XCII. INVESTIGATIONS INTO THE CIRCULATION OF SOME HEAVY METALS IN THE ORGANISM (MERCURY, BISMUTH AND LEAD).

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THE investigations contained in this paper comprise a series of quantitative analyses, performed with the aid of two very sensitive analytical methods. These methods we owe, the one (Hg), to Dr Christiansen, the other (Bi and Pb), to Prof. G. Hevesy.

The three metals in question show a great similarity in the organism, which makes it reasonable to subject them to a comparative examination.

The experiments were almost all made on rabbits, and carried out in the following way. The rabbit is placed in a cage which permits of the collecting of all the urine and faeces eliminated daily. The metal compound to be investigated is injected at short intervals, in different portions of the muscles of the animal's limbs. After 10–20 days the rabbit is killed under a narcotic by bleeding. The principal organs, heart, lungs, liver, kidneys and intestines, together with a sample of the blood, are removed for examination.

After this the portions of the muscle, where the injection has been performed, are excised in order to ascertain the amount of metal remaining. In some cases it was comparatively easy to find and excise the parts where the injection has taken place, which contain the unabsorbed remains of the metal. In other cases it was considerably more difficult. With bismuth hydroxide it was even necessary to add a little lamp-black to the oil suspension. The values arrived at must therefore be taken only as minimum values.

The material to be analysed will be: (1) the daily eliminated amount of urine and of faeces; (2) parts of muscles containing the remaining deposits of the metal compounds injected; (3) the most important viscera; (4) in some cases the total remaining parts of the rabbit's body.

The results arrived at are given below, partly in numbered columns, partly—to simplify the survey—in a series of diagrams. The following descriptions will serve to explain these latter.

(1) The oblong rectangular columns show how much metal is contained in the amount of metal compound examined which is injected on the day

stated by the dates under the columns. A scale for the amount of metal will be found on the left side of each diagram. Where an analysis has failed it is marked with a question mark.

(2) The shaded area of each column represents the amount of metal, which was found, by analysis of the muscular tissue, to be unabsorbed.

(3) The lowest black transverse column gives the quantity found daily in the urine.

(4) The upper transverse column gives the quantity of metal contained in the faeces. Analyses which failed are shown by vertical lines. An empty space shows that no faeces were passed that particular day.

(5) The black oblongs at the top show the metal contained in the different viscera and blood. The tall black column or pillar found on the right hand of some of the diagrams gives the amount of metal contained in the remaining portions of the body.

MERCURY.

The analytical method used comprised destruction of organic substances, precipitation with sulphuretted hydrogen, solution of the precipitate and electrolysis on thin gold electrodes, which were weighed on a Nernst micro-balance.

The method possesses an accuracy of 0.03 mg.

A detailed account of the method is given by Lomholt and Christiansen [1917].

Four different Hg-compounds were investigated, each representing one of the four principal groups of mercurial compounds used in the treatment of syphilis.

Mercurium benzoicum. A 2% water solution of mercurium benzoicum was used. 0.75 cc. of this was given each time. As the rabbit showed slight inflammation of the kidneys after injection No. 2, the injections were stopped for some days. The result of the analysis will be clear by the accompanying table (Diagram 1).

The preparation is absorbed quite regularly and rather quickly. The elimination curve of the urine accords well with this. A decided rise is not perceptible until towards the end, after several injections have been given on a number of consecutive days. The elimination in the faeces is much smaller than in the urine, and remains fairly constant during the period.

Acidum mercurisalicilicum. An injection of a 15 per cent. suspension in olive oil was given on alternate days. The injected places in the muscles were in some cases clearly defined, in others but very faintly. Consequently the amount of Hg found here was probably somewhat too small. But no doubt it is a preparation, which is absorbed very quickly. Moreover the elimination in urine and faeces soon becomes very considerable (Diagram 2).

Calomel. A 20% suspension of calomel (*vapore paratum*) was used. The injected places appeared well defined against the sound muscle tissues, and

Rabbit No. 1. (Diagram 1.) Weight: 4200 g.
Compound injected: Mercurium benzoicum (2 % solution).

