THE BLOOD CHEMISTRY OF THE LOWER MONKEYS

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There is little information in the literature on the chemical statics and dynamics of the composition of the blood of the higher and lower monkeys. Nevertheless, if only from the point of view of comparative biochemistry, the importance of this information is difficult to overestimate. Much more attention has been paid to the monkey in comparative physiology than in biochemistry. The comparative biochemical value of the incomplete and sparse information on the biochemistry of monkeys is lowered by the fact that only in rare cases have comparable findings been obtained from investigations carried out on man and monkeys simultaneously and by the use of the same methods.

In this paper we give some findings from our laboratory on the content of various proteins and minerals in the blood of the lower monkeys and on their comparison with corresponding results of analysis of the blood of healthy human subjects.

EXPERIMENTAL METHOD

Investigations were carried out on lower monkeys – Macacus rhesus (9 males and 3 females, weighing from 2.2 to 6.9 kg and aged from 2 to 4 years). Blood was taken from the auricular vein after preliminary fasting for 16 hours.

For the purpose of comparison, two analyses were made of the venous blood of a group of healthy men and women (10 persons), aged from 19 to 25 years, at the same time and using the same methods of investigation. In the blood of the monkeys and the human subjects we determined the proportions of the protein fractions of the serum by paper electrophoresis, the content of glycoproteins in the serum, the carbonic anhydrase activity in whole blood, the amylase, aldolase and alkaline phosphatase activity of the serum and the content of various minerals.

EXPERIMENTAL RESULTS

Table 1 gives some idea of the proportions of the protein fractions in the serum of man and monkeys.

The results shown in Table 1 are in complete agreement with the findings of Deutsch and Goodloe [2] in monkeys, by means of the classical Tisellius method of electrophoresis.

In considering the problem whether the pattern of the protein fractions of the blood of the monkeys examined shows any special features which might be regarded as pertaining to the species, it can only be mentioned that the percentage of α_1 – and α_2 – globulins in the serum of monkeys is significantly lower and that of the γ-globulins is significantly higher than in human serum.

According to Deutsch and Goodloe, the proportion of γ-globulins in the plasma of man and monkeys (Macacus rhesus) is the same. These workers found a qualitative difference between the plasma of man and monkeys, for in the latter an electrophoretic fraction is present coming in front of the albumins (the nature of this fraction was not established), and so also is a fraction of α_3-globulins, which is also found in the blood of the cat and guinea pig. From the findings of these workers the quantitative differences are less pronounced in character.

TABLE 1

Content of Protein Fractions in the Serum of Healthy Human Subjects and Monkeys

Object of the examination	No. of examinations	Protein content, %				
		albumin	α_1-globulins	α_2-globulins	β-globulins	γ-globulins
Man	10	64,3	5,4	6,6	9,7	13,8
Monkey (Macacus rhesus)	12[1]	62,3	3,6	4,1	12,1	17,8

* Blood was taken for analysis from 4 monkey twice, and from one monkey 3 times. The results of each analysis are shown here as a single investigation.

TABLE 2

Glycoprotein Content of the Serum of Healthy Human Subjects and Monkeys

Object of the examination	No. of examinations	Limits of variation, mg%			
		hexose combined with protein	hexosamine, combined with protein	neuraminic acid	seromucoids (mucoproteins) in the form of hexose
Man	10	104—143	78—106	56—71	9—15
Monkey (Macacus rhesus)	12	78—109	63—102	73—101	14—31

TABLE 3

Enzyme Content of the Serum of Healthy Human Subjects and Monkeys

Object of the examination	No. of examinations	Enzymes, in conventional units			
		amylase, by King's method	aldolase, by Brunn's method	alkaline phosphatase, by Bodansky's method	carbonic anhydrase, by the Brickman-Krebs method
Man	10	85—195	3,0—8,0	1,6—4,8	2,3—2,8
Monkey (Macacus rhesus)	10	55—280	1,8—16,2	2,5—20,3	2,2—2,9

In Table 2 are given the results of the estimations of the glycoproteins in the serum.

In respect to monkeys the results given are those of single analyses and they are only a rough guide. Nevertheless these results do give grounds for the assumption that a more intensive study of the glycoproteins in the serum of monkeys (anthropoid as well as lower) would be of considerable interest to comparative biochemistry. Species differences in the biochemistry of the glycoproteins, if they are confirmed, may be of importance in discovering the role of these, as yet very little studied, compounds in the pathological chemistry of man (and in particular, in the pathological chemistry of cancer and tuberculosis).

So far as specific proteins – the enzymes – are concerned, information in the literature is very sketchy.

In analyzing the results in Table 3, the wide range of variation in amylase activity in the serum of monkeys must be pointed out. These variations in amylase titer were observed not only during our investigation of different monkeys, but also in the same monkey over a period of 15 days. If this finding is compared with the

TABLE 4

Content of Minerals in the Blood of Healthy Human Subjects and Monkeys (Macacus rhesus).

