tibbets, J. Clin. Inv. **11**, 395, 1932.

[2] comp. C. H. Fiske, J. Biol. Ch. **49**, 171, 1921. S. Bellac, J. Chaussin, H. Langier and T. Ranson, C. R. **207**, 90, 1938.

[3] R. E. Havard and G. A. Reay, Biochem. J. **20**, 99, 1926.

measurements have shown that a part of the inorganic P present in the urine remains in solution after precipitation with magnesia or the magnesium citrate reagents. In view of the low activity of many of the faeces samples, we had to work up several gms. of dry faeces. It was too troublesome to dissolve such a comparatively large amount; we have therefore chosen the following procedure: The sample was first treated with nitric acid and then dried on a sand bath below 300°, to avoid loss of phosphorus. The activity of the substance was then determined. Another known part of the faeces sample, in most cases weighing only 30 mgm., was digested in a Kjeldahl flask and its P content determined by the colorimetric method.

Table I.

Time after administration of labelled P	Volume of urine in cc.	Specific activity of urine P (% of the labelled P administered found in 1 mgm. P)
3 hours	130	0.0051
5 —	80	0.015
7 —	110	0.0109
10 —	156	0.0059
11 —	88	0.0052
22 —	348	0.0033
27 —	170	0.0038
34 —	140	0.0024
44 —	570	0.0017
3 days		0.0013
6 —		0.00056
8 —		0.00064
13 —	Daily average	0.00052
16 —	950	0.0005
26 —		0.0006
32 —		0.00027
43 —		0.00016

Excretion of labelled phosphorus through the kidneys.

In the experiment described first the urine of a 40 years old female patient suffering from diabetes was investigated. The labelled sodium phosphate of neglegible weight was given with a glass of milk. We intended originally to investigate the excretion of the above mentioned patient after treatment with insulin as well; however, because the patient was soon discharged from the hospital, this investigation could not be carried out.

The average daily P excretion in the urine was found to be 950 mgm., the maximum of the specific activity of the urine P is reached after 5 hours (comp. Table I). The rapid decrease of the specific activity of the urine P, in the later stage of the experiment, is due to the rapid decrease of the plasma P activity with time; the labelled phosphate ions of the plasma being replaced by unlabelled ones already present in the body, primarily in the skeleton and the muscles. The specific activity of urine P, which is derived from the plasma inorg. P, first increases with time, due to the increased absorption of the labelled P administered into the circulation. Besides, by interaction with tissue phosphate, the plasma inorganic phosphate also becomes "diluted" by unlabelled P absorbed into the circulation from the food taken. The latter will therefore also influence the specific activity of the urine P.

In the experiment recorded in Table II the urine of a 22 years old male subject was investigated. The subject took only a minimal amount of food and drink. His daily urine excretion amounted to 610 cc. only containing 660 mgm. P.

In the course of the first day 6.8 $^0/_0$, in the course of

Table II.

Time since administration of the labelled P in hours	Volume of urine in cc.	Specific activity of urine P
3	75	0.0158
5	52	0.0205
7	59	0.0103
9	38	0.0090
11	54	0.0063
18	180	0.0049
23	150	0.0035
25	46	0.0026
27	50	0.0027
30	115	0.0032
33	80	0.0026
39	145	0.0022
48	175	0.0015
51	110	0.00097

the second day 3,3 % of the labelled P was excreted through the kidneys. Higher figures were found in the experiment on p. 10.

In the experiment recorded in Table III we wanted to ascertain the amount of labelled P excreted after a very short time. The male subject, 23 years old, excreted daily 750 cc. urine containing 825 mgm. P.

Tabel III.