Elimination.

Date	Injected Hg mg.	Hg found 8. i. (unabsorbed) mg.	Hg found in the urine mg.	Hg found in the faeces mg.	Total quantity of eliminated Hg (mg.)
28. xii.	6.3	0.40			
29.			0.21	0.31	0.52
30.	6.3	2.11	0.43	0.14	0.57
31.			0.15	0.16	0.31
1. i.			0.05	0.11	0.16
2.			0.16	0.08	0.24
3.			0.32	0.14	0.46
4.	6.3	3.21	0.25	0.16	0.41
5.			0.23	0.23	0.46
6.	6.3	3.78	0.39	0.23	0.62
7.	6.3	5.20	0.34	0.05	0.39
8.	6.3	6.00	1.87	0.20	2.07
		20.70	4.40	1.81	6.21
		67.59 %		32.41 %	

Circulation of Hg.

	Weight of the organs (g.)	Quantity of Hg. found (mg.)	Contents per 100 g.
Heart	17	0.08	0.47
Lungs	18	0.06	0.33
Liver	118	0.57	0.49
Kidneys	20.5	0.45	2.20
Small intestine + faeces	121	0.47	0.39
Large " " "	115	0.36	0.32
Blood	110	0.13	0.12
Other part of the rabbit		4.80	
		6.92

Diagram 1. Mercurium benzoicum.

Rabbit No. 2. (Diagram 2.) Weight: 2160 g.
Compound injected: Acidum mercurisalicyclicum.

Elimination.

Date	Injected Hg mg.	Hg found 16. x. (unabsorbed) mg.	Hg found in the urine mg.	Hg found in the faeces mg.	Total quantity of eliminated Hg (mg.)
7. x.	4.4	0.10			
8.			0.63	0.05	0.68
9.	4.4	?	0.41	0.31	0.72
10.			1.63	0.38	2.01
11.	5.8	1.12	1.44	0.13	1.57
12.			0.52	0.48	1.00
13.	5.8	0.81	0.42	0.29	0.71
14.			0.63	0.41	1.04
15.	7.3	5.41	0.67	0.33	1.00
16.	5.8	4.10	0.72	0.43	1.15
		11.54	7.07	2.81	9.88
			71.55 %	28.45 %	

Circulation of Hg.

	Weight of the organs (g.)	Quantity of Hg found (mg.)	Contents per 100 g.
Lungs	22	0.05	0.23
Liver	75	0.87	1.16
Kidneys	17.5	0.88	5.03
Small intestine + faeces	60	0.33	0.55
Large " " "	90	0.48	0.53
Blood	55	0.11	0.20
Other part of the rabbit		6.40	
		9.12

Diagram 2. Acidum mercurisalicyclicum.

Rabbit No. 3. (Diagram 3.) Weight: 3900 g. Compound injected: Calomel.

Elimination.

Date	Injected Hg mg.	Hg found 20. i. (unabsorbed) mg.	Hg found in the urine mg.	Hg found in the faeces mg.	Total quantity of eliminated Hg (mg.)
11. i.	8.0	3.1			
12.			0.11	0.15	0.26
13.			0.18	0.13	0.31
14.	8.0	4.3	0.23	0.10	0.33
15.			0.32	0.16	0.48
16.	8.0	3.8	0.34	0.15	0.49
17.			0.42	0.10	0.52
18.	8.0	4.6	0.40	0.23	0.63
19.	8.0	4.6	—	0.16	0.16
20.	8.0	5.9	1.05	0.25	1.30
		26.3	3.05	1.43	4.48
			68.08 %	31.92 %	

Circulation of Hg.

	Weight of the organs (g.)	Quantity of Hg found (mg.)	Contents per 100 g.
Heart	13	0.21	1.61
Lungs	40	0.10	0.25
Liver	70	0.26	0.37
Kidneys	16	0.34	2.12
Small intestine + faeces	63	0.12	0.19
Large " " "	140	0.27	0.20
Blood	75	0.10	0.13
Other part of the rabbit		6.40	
		7.80

Diagram 3. Calomel.

were easy to remove. The analysis shows that the absorption takes place slowly, but very regularly. A corresponding regularity is also shown in the elimination in the urine. This rises regularly, while the elimination in faeces is considerably less, and rises but slightly (Diagram 3).