Minerals	Whole blood		Plasma or serum		Red blood cells	
	monkeys	man	monkeys	man	monkeys	man
Calcium, mg%	9—13,2	9—11	—	—	—	—
Iron, mg%	29—48	49—56	—	—	—	—
Copper, γ%	57—92	77—106	—	—	49—77	32—111
Zinc, mg%	—	—	0,36	0,21	0—88	0—144
Silicon, γ%	51—64	49—56	20,26	15—26	—	—
Iodine, γ%	4,4—8,3	6,0—8,5	—	—	—	—
Sulfur, mg%						
nonprotein	—	—	5,6—8,1	7,7	—	—
inorganic	—	—	4,8—6,2	2,8	—	—
organic	—	—	1,4—2,3	1,9	—	—
total oxidized	—	—	4,3—7,1	5,8	—	—

TABLE 5

Content of Nonprotein Nitrogenous Compounds in the Blood of Healthy Human Subjects and Monkeys

Object of the examination	No. of examinations	Urea, as mg% of nitrogen	Creatinine as mg% of nitrogen	Uric acid as mg% of nitrogen	Amino-acids, as mg% of nitrogen	Reduced glutathione, mg%	Ergothioneine, mg%
Man	10	10,2—15,3	0,45—0,72	0,75—1,2	5,8—7,9	21,0—28,5	2,1—3,8
Monkey (Macacus rhesus)	10	8,9—14,6	0,9—2,3	0,28—0,65	5,9—8,3	8,0—19,4	0,0

statement by S. D. Balakhovskii [1] that the variations in the amylase titer in the blood of a healthy person are small, then this might be regarded as a species peculiarity of the lower monkeys; however simultaneous observations on healthy persons (see Table 3) show the possibility of a similar lability in the amylase titer in human blood also.

The aldolase activity of the serum of lower monkeys also differs from that of healthy human subjects by its wider limits of variation and its higher maximum. Still more pronounced are the differences in phosphatase activity. The alkaline phosphatase content of the serum of the Macacus rhesus monkey differs markedly from that of adult human subjects and in some ways resembles the variations in the alkaline phosphatase titer in the blood of infants. It is impossible also to exclude completely the possible presence of abortive and incipient forms of rickets in the monkeys examined, kept in captivity, and as we know this is characterized by a raised blood phosphatase titer. The figures of carbonic anhydrase activity in the whole blood of the Macacus rhesus monkey and of man almost coincide.

Figures showing the mineral content of the blood of human subjects and monkeys are given in Table 4.

As may be seen from Table 4, no particular differences are found in the mineral content of the blood of man and the lower monkeys. Unfortunately the results in respect to the individual component salts of the blood in monkeys were obtained at different times of the year, which does not allow possible seasonal variations in the component salts to be detected. In addition, whereas there is a general similarity in the mineral composition of the blood, human red cells are slightly richer in zinc; this is not completely in agreement with the degree of

activity of the enzyme carbonic anhydrase (which includes zinc in its composition), found in human blood, which does not differ from its activity in the blood of monkeys. Slight differences in the range of variations of the iodine content of the blood of the monkeys examined do not give grounds for this to be regarded as a peculiarity of the biochemistry of these animals. If we consider that the iodine content of the blood reflects the functional activity of the thyroid gland, there are no grounds for postulating any species differences in this activity in monkeys.

The slightly smaller content of iron and copper in the whole blood of the monkeys may be compared with the smaller content of total protein (and in particular of hemoglobin) in their blood. The average quantity of hemoglobin per 100 ml of whole blood in Macacus rhesus is 12.3 g, which is slightly below the normal hemoglobin content of human whole blood.

Figures for nonprotein nitrogenous compounds in the blood of human subjects and monkeys are shown in Table 5.

The figures given in Table 5 demonstrate considerable differences in the distribution of nonprotein nitrogenous compounds between the blood of man and the lower monkeys (higher concentration of creatinine, lower concentration of uric acid and glutathione, absence of ergothioneine from the blood of monkeys).

It must be pointed out that the lower monkeys excrete very little uric acid as such, but convert it into allantoin, which is a characteristic feature of the majority of mammals with the exception of the anthropoid apes and man. This may be compared with the figures given above of the low level of uric acid in the blood of the lower monkeys. Although allantoin may be detected in small quantities in human urines (the urine of newborn infants contains a considerable quantity of allantoin), this biochemical characteristic of the urine of the lower monkeys is of interest. It may be that the anthropoid apes (like man) are deficient in the enzyme uricase, which is responsible for the conversion of uric acid into allantoin.

This biochemical feature of the lower monkeys thus places them closer to the other mammals than to the higher monkeys and man. It is very likely that this resemblance is also apparent in the distribution of uric acid between the body fluids (blood, urine, sweat), the more especially as, for instance, the sweat glands in the anthropoid apes are well developed, but in the lower monkeys they are confined to the sole.

It may be concluded from these results described that whereas the mineral metabolism of the lower monkeys shows considerable resemblance to that of man, a more detailed study of the metabolism of nitrogenous compounds evidently provides results demonstrating species characteristics of the metabolism of monkeys.

SUMMARY

A comparative biochemical examination of the blood of healthy people and of lower monkeys was conducted. The content of various proteins and mineral substances in the blood of lower monkeys (Macacus rhesus) was compared with that in healthy people. Certain differences in the content of proteins and in the distribution of the nonprotein nitrogen substances in the blood of human beings as compared to the blood of lower monkeys may be considered to be species specific. On the other hand the indices of the mineral metabolism in lower animals show a considerable similarity to these indices in man. Therefore, a further profound study of the nitrogen metabolism indices has future prospects from the comparative-biochemical point of view.

LITERATURE CITED

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[2] H. F. Deutsch and M. Goodlce, Journ. Biol. Chem. 161, 11, (1947).

* In Russian.