Time since administration of the labelled P	Volume of urine in cc.	Specific activity of urine P
20 min.	90	0.00076
45 min.	16	0.008
18 hours	520	0.0073

After the lapse of 20 minutes an easily detectable part of the labelled phosphorus was thus found in the urine amounting to 0.1 % of the labelled P administered. From the rate of urine production by the subject in question we can conclude that only about 10 cc. urine were produced in the course of the experiment, 80 cc. being already present at the beginning of the experiment in the bladder. By taking account of the latter the specific activity of the P found in the urine formed within the first 20 minutes work out to be 0.0068, i. e. each mgm. P found in the urine, produced within the first 20 min. after drinking the labelled sodium phosphate solution, contained 0.0068 % of the phosphorus atoms present in the latter.

The fourth male subject investigated, 50 years old, excreted daily 730 cc. urine containing 790 mgm. P. The daily excretion was high, namely 21.1 % in the course of the first and 6.4 % in the course of the second day. The specific activities are seen in Table IV.

In another set of experiments 5 cc. of a physiological sodium chloride solution were injected into the veins of each

Table IV.

Time after administration of the labelled P in hours	Volume of urine in cc.	Specific activity of urine P
4	125	0.047
18.5	590	0.0109
25	100	0.0043
28	87	0.0037
30.5	70	0.0035
34	130	0.0028
35	57	0.0026
38	160	0.0032
45	150	0.0028
75	800	0.0018

Table V a.

Labelled P administered per mouth. Age of female subject 28 years, weight 65 kg.

Urine.

Time after administration of labelled P in days	Total volume in liter	Total P content in gm.	% of total activity administered, present in urine
0—15	14.98	7.787	10.3
15—39	25.25	14.400	5.3
39—52	12.98	8.239	3.6
52—76	25.58	9.093	1.5

Excretion of labelled P in the course of 76 days 20.8 %.
Total P excretion in urine 39.519 gm.
Daily P average excretion 0.520 gm.

Table V b.

Faeces.

Time after administration of labelled P in days	Amount of dry faeces in gm.	Total P content in gm.	% of total activity administered, present in faeces
0— 9	265.7	3.600	4.44
0—15	640.2	4.840	5.46
15—33	900.5	7.185	0.98
33—41	333.1	2.135	0.14
41—53	438.6	2.744	0.08

Excretion of labelled P in the course of 53 days 6.7 %.
Total P excretion in faeces 16.924 gm.
Daily average P excretion 0.320 gm.

Table VI a.

Labelled P administered per subcutaneous injection. Age of female subject 20 years, weight 65 kg. at the beginning of the experiment and 70 kg. at the end.

Urine.

Time after administration of labelled P in days	Total volume in liter	Total P content in gm.	% of total activity administered, present in urine
0—16	18.75	13.00	8.0
16—40	24.79	16.91	3.1
40—53	15.25	16.17	1.7
53—77	27.20	12.24	1.5

Excretion of labelled P in the course of 77 days 14.3 %.
Total P excretion in urine 52.32 gm.
Daily P excretion 0.680 gm.

Table VI b.

Faeces.

Time after administration of labelled P in days	Amount of dry faeces in gm.	Total P content in gm.	% of total activity administered, present in faeces
0— 6	132.6	2.585	0.60
6—17	572.6	9.360	0.84
17—38	636.5	7.070	0.12
38—45	214.7	2.815	0.10

Excretion of labelled P in the course of 45 days 1.7 %.
Total P excretion in faeces 19.245 gm.
Daily P excretion 0.447 gm.

of twelve human subjects. The solution contained 1 mgm. P as sodium phosphate, and also ^{32}P showing an activity of 10^{-5} milliCurie. We carried out these experiments to find out if the percentage of the activity, excreted within the first 24 hours through the kidneys, varies much from individual to individual. Though the human subjects were kept on the same diet, both the total P content and also the activity excreted within the first 24 hours varied markedly from individual to individual, as seen in Table VII.

Table VII.

% of labelled sodium phosphate, administered per intravenous injection to human subjects, excreted within the first 24 hours through the kidneys.