Oleum cinereum. A preparation of 50 % metallic mercury finely divided in oil; of this a quantity equivalent to 22 mg. Hg was given every third day. The first places injected were well defined, but not the later ones. The results show a very slow absorption.

Rabbit No. 4. (Diagram 4.) Weight: 4350 g.

Compound injected: Metallic mercury (50 % oil suspension).

Elimination.

Date	Injected Hg mg.	Hg found 6. ii. (unabsorbed) mg.	Hg found in the urine mg.	Hg found in the faeces mg.	Total quantity of eliminated Hg (mg.)
20. i.	22	13.8			
21.			0.05	0.05	0.10
22.			0.05	0.05	0.10
23.	22	14.8	0.11	0.08	0.19
24.			0.17	0.12	0.29
25.			0.28	0.14	0.42
26.	22	14.1	0.21	0.13	0.34
27.			0.36	0.23	0.59
28.			0.42	0.21	0.63
29.	22	16.3	0.30	0.17	0.47
30.			0.33	0.14	0.47
31.			0.38	0.13	0.51
1. ii.	22	18.8	0.51	—	0.51
2.			0.62	0.08	0.70
3.			0.58	0.08	0.66
4.	22	18.7	0.72	0.03	0.75
5.	22	19.7	0.67	0.03	0.70
6.			0.81	0.12	0.93
		116.2	6.57	1.79	8.36
			78.59 %	21.41 %	

Circulation of Hg.

	Weight of the organs (g.)	Quantity of Hg found (mg.)	Contents per 100 g.
Heart	18	0.16	0.89
Lungs	35	0.07	0.20
Liver	65	0.42	0.65
Kidneys	16	0.28	1.75
Small intestine + faeces	75	0.22	0.29
Large " " "	140	0.18	0.13
Blood	90	0.09	0.10
		1.42	

Experiments on patients [Lomholt, 1919, 1920] have shown that the absorption can be extremely irregular.

The elimination in the urine showed a slow, but regular rise corresponding to the absorption. In the faeces far less is eliminated and there was no regular rise (Diagram 4).

Diagram 4. Oleum cinereum (Hg).

The Distribution of Mercury in the Organism (Diagram 15).

There is an unmistakable conformity in all the experiments in the proportion between the amounts eliminated in the *urine* and those eliminated in the *faeces*. The urine constitutes in Exps. 1 and 2, 70 % of the collective amount; in 3, 68 %; and in 4, 79 %. This agrees with the fact that the *kidneys*, in percentage, are the organs by far the richest in metal. They contain about the same quantity as the liver although the latter is about six times as large. Thus the percentage in the kidneys is far greater than in the liver.

After the kidneys comes the *liver*. This must be regarded as the second most important organ for the elimination of mercury, rather than the great intestine, as is the opinion of many. If one considers the accompanying analyses of the small and large intestines, with their contents, it can be seen that in each of these considerable amounts are found. If the large intestine were the principal part for elimination of the mercury found in the faeces, one would expect to find small amounts of Hg only in the small intestine. But we always find considerable quantities, and these come assuredly from the liver. The *lungs* contain only a small amount of mercury. The same is

the case with the *heart*. Also in the *blood* there are only extremely small quantities found.

A considerable amount of metal was found in the remaining portion of the body of the rabbits. But one may hardly suppose that all this mercury was really absorbed from the injected places, and from thence carried to the tissue. Some portion has been removed most likely in a purely mechanical manner, a little way from the injected spot, and therefore has not been included in the excision.

The percentage distribution of the mercury in the organism is almost uniform in all the four investigated metal-compounds, but the actual amount of mercury found is proportionately far greater with the quickly absorbed preparations (mercurium benzoicum and acidum mercurisalicyclicum) than with calomel, and especially with metallic mercury.

BISMUTH.

