Letters to the Editor

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Molecular Weights of the Blood Pigments of the Invertebrates

BY means of the ultra-centrifugal method, it has recently been shown that the red blood pigment of the annelids is not identical with the hæmoglobin of the vertebrates as was previously assumed, but is a protein more allied to chlorocruorin and hæmocyanin with regard to molecular weight[1]. It was suggested that a comparative study of the properties of the respiratory proteins throughout the animal kingdom might bring to light interesting relationships between the various groups of animals. Such an investigation has now been started, and although so far only some forty species have been studied, a number of regularities have been found which seem to merit general attention.

Four types of respiratory proteins are known from the blood of the invertebrates, a red pigment (erythrocruorin), a green pigment (chlorocruorin), a blue pigment (hæmocyanin) and a pigment of reddish brown colour (hæmerythrin). In the following, only the first three types will be considered.

Of the erythrocruorin type we have found five different forms dissolved in the blood and two forms in blood corpuscles differing with regard to sedimentation constant. Each of the five forms of the first type is characteristic of one of the following groups of invertebrates: oligochæte worms, polychæte worms, gastropods, crustaceans, insects. The two forms of the second type have been found in the erythrocytes of the capitellide and glyceride worms. For the chlorocruorin type only one sedimentation constant has been observed. For the hæmocyanin type we have found six sedimentation constants representing the following animal groups: gastropods, cephalopods (two different constants), xiphosurans, crustaceans (three different constants). Within some of these groups several species have been studied, all of which give the same sedimentation constant with a probable error of about 2 per cent. It is not possible to determine the molecular weight with the same degree of accuracy, but the fact that the sedimentation constants agree so closely makes it extremely probable that the molecular weights are also almost identical.

Among the polychæte worms six species belonging to six different families possess respiratory pigments with the same sedimentation constant, namely, $57 \cdot 5 \times 10^{-13}$ (corresponding to a molecular weight[2] of 2,850,000). Among the gastropods no less than eleven species representing seven different families show the same sedimentation constant of $99 \cdot 5 \times 10^{-13}$ (corresponding to a molecular weight[3] of 5,000,000) and among the crustaceans five species of three families have the constant $23 \cdot 0 \times 10^{-13}$. The lowest sedimentation constant for a respiratory pigment dissolved in the blood is found for the erythrocruorin of the insects (*Chironomus* larvæ). It is only about half that of the constant of the hæmoglobin of the vertebrates and therefore corresponds to a comparatively very low molecular weight. Only a few invertebrates possess red blood corpuscles. So far, we have only had the opportunity of studying the respiratory proteins from two such species. It is noteworthy that in both cases low sedimentation constants were found.

The constancy of the molecular weights of the respiratory blood proteins within various animal groups becomes still more puzzling when the following facts are taken into consideration. The erythrocruorin and the chlorocruorin of the polychæte worms, the erythrocruorin of *Planorbis* and the hæmocyanin of *Calocharis*, the erythrocruorin of the polychæte worms and the hæmocyanin of *Sepia* and probably the erythrocruorin of *Daphnia* and the hæmocyanin of *Eupagurus* have identical sedimentation constants and therefore probably identical molecular weights. The measurement of the absorption of light in the visible part of the spectrum for the blood proteins of the gastropods has further shown that the hæmocyanins of *Helix*, *Paludina* and *Littorina*, which have the same molecular weight, nevertheless are distinctly different with regard to the chemical constitution of the active group of the molecule. A detailed and systematic investigation of the isoelectric points of the respiratory proteins of the invertebrates, now being carried out in this laboratory by Dr. K. O. Pedersen, has brought to light another circumstance of considerable importance. He has found that, as a rule, each species is characterised by a special value of the isoelectric point of its blood pigment. This means that the chemical composition of the blood pigment varies from one species to another, although the mass of the molecule remains practically constant.

It seems, therefore, that only a few molecular masses are stable and that it would depend upon the composition of the molecule with regard to various amino-acids whether one or the other of the different possibilities is realised. The constancy of the molecular weight within a certain animal group would then be a measure of the similarity of certain chemical processes leading to the formation of the respiratory protein.

The regularities in the sedimentation constants which we have found seem to justify an effort to extend this investigation to other species and other groups of animals possessing respiratory proteins.

THE SVEDBERG.
ASTRID HEDENIUS.

Laboratory of Physical Chemistry,
University of Uppsala.

Jan. 21.

[1] T. Svedberg and Inga-Britta Eriksson, NATURE, 130, 434, Sept. 17, 1932.
[2] Unpublished determination by Miss I.-B. Eriksson.
[3] T. Svedberg and E. Chirnoaga, *J. Amer. Chem. Soc.*, **50**, 1399; 1928.

Virus Diseases and Intracellular Inclusions in Plants

VIRUS diseases of both plants and animals are often characterised by the production of abnormal inclusion bodies within the cells of the host. The bodies are usually of more or less spherical form and are protein in nature. Although they commonly accompany virus diseases, they have not been found to occur in hosts infected with any other type of disease, nor are they at all similar to the many intracellular inclusions formed in normal healthy plants.

These virus inclusion bodies have attracted much attention and various theories as to their origin and