Human subject	Weight in kg.	Volume of urine in cc.	Total P in mgm.	% of labelled P recovered	Specific activity of faeces P
A	75	425	630	14.5	0.023
B	75	1515	1370	20.0	0.015
C	50	716	792	19.0	0.024
D	66	926	864	12.4	0.015
E	73	850	994	23.0	0.023
F	56	833	373	9.9	0.027
G	62	790	839	8.0	0.096
H	71	1164	1061	8.5	0.0080
I	80	1100	561	4.0	0.0071
J	61	632	707	14.4	0.020
K	64	420	518	8.9	0.017
L	71	1405	703	12.3	0.018

Excretion of labelled phosphorus through the bowels and the kidneys.

In the case of 2 female subjects we investigated the excretion in urine and faeces over a period of several weeks. The results are seen in Tables V a and V b, resp. VI a and VI b.

In the first experiment (Table V) the labelled phosphorus found in the faeces was partly non absorbed P and partly such originating from the body proper. In the second experiment, registered in Tables VI a and VI b, the labelled P being not given by mouth, the labelled P present in the faeces must have originated solely from the body phosphorus and got through the digestive juices into the faeces. The lower total phosphorus excretion in the last mentioned case (Table VI) is presumably partly due to the remarkable increase in weight of the subject in question during the experiment.

Comparison of excretion through the bowels and the kidneys.

From the labelled P administered by mouth, in the course of two months, 6.7 % were excreted in the faeces. When given by subcutaneous injection about 1.7 % left through the bowels. The latter must have reached the intestinal tract with the digestive fluids. These carry labelled P just as well when the latter was administered by mouth; we have therefore to assume that somewhat less than $^1/_4$ of the 6.7 % labelled P found in the faeces originated from the body proper. The same ratio was found in our former experiments[1], while the absolute amount excreted in the course of the first week was in those cases 2.5 times as high as found in the present cases. The labelled phosphate which left the body unabsorbed was therefore 6.7 %—1.7 % = 5.0 %. We will now turn our attention to the result of chemical analyses which indicate the excretion of total P contained in the diet of the subjects.

[1] O. Chiewitz and G. Hevesy, l. c.

From the total P of the diet excreted 33 % and 35 % left the body through the bowels in two experiments, thus a decidedly higher figure than found for the excretion of the labelled sodium phosphate. It is also higher than found in a former case for the amount of labelled P which left the body absorbed (13 %). To account for this discrepancy two different explanations can be put forward. According to one explanation, phosphorus present in some of the organic phosphorus compounds of the food is less effectively resorbed than the labelled inorganic phosphorus added to the food. Such P is only split off in the lower region of the intestinal tract, in which place it has more chance to form insoluble calcium phosphate, for example, than in the more acid upper region. An alternative explanation is that it is not the binding of the phosphorus in the compound which matters, but the mechanical protection of the phosphorus compounds present in the food. From solid undigested particles the phosphorus particles will not be leached out properly. As to the resorption of phosphorus, in a recent work, carried out in Verzar's laboratory, Laskowski[1] has shown that the phosphate radical present in sodium glycerophosphate, introduced artificially into the upper part of the small intestine, splits off rapidly. The effect of this fast process is that the phosphate of the above mentioned compound is absorbed into the circulation as quickly as that of the sodium phosphate. When experimenting on rats an absorption of 68 % of the P administered was ascertained, after the lapse of one hour, with either compound. In the case of sodium phytin 62 %, in that of sodium diphosphoglycerinate only 42 % of the P content was resorbed. When the

[1] M. Laskowsky, Biochem. Z. **292**, 312, 1937.