An exact estimation of small quantities of mercury is very difficult. But it is still more difficult to estimate small amounts of bismuth. However, by the use of the radio-chemical method, first suggested by Hevesy and Paneth [1922], it becomes rather a simple matter, and also very exact. Small quantities of the radio-active bismuth isotope, radium E, are mixed with the quantity of inactive bismuth that is to be used in the experiment. When the radio-activity of the mixture is known, it is possible always to estimate the quantity of bismuth in an analysis, by simply determining the β -radiation of this, i.e. of the radium E contained in it. The proportionate mixture between active and inactive bismuth is in every case absolutely constant, and unchanged by anything whatever.

The organic substances are simply burnt away, the ash is spread out upon a shallow glass bowl, dried, and the β -radiation estimated [Christiansen, Hevesy and Lomholt, 1924].

The method permits of a good degree of exactitude when the radio-activity is not very small. Here the period of half decay—which for radium E is five days—plays a considerable part. Longer than after four periods, we have not undertaken any determination. The quantity of radium E used in each experiment was that produced by the disintegration of the emanation corresponding to a quantity of radium of 2–4 curies.

The two following compounds of bismuth were examined: bismuth quinine iodide (Viochine) and bismuth hydroxide.

The procedure was altogether parallel with that of the mercury experiments. Regard for the great quantities of ash hindered us from undertaking the estimation of bismuth in the remaining portions of the rabbit body. In the final experiment with $\text{Bi}(\text{OH})_3$ (Diagram 11) we carried out a preliminary precipitation with H_2S after 0.1 g. of inactive bismuth had been added and in this way succeeded in estimating this amount also.

Rabbit No. 5. (Diagram 5.) Weight: 1900 g. Compound injected: Viocline.

Elimination.

Date	Injected Bi mg.	Bi found 11. ii. (unabsorbed) mg.	Bi found in the urine mg.	Bi found in the faeces mg.	Total quantity of eliminated Bi (mg.)
1. ii.	2.65	1.20			
2.	2.65	1.34	0.07	0.01	0.08
3.	2.65	1.88	0.31	0.01	0.32
4.	2.65	?	0.31	—	0.31
5.	2.65	2.07	0.25	0.16	0.41
6.	2.65	2.55	?	0.16	0.16
7.	2.65	1.97	0.35	0.31	0.66
8.			0.32	0.21	0.53
9.			?	0.18	0.18
10.			0.39	0.11	0.50
11.			0.17	—	0.17
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		11.01	2.17	1.15	3.32
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			65.36 %	34.64 %	

Circulation of Bi.

	Weight of the organs (g.)	Quantity of Bi found (mg.)	Contents per 100 g.
Heart	8	0.01	0.12
Lungs	9	0.01	0.11
Liver	78	0.08	0.10
Kidneys	16.5	0.35	2.00
Small intestine + faeces	?	?	?
Large " " "	?	?	?
Blood	50	0.02	0.04
		0.47

Rabbit No. 6. (Diagram 6.) Weight: 1500 g. Compound injected: Viochrome.

Elimination.

Date	Injected Bi mg.	Bi found 24. ii. (unabsorbed) mg.	Bi found in the urine mg.	Bi found in the faeces mg.	Total quantity of eliminated Bi (mg.)
15. ii.	2.5	1.50			
16.	2.5	0.76	0.08	0.05	0.13
17.	2.5	1.52	0.03	0.05	0.08
18.	2.5	?	0.04	0.04	0.08
19.	2.5	0.79	0.07	0.06	0.13
20.	2.5	1.52	0.04	0.08	0.12
21.	2.5	1.50	—	—	—
22.	2.5	1.55	0.20	0.07	0.27
23.	2.5	0.74	0.21	0.07	0.28
24.			0.62	0.05	0.67
		9.88	1.29	0.47	1.76
		73.30 %		26.70 %	

Circulation of Bi.

	Weight of the organs (g.)	Quantity of Bi found (mg.)	Contents per 100 g.
Heart	4	0.01	0.25
Lungs	7.5	0.02	0.27
Liver	50	0.05	0.10
Kidneys	10	0.14	1.40
Small intestine—faeces	?	0.11	?
Large " " "	?	?	?
Blood	35	0.01	0.03
		0.34

Diagram 6 Viochrome.

