

This work was supported by grants from the Life Insurance Medical Research Fund, the Health Research Council of the City of New York (U-1045), and the National Heart Institute, U.S. Public Health Service.

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Vitamin B₁₂ in the Serum of the Rhesus Monkey

Most investigations of the physiology of vitamin B₁₂ have been carried out in man or laboratory animals other than the sub-human primates. Indeed, it has been specifically noted that vitamin B₁₂ deficiency has not been produced experimentally in monkeys¹⁻³, and those macrocytic anaemias which have been induced are known to respond to treatment with folic acid (sometimes in association with ascorbic acid) but not to vitamin B₁₂ (ref. 4).

Recently, two rhesus monkeys in our colony developed a paralysis which called to mind sub-acute combined degeneration of the cord in man and which improved following treatment with parenteral vitamin B₁₂. This led us to measure the serum levels of the vitamin in other monkeys in the colony. Using the microbiological assay method with *Euglena gracilis*⁵, the level of vitamin B₁₂ was estimated in the sera of three male and 18 female normal untreated adult rhesus monkeys (*Macaca mulatta*) which had been in the colony for 1-15 years. The mean figure of 56.6 µg/ml. (S.D. 20.8) is very low compared with the levels found in other mammals (not less than 200 µg/ml. by the same technique⁶), and with the range of normal in man (mean value 390 µg/ml.⁵); in fact, it is the value to be expected in cases of pernicious anaemia in relapse.

Low levels similar to those which we have found have already been observed by Wilson and Pitney⁷ in 17 young rhesus monkeys which had been on a standard laboratory diet for many months. The mean serum-level of 120 µg/ml. was accepted by them as normal for the species. Das Gupta *et al.*⁸ found even lower levels in six healthy young rhesus monkeys (mean value 56.8 µg/ml.) living on the "usual animal room diet", and they commented that the somewhat higher figures obtained by Wilson and Pitney⁷ might have been due to the higher vitamin B₁₂ content of their 'natural' laboratory diet.

Repetitions of the tests on our monkeys have shown that the levels of vitamin B₁₂ remain consistently low. On the other hand, monkeys that have been in the laboratory environment for only a short period showed higher levels at the time of the first test, but the values fell to the low figure characteristic of the rest of the colony within three months. Estimates on a group of 29 monkeys examined within five weeks of captivity and immediately on arrival in Britain gave a mean value of 208.2 µg/ml. (S.D. 93.2). These findings imply that monkeys in their natural habitat have satisfactory amounts of vitamin B₁₂ in their serum as judged by the standards of man and other mammals, perhaps as the result of a more varied diet in the wild state.

The ordinary diet fed to our monkeys consists of potatoes, bread, carrots and other root vegetables, green

vegetables and fresh fruit, and is supplemented with 'Bemax', ascorbic acid and halibut liver oil. This diet has been thought to be adequate since monkeys have been kept on it in apparently good health for long periods of time—up to 24 years—and since haematological examinations have never revealed any notable changes. Further examinations of the blood from these monkeys now known to have low vitamin B₁₂-levels have also failed to show any significant evidence of anaemia.

This overall picture of very low levels of serum vitamin B₁₂, usually without obvious signs or symptoms of deficiency, in monkeys on a vegetarian diet seems closely to resemble the findings in strict vegetarians^{9,10}, where low serum B₁₂ values are not necessarily associated with anaemia or gross neurological changes. In many other species, however, there is evidence that vitamin B₁₂ deficiency may lead to a range of disorders including retardation of growth, congenital deformity, increased incidence of demyelinating disease of the nervous system and a number of lesser effects (for review see ref. 2). Special mention may also be made of the many reports that the deficiency has some ill-defined influence on the reproductive processes¹¹⁻¹⁴. We intend particularly to study the influence of vitamin B₁₂ supplements in our group of breeding females the fertility of which has proved to be disappointingly low, and would suggest that other users of laboratory primates might consider the possible effect of low levels of vitamin B₁₂ in the serum in the interpretation of their results.

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Serum Iron in Normal and Castrated Mammals

Most authors are agreed that there is a sexual difference in serum iron values in man.

Previous work^{1,2} carried out on six kinds of mammals has not, however, shown this difference. On the other hand, it seems beyond doubt that the gonads have a definite effect on iron metabolism in some species. The castration of rats³ and rabbits⁴ modifies the level of serum iron and in the former affects hepatic deposit⁵.

The injection of sex hormones has also a certain influence on other species, and it has been seen how the oestrogens reduce the serum iron in rats⁴ and in rabbits⁶.

In the work recorded here, I have examined the influence of gonads on the serum iron values and the total iron-binding capacity in 5 species of mammals—bull, horse, ass, lamb and pig. For this purpose the values for normal and castrated specimens are compared. The results obtained with the first three species have already been given⁷.