phosphorus compounds were introduced into the lower part of the small intestine the percentage adsorbed into the circulation was much smaller[1] and amounted, in the case of sodium phosphate, to 38 % of that introduced. The difference observed is presumably due partly to the greater activity of phosphatases in the upper part of the intestinal tract, partly to the greater acidity prevailing there. We mentioned already that low acidity is favourable to the formation of insoluble phosphorus compounds. In so far as some of the phosphorus compounds present in the food decompose or get leached out in lower parts of the intestine, the yield will be lower and this may explain the difference observed between the absorption of labelled sodium phosphate and the total phosphorus present in the diet of the human subjects in question. We have also to consider that a part of the phosphorus may be contained in undigested fractions of the diet taken, protected by mechanical obstruction from the leaching effect of the digestive juices. We can expect more information on these points by replacing the administration of labelled sodium phosphate by that of vegetables grown on labelled soil and thus containing labelled phosphorus compounds. We can also feed labelled eggs, layed by hens to which labelled sodium phosphate was administered, or labelled meat. The tracing of to what extent the labelled P is absorbed from these foodstuffs is to be expected to supply us with important information as to their digestibility and seems to be a rational approach to the study of digestion, especially if foodstuffs containing other labelled elements beside phos-

[1] comp. also F. Verzar and H. Wirz, Biochem. Z. **292**, 174, 1937.
[2] L. Hahn, G. Hevesy and E. Lundsgaard, Biochem. J. **31**, 1705, 1937.

phorus could be administered as well. We can, however, also obtain a knowledge as to the amount of unresorbed P present in the faeces by an easier method than that sketched above, a method which we will describe in the following.

Origin of faeces phosphorus.

Let us assume that all phosphorus present in the food is absorbed into the circulation. In this case all labelled P found in the faeces must originate from the body proper. It is ultimately the plasma inorganic phosphorus which is responsible for the formation of the phosphorus compounds present in the digestive juices and, therefore, the specific activity (activity per mgm. P) of the faeces P should, in the above mentioned case, be equal to that of the plasma P. The specific activity of the inorganic plasma P being equal to that of the urine P we shall expect to find the specific activity of the faeces P to be equal to that of the urine P. If the above assumption does not hold and a part of the faeces P is unabsorbed inactive P originating from the undigested food, in that case the specific activity of the faeces P will be found to be lower than that of the urine P. The ratio $\frac{\text{specific activity of faeces P}}{\text{specific activity of urine P}} \times 100$ gives the percentage of P present in the faeces which originates from the body proper. If the food P is, for example, quantitatively absorbed, then the above ratio will work out to be 100. It is clear that different objections can be raised against the above considerations. One may object on the grounds that the specific activity of the plasma P, after the active P was added to the food, will first increase and then decrease, its variation with the time being thus an intricate one. Another objection which can be raised is that the tissue P of the organs involved will also participate in the formation of the phosphorus compounds present in the digestive juices. These objections will not, however, be valid if we, before comparing the specific activity of urine P and faeces P, wait a considerable time, after administering the labelled P, before collecting the urine and faeces samples; preferably samples should be collected for several days. After the lapse of a considerable time, most P present in the different compounds of the organs responsible for the production of the digestive juices will be in exchange equilibrium with the plasma P, these showing thus the same specific activity.[1] In Tables Va and Vb the amount of P found in urine and faeces and also its total activity is stated, from which the specific activities could be evaluated. In view of the very long duration of the experiment in question and the comparatively low activities shown by many of the faeces samples, the accuracy of these experiments did not suffice to carry out such a calculation. To enable us to determine with sufficient accuracy the ratio of the specific activity of the urine P and the faeces P, we administered labelled sodium phosphate having an activity of about $^1/_{1000}$ milliCurie to a female subject and investigated the urine and faeces collected after the lapse of 7 and 8 days resp. As the faeces, collected after the lapse of 8 days, actually accumulated in the bowels at a somewhat earlier date it is advisable not to compare urine and faeces collected the same day, but to compare the

[1] A possible source of error may be found in the different rates of decrease of the specific activity of the inorganic P and of some forms of organic P present in the body (comp. G. Hevesy and A. H. W. Aten, Kgl. Danske Vidensk. Selsk. Biol. Medd. XIV, 5 p. 35, 1939).