Rabbit No. 7. (Diagram 7.) Weight: 1770 g. Compound injected: Viocline.

Elimination.

Date	Injected Bi mg.	Bi found 2. iv. (unabsorbed) mg.	Bi found in the urine mg.	Bi found in the faeces mg.	Total quantity of eliminated Bi (mg.)
20. iii.	1.55	0.51			
21.	1.55	0.75	0.01	0.03	0.04
22.	1.55	0.72	0.03	0.01	0.04
23.	1.55	1.01	0.06	0.03	0.09
24.	1.55	0.39	0.08	0.03	0.11
25.	1.55	0.42	0.08	0.08	0.16
26.	1.55	0.86	0.08	0.05	0.13
27.	1.55	0.75	0.17	0.06	0.23
28.	1.55	1.15	0.20	0.05	0.25
29.	1.55	1.13	0.22	0.08	0.30
30.			0.14	0.05	0.19
31.			0.14	0.04	0.18
1. iv.			0.13	0.04	0.17
2.			0.13	0.04	0.17
		7.69	1.47	0.59	2.06
		71.36 %		28.64 %	

Circulation of Bi.

	Weight of the organs (g.)	Quantity of Bi found (mg.)	Contents per 100 g.
Heart	5	0.01	0.20
Lungs	8	0.01	0.13
Liver	72	0.05	0.07
Kidneys	11	0.10	0.90
Small intestine + faeces	65	0.08	0.12
Large " " "	110	0.09	0.08
Blood	45	0.01	0.02
		0.35

Diagram 7. Viocline.

Rabbit No. 8. (Diagram 8.) Weight: 2680 g.

Compound injected: Bismuth hydroxide.

Elimination.

Date	Injected Bi mg.	Bi found 27. iv. (unabsorbed) mg.	Bi found in the urine mg.	Bi found in the faeces mg.	Total quantity of eliminated Bi (mg.)
13. iv.	3.80	1.22			
14.	3.80	0.77	0.14	0.00	0.14
15.	3.80	0.56	0.28		0.28
16.	3.80	0.38	0.20	0.14	0.34
17.	3.80	1.87	0.26	0.23	0.49
18.	3.80	0.47	0.30	0.09	0.39
19.	3.80	0.84	0.49	0.23	0.72
20.	3.80	0.48	0.35	0.21	0.56
21.	3.80	1.59	0.35	0.19	0.54
22.			0.28	0.14	0.42
23.			0.42		0.42
24.			0.33	0.40	0.73
25.			0.23	0.16	0.39
26.			0.44	0.14	0.58
27.			0.30	0.42	0.72
		8.18	4.37	2.35	6.72
			65.03 %	34.97 %	

Circulation of Bi.

	Weight of the organs (g.)	Quantity of Bi found (mg.)	Contents per 100 g.
Heart	9	0.12	1.33
Lungs	17	0.07	0.41
Liver	102	?	?
Kidneys	19	0.56	2.94
Small intestine + faeces	?	?	?
Large " " "	?	?	?
Blood	50	0.16	0.32
		0.91

Diagram 8. I. (BiOH)₃.

Rabbit No. 9. (Diagram 9.) Weight: 2460 g.
Compound injected: Bismuth hydroxide.

Elimination.

Date	Injected Bi mg.	Bi found 25. v. (unabsorbed) mg.	Bi found in the urine mg.	Bi found in the faeces mg.	Total quantity of eliminated Bi (mg.)
14. v.	16	1.5			
15.	16	3.0	0.06	0.00	0.06
16.	16	4.0	0.30	0.04	0.34
17.	16	?	0.36	0.06	0.42
18.	16	?	0.09	0.16	0.25
19.	16	14.0	0.51	0.09	0.60
20.	16	?	0.54	0.15	0.69
21.	16	13.0	0.53	0.22	0.75
22.			0.54	0.34	0.88
23.			0.87		0.87
24.			0.86	0.17	1.03
25.			0.40	0.08	0.48
		35.5	5.06	1.31	6.37
			79.43 %	20.57 %	

Circulation of Bi.

