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EXPERIMENTAL STUDIES RELATING TO SHIP-BERI-BERI AND SCURVY.

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(Plates XVII and XVIII.)

II. ON THE ETIOLOGY OF SCURVY.

- (1) *On the macroscopical alterations in the tissues of guinea-pigs which had been fed exclusively on bread, groats, and unpeeled grain.*

BY experimenting with the " one-sided " diets which were used in the experiments, mentioned in the foregoing paper on polyneuritis in poultry, we found that guinea-pigs also contract a disease, and that this disease is accompanied by very characteristic changes.

The present section of our paper deals with the 64 animals that died in 18 days or more when fed on ground or unground oats, barley, rye, or wheat and water. To these we add one animal fed on rye-bread that died in 15 days. The weight of the animals was usually 300—600 gms. Apart from two guinea-pigs fed on a mixture of oats and rye-bread, each animal received one single nutriment only.

During the experiment the animals became emaciated, the corresponding total loss of weight being, on an average, 40 % of the weight at the beginning of the experiment. In some cases the weight decreased uniformly, but as a rule the animals at first lost weight, then either increased or remained unchanged for 3—14 days, and finally exhibited a definite decrease in weight during the week or so preceding death.

Moreover, these experiments afforded, in other respects, quite different results to those obtained with pigeons. In the first place it must be pointed out that the majority of the guinea-pigs exhibited, at the post-mortem, *pronounced haemorrhages*. These haemorrhages appeared most frequently in the muscles of the hind-limbs, where they sometimes infiltrated large portions of both thighs and legs.

We further found at the post-mortem, a pronounced fragility of the bones. This remark applies in several instances to the tubular bones, and repeatedly when removed from the body the upper epiphyses of one or even both humeri or tibiae, or the lower epiphyses of one or both femora, separated from the corresponding shafts. Microscopic examination proved that this was due to fractures of the shafts just below the intermediate cartilages. As will be shown in the next section of this article, we have, in other cases where no macroscopical separations of this nature took place, found microscopically smaller or larger fissures passing horizontally through the shafts just below the epiphyseal lines, but without laceration of the periosteum: or there appeared microscopical fractures of the cortical substance.

It will be seen therefore that the principal points of the observations described above were :

- (1) *Haemorrhages*.
- (2) *Loose teeth*, connected in several cases with a marked hyperaemia of the gums on the front of the incisors, and also in some instances with macroscopical haemorrhages under the mucous membrane of the gums.
- (3) *A certain fragility of the bones*, sometimes connected with demonstrable *intra vitam* fractures at the ends of the shafts.

From these observations we were led to assume that the disease might possibly be *scurvy*.

In the first place we have tried to ascertain whether the malady described instead of being due to a direct effect of the food is caused simply by *starvation*. Because, as mentioned above, the animals, at their death, are found to have lost about 40 % of their original weight, and because they do not eat much for about the last week of their life. Therefore, as a control, we gave two animals water only, while three others received daily 40—60 gms. of cabbage each (otherwise they eat, when fed on cabbage only, between 100 and 200 gms. a day).

It is thus evident that scurvy *cannot* be caused in guinea-pigs either by simple starvation or by diets of *any* kind; *on the contrary, the disease originates in these animals as well as in man as a result only of certain special diet.*

(4) *On the effects of certain so-called antiscorbutic nutriments and of certain salts added to bread or oats.*

In order to obtain further evidence as to whether the disease described in the two first sections of this article is identical with human scurvy or not, we have tried to find our bearings as regards a possible preventive effect of some of the nutriments known as "antiscorbutics" from human experience. For this purpose we fed several animals on oats, bread or rice mixed with fresh apples, fresh potatoes, fresh lemon-juice or cabbage. Finally, we also for reasons mentioned below, examined the effects of an addition of carbonate of lime, in some cases also of a mixture of this salt and neutral phosphate of lime.

CONCLUSIONS.

We have seen in the foregoing sections of this article, that a one-sided diet consisting of various sorts of grain, groats and bread, produces in guinea-pigs a disease that corresponds, macro- as well as microscopically, to human scurvy.

On the other hand, we have found that this disease does not occur after a one-sided diet consisting of fresh cabbage or fresh potatoes, whereas it again is produced by dried potatoes. That is, the disease originates in guinea-pigs as well as in man as a result of a diet confined to some special nutriments.

We have further observed that the disease is favourably influenced by different sorts of nutriments known, from human experience, as "antiscorbutics." We have, however, also found that at least one of these nutriments, that is cabbage, loses a deal but not all of its preventive power when boiled for half an hour at 110°C.

Finally we have quoted several examples showing that the same or similar one-sided diets that produce the disease in guinea-pigs, have repeatedly produced scurvy in man.

However, we have not, hitherto, been able to produce the disease that has been the proper aim of our experiments, that is the younger brother of scurvy or ship-beri-beri. It is true, we have repeatedly, in guinea-pigs, seen abortive cases of scurvy recalling the latter disease. This problem is, however, by no means clear. Nor have we, hitherto, been able to make experiments explaining, in an unmistakable way, why the one-sided diets, mentioned above, produce scurvy.

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