Table VIII.

Specific activity of urine P and faeces P of a female subject 7 resp. 8 days after administration of labelled sodium phosphate per intravenous injection.

Fraction	Number of counts	P content in mgm.	Specific activity (% of the activity administered per mgm. P)
Urine P	107.4	9.01	11.9
Urine P	118.9	9.80	12.1
Faeces P	53.9	18.60	2.9

faeces with the urine collected one day previously. The result of this experiment is seen in Table VIII. The specific activity of the total faeces P is only 24 % of that of the urine P, the faeces P must therefore to a large extent originate from non-absorbed food, which is the only source of non-active P. It follows from the above figure that 76 % of the P present in the faeces of the human subject in question is non-absorbed P, the rest originating from the body proper. This is, however, not to be interpreted as indicating a phosphorus absorption of the food taken amounting to only 24 %. When interpreting the above figure, we must take into account that the P excreted through the kidneys amounts to about twice of that lost through the bowels, and the sum of both values represents the total P present in the food, if we assume that the subject in question is in P balance. We then find that only 25 % of the total P present in the food was not absorbed into the circulation.

Through the courtesy of Dr. Kjerulf-Jensen, who is investigating the P metabolism of a human subject by making use of radioactive P, we could investigate the faeces P and the urine P collected 28 days after administration of labelled P. The results are seen in Table IX.

Table IX.

Specific activity of urine P and faeces P of a female subject 28 days after administration of labelled sodium phosphate by subcutaneous injection.

Fraction	Specific activity
Urine P	8.07
Urine P	8.10
Faeces P [1]	1.77

From the ratio of the specific activities it follows that 20 % of the P precent in the faeces was of endogenous origin and that of the total P present in the food 27 % was not absorbed into the circulation.

Excretion by rats.

We determined also the ratio of the specific activities of the urine P and faeces P excreted by a rat to which labelled sodium phosphate was administered, by subcutaneous injection, 98 days previously. The results are recorded in Table X. The rate of the specific activities is 2.4, thus 59 % of the P found in the faeces originates from non-absorbed food P. The faeces P making 57 % of the total excreted P, we can conclude that, from the total food P taken

[1] 18 % of the total P found in the faeces was residual P obtained after the removal of the acid-soluble P (mostly calcium phosphate) and the traces of phosphatide P present. The specific activities of the different P fractions differed only to a minor extent.

by the rat, 33 % was unabsorbed.[1] The daily diet of the rat contained about 30 mgm. P.

Table X.

Specific activity of urine P and faeces P of a rat 98 days after administration of labelled sodium phosphate by subcutaneous injection. Weight of rat 208 gr.

Fraction	Specific activity (% of the activity administered per mgm. P)
Urine	0.39×10^{-2}
Faeces	0.16×10^{-2}

Similar values for the ratio of the specific activity of the urine P and faeces P were obtained in experiments with other rats kept on the same diet. The values obtained were 2.29, 2.47, 2.61, and 3.10 respectively. The samples were collected 30, 98, 10, and 20 days respectively after the administration of labelled sodium phosphate.

It is of interest to compare these figures with those obtained when labelled sodium phosphate is administered to the rat by mouth, the animal killed, and the activity of the total intestinal tract investigated after the lapse of 4 hours. Such determinations were carried out by several investigators. We found[2], 4 hours after administering labelled sodium phosphate (having a P content of about 1 mgm.) to a fasting

[1] K. M. Henry and S. K. Kon, (Biochem. J. **33**, 173, 1939.) emphasized recently that a large part of the P present in the gut becomes fixed by intestinal bacteria and is thus no longer available to the host. Bacterial bodies account for about 40 % of the dry weight of rat faeces and P is a more essential component of bacteria than Ca.