	Weight of the organs (g.)	Quantity of Bi found (mg.)	Contents per 100 g.
Heart	7	0.01	0.14
Lungs	15	0.04	0.27
Liver	127	0.12	0.09
Kidneys	17	0.37	2.17
Small intestine + faeces	?	?	?
Large " " "	?	?	?
Blood	70	0.01	0.014
		0.55

The two preparations investigated appeared to offer only slight variations. On one particular point they offered somewhat greater difficulties than the mercury experiments.

Bismuth causes less reaction in the muscular tissue than mercury. The injected areas are therefore less well defined and especially with the deposits of $\text{Bi}(\text{OH})_3$. In the two first experiments we found surprisingly low, irregular values for these latter deposits, which could only be explained by the excision having been incomplete. We then tried mixing a little lampblack with it, and found more satisfactory values (III and IV, Diagrams 10 and 11), as we could more easily follow the trail of the black specks.

Diagram 11. IV. $\text{Bi}(\text{OH})_3$.

Three experiments were made with viochrome (Diagrams 5, 6, 7) there being a daily injection of a small quantity of this compound. All these three experiments resembled each other greatly. The absorption takes place fairly slowly, but sometimes almost capriciously (Diagram 7).

Of the four hydroxide experiments (Diagrams 8, 9, 10, 11) the first two show, as regards the injected deposit, very great irregularities (see above). Exps. III and IV are in this respect remarkably better, but even they are not fully dependable. The very large amount of bismuth found in the remainder of the body in Exp. IV points to this. A considerable part of this assuredly comes from the unabsorbed quantities in the surroundings of the injected parts.

The elimination in urine and faeces shows conditions very much like those in the mercury experiments. The chief part is eliminated in the urine (about $\frac{2}{3}$) and the elimination rises during the experiments, though often with considerable irregularity. As regards the faeces the values were much smaller and especially the rise was less pronounced; the irregularities somewhat more than in the urine.

The elimination was studied in five cases. In the first four the proportion between injected and eliminated Bi was much the same. In the fifth (Diagram 9) the elimination was proportionally small. Probably this is due to the fact that the total quantity injected here was about six times as large as in the other four experiments.

The distribution of bismuth in the organism (Diagram 15).

The distribution proved to be very much alike in all the seven experiments.

The greatest amount of bismuth is always found in the *kidneys*; not only relatively, but also positively. As a rule about twice as much is found in the kidneys as in the liver, though this latter is six or seven times as large.

Diagram 12. Bi.

This is in perfect harmony with the fact, that far the greater part of the bismuth leaves the body through the kidneys, while the intestines come in the second rank. The chief part of this bismuth comes without doubt from the *liver*, as is the case with mercury. Unfortunately I have only two experiments with the great and small *intestines*; but they both agree. The amount in *heart* and *lungs* is minimum, and the same is the case with the *blood*.

I found an excellent corroboration of this in a series of experiments on guinea-pigs (Diagram 12). I injected 10 mg. Bi in a very weak solution of

nitrate into the muscular tissue of four guinea-pigs of a like size, and at the same time. Twenty-four hours later one was killed; after two days another; after four days the third; and after six days the fourth. The results are given on Diagram 12 and hardly require any comment.

It will be seen easily that the bismuth compounds and the mercury compounds (and especially calomel) resemble each other very much as regards circulation and elimination.

This agrees perfectly with their well-known resemblance to each other in other points; they cause the same symptoms of intoxication (nephritis, stomatitis and colitis) and possess the same peculiar effect on syphilis.

LEAD (Diagrams 13 and 14).

The analytical method used was quite parallel with that in the bismuth experiments, only that instead of radium E an isotope of lead (radium D) was employed [Hevesy, 1923].

Diagram 13. I. $\text{Pb}(\text{OH})_2$.

Diagram 14. II. $\text{Pb}(\text{OH})_2$.

Only one lead compound was investigated and only two experiments on rabbits took place, which however gave results agreeing well with each other. Exp. 1 was in particular very successful. Exp. 2 was hindered by irregularities, as the rabbit expelled both urine and faeces in a quite unusually irregular way.