[2] G. Hevesy and O. Rebbe, Kgl. Danske Vidensk. Selsk. Biol. Medd. (in print).

rat, that the total digestive tract and its content contained 12.7 % of the phosphate administered; thus more than 87.3 % was absorbed. The latter figure represents the lower limit, since some of the active P present was actually absorbed and got subsequently with the digestive juices into the intestinal tract again and some active P present in the food exchanged with the tissue phosphate of the intestinal tract before the active P had an opportunity to be absorbed. Still higher figures for the labelled P absorbed into the circulation are recorded by ARTOM, SARZANA and SEGRE[1], namely 88—97.9 %; the duration of their experiments was appreciably longer, it varied from 9 hours to 4 days. A smaller absorption was found by DOLS and JANSEN[2]; after the lapse of 8 hours, the stomach and small intestine alone are stated by them to have contained 4.1—15.4 % of the labelled sodium phosphate administered. COHN and GREENBERG[3] found that, in the course of 8 hours, only 60—70 % of the labelled sodium phosphate administered got absorbed.

The above data inform us as to the lower limit of the rate of absorption of the sodium phosphate administered, which can materially differ from the rate of absorption of the phosphorus contained in the food, as discussed on p. 14. We get, however, trustworthy information on the latter point by comparing the specific activity of the urine P and the faeces P. As already mentioned, this comparison is based on the assumption that the specific activity of the P contained in the urine is equal to that of the P present in the digestive juices. We tested this

[1] C. ARTOM, G. SARZANA and E. SEGRE, Archiv Internat. Physiol. **47**, 245, 1938.

[2] J. L. DOLS and B. C. P. JANSEN, Koninklijke Akad. van Wetenschappen **40**, No. 6, 1937.

[3] W. E. COHN and O. M. GREENBERG, J. Biol. Chem. **123**, 185, 1938.

assumption in the following way: Labelled sodium phosphate was administered to a cat, the animal was sacrificed after 17 days fasting and the phosphorus contained in the last urine produced, and also in the sample removed from the small intestine, investigated. We found 1 mgm. P contained in each sample to have, within the error of the experiment (± 4 %), the same activity. The latter amounted to 0.003 % of the total activity administered.

Informations on the amount of endogenous P present in the faeces were also obtained by determining the P content of the faecal output of fasting animals.[1] The conditions prevailing in such experiments are, however, far from being physiological ones. The amount of the digestive juices, and thus also of the phosphorus secreted into the digestive tract, will much depend on the amount and quality of the food administered. When, for example, 50 gm. oil and 300 mgm. labelled P as sodiumphosphate were administered[2] to a fasting dog and the total P content of the intestinal tract investigated, after the lapse of 5 hours, the latter was composed to an extent of about 75 % of P of endogenous origin.

Summary.

After the lapse of 20 minutes a slight amount (about 0.01 %) of the radioactive phosphorus atoms taken by mouth as sodium phosphate can be recorded in the urine of a human subject. In the course of the first day 4—12 % of the amount taken was recovered. When administering the labelled phosphate by intravenous injection the figures varied between 4 and 23 %.

[1] R. Nicolaysen, Biochem. J. **31**, 107, 1937.
[2] G. Hevesy and E. Lundsgaard, Nature **140**, 275, 1937.

Phosphorus contained in the normal diet is less efficiently absorbed than sodium phosphate. As much as about 30 $^0/_0$ of the former leaves through the bowels. To what extent the latter is unabsorbed (exogenous) P and to what extent it is endogenous, thus derived from the body proper, can be determined by comparing the specific activity of the faeces P with that of the urine P. Such a comparison leads to the result that, in the cases investigated, 70—80 $^0/_0$ of the phosphorus present in the faeces was non-absorbed food P.

Similar determinations were also carried out on the excreta of rats.

It is emphasized that important information on the digestibility of different foodstuffs could be obtained by administering foodstuffs containing labelled phosphorus and other labelled elements, for example of vegetables grown on a soil containing labelled phosphate.

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