To the emulsion used, lamp-black was added. This is probably the reason that the investigations of the injected deposits gave rather good results. This goes to prove slow, but quite regular absorption.

The conditions of elimination are best seen in Exp. 1. In the urine it is very gentle and regular. That in the faeces is considerably less regular. But what specially catches our attention is, that the amount eliminated by this way is greater than that by the kidneys (52·8 % against 47·2 %). In Exp. 2 this is still more noticeable.

Rabbit No. 12. (Diagram 13.) Weight: 2300 g.

Compound injected: Lead hydroxide.

Elimination.

Date	Injected Pb mg.	Pb found 28. xii. (unabsorbed) mg.	Pb found in the urine mg.	Pb found in the faeces mg.	Total quantity of eliminated Pb (mg.)
17. xii.		1·25			
18.	2·0	1·33	0·02	0·02	0·04
19.			0·08	0·03	0·11
20.	2·0	1·25	0·05	0·05	0·10
21.			0·06	0·04	0·10
22.	2·0	1·59	0·07	0·15	0·22
23.			0·07	0·11	0·18
24.	2·0	1·51	0·10		0·10
25.			0·06		0·06
26.			?	0·15	0·15
27.			0·08	0·11	0·19
28.	2·0	1·57	?		
		8·50	0·59	0·66	1·25
			47·2 %	52·8 %	

Circulation of Pb.

	Weight of the organs (g.)	Quantity of Pb found (mg.)	Contents per 100 g.
Heart	6	0·01	0·17
Lungs	12	0·01	0·08
Liver	120	0·19	0·16
Kidneys	15	0·09	0·60
Small intestine + faeces	120	0·04	0·03
Large " " "	150	0·16	0·11
Blood	50	0·01	0·02
Other part of the rabbit	1700	1·20	
		1·71	

Rabbit No. 13. (Diagram 14.) Weight: 2730 g.

Compound injected: Lead hydroxide.

Elimination.

Date	Injected Pb mg.	Pb found 17. ix. (unabsorbed) mg.	Pb found in the urine mg.	Pb found in the faeces mg.	Total quantity of eliminated Pb (mg.)
31. viii.	3.0	1.87			
1. ix.	4.0	?		0.33	0.33
2.			0.06	0.26	0.32
3.					
4.	4.0	2.00	0.17	0.18	0.35
5.					
6.			0.28	0.24	0.52
7.	4.0	3.00			
8.	4.0	?		0.30	0.30
9.			0.25	0.37	0.62
10.	4.0	2.80	0.31	0.11	0.42
11.				0.29	0.29
12.			0.44	0.18	0.62
13.					
14.				0.22	0.22
15.			0.18	0.28	0.46
16.					
17.			0.10	0.41	0.51
			9.67	1.79	3.17
			36 %	64 %	4.96

Circulation of Pb.

	Weight of the organs (g.)	Quantity of Pb found (mg.)	Contents per 100 g.
Heart	7	0.04	0.57
Lungs	10	0.05	0.50
Liver	55	0.30	0.55
Kidneys	12	0.20	1.67
Small intestine + faeces	?	0.15	?
Large " " "	?	0.44	?
Blood	50	0.01	0.02
		1.19	

The Distribution of Lead in the Organism. (Diagram 15.)

In agreement with the above-mentioned facts as to the conditions of elimination, there is found here a considerably greater amount of metal in the *liver* than in the *kidneys*, about twice as much. In *heart, lungs* and *blood* only quite a small amount is found. The great intestine contains in both cases more than double as much as the small intestine. Nevertheless it will be natural also here to regard the liver as that part from which the chief amount of the lead found in the evacuation comes. Faeces often pass through the great intestine very slowly.

SUMMARY.

The three metals investigated showed much the same conditions in the organism. Still, there seems to remain a slight difference. With bismuth, the kidneys (and the urine) play by far the most prominent rôle, with lead,

the liver (and the faeces) seems to be just as important. Mercury comes between the two, but somewhat nearer to bismuth than to lead.

Diagram 15. Viscera.

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