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THE DISEASES OF OCCUPATIONS

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CHAPTER V

THE ANCIENT METALS

THE metals have been arbitrarily distributed among three chapters, *The Ancient Metals*, *The Other Metals* and *The Newer Metals*. Even more arbitrarily, under the second of these headings we have included arsenic, a metalloid, and phosphorus, a non-metal. In the third section two further metalloids are described, namely selenium and tellurium. *The Newer Metals* are those more recently introduced into industry than the others.

THE METALS

The division of elements into metals and non-metals is but a rough classification adopted for convenience. Exact subdivision is not practicable, for some elements have properties characteristic of both metals and non-metals. These hybrids are known as *metalloids* or *half-metals*. They include antimony, arsenic, bismuth, silicon, selenium and tellurium.

Innocent Metals with Poisonous Compounds

A metal may enter the tissues without acting as a poison. Thus, silver produces no toxic symptoms although it can bring about lifelong disfigurement in the form of generalized argyria. Other metals which are themselves harmless nevertheless form certain toxic compounds. Thus, nickel is innocent of toxic effects, yet the inhalation of nickel carbonyl causes destructive lesions in the lungs. Relatively large quantities of tin can be dissolved by acid materials preserved in tin cans without imparting any taste or flavour to food materials and without producing injury on ingestion. Yet tetramethyl tin is intensely poisonous to nervous tissues, and tin tetra-hydride is more toxic than arsine.

Effects of Organo-metallic Compounds

A metal or a compound of a metal may have a different effect according to whether it exists in organic or inorganic form, whether its physical properties are those of a solid, a liquid or a gas, whether the valency of the metal radical is high or low, or whether it falls upon the skin or enters the body through the respiratory or alimentary tract. Thus, arsine acts as a powerful hæmolytic poison whereas the inorganic compounds of arsenic never produce this effect. Men poisoned by tetra-ethyl lead show cerebral symptoms and signs, the well-known symptoms of poisoning by inorganic compounds of lead being absent. Similarly, men poisoned by methylmercury compounds do not show the symptoms and signs of poisoning by the metal itself, but they present the picture of a unique disease of the nervous system. A third metal showing a specific selection for certain parts

THE ANCIENT METALS

of the brain is manganese. This attacks the nucleus and the caudate nucleus, and the signs of involvement of the extrapyramidal system. The white phosphorus, an allotrope of phosphorus causes necrosis of the liver. Some compounds are inhibitors of cholinesterase in the nervous system.

Physical Form of Metallic Compounds

The physical form in which a metallic compound is presented may determine its toxicity. Thus, lead fume, when inhaled as freshly formed fume, is more toxic than as dust. The different effect is probably due to the size of the fume. Lead absorption is always greater for freshly formed lead fume. Thus, in the case of lead, in the case of freshly formed with an oxy-acetylene flame, 100 per cent of particle size. The effects of a metallic compound on the portal of entry. Thus, workers exposed to lead suffer from tremor, whereas this symptom is rubbed into the skin.

Distinctive Toxic Effect of each Metal

The behaviour of metals and their compounds is more complex than that of great groups of organic compounds or the halogenated hydrocarbons which permit some evaluation of the toxicity of members of the group from what we know of metallic compounds is an exception to the rule. Hydrogen selenide and hydrogen telluride are hæmolytic poisons. Fortunately, only the most common are hazardous. It follows that in discussing the toxicity of metals and their compounds, each one must be considered on its merits.

THE ANCIENT METALS

Naturally some metals have been in use since prehistoric times. It is possible to trace with some accuracy, over the history of the use of lead and mercury. Hippocrates was probably the first of the ancient physicians to describe the cause of colic, and Pliny describes mercury poisoning of slaves. But new uses for these ancient metals and some of their compounds, especially the newly introduced into industry.

LEAD

Lead poisoning may occur in industry in connection with the use of the inorganic compounds of lead, and (

adults are exceptional. The converse of the Australian cases. Peronei, extensor digitorum longus are affected in varying degree. An ilio-psoas and quadriceps extensor muscles followed by cramps, fibrillation (fig. 81), together with spasticity of the ankle clonus and extensor plantar supervene, the condition becomes chronic lateral sclerosis.

Lead is a muscle disease. Fatigue plays an important part in the muscles attacked. Experimental evidence indicates that the diffusion of lead begins in muscle. Thus Aub and Burton which showed that the diffusion of lead in frog's skeletal muscle immersed in lead when lead salts are added to the bath indicate that lead may readily alter muscle. They were followed by others which showed that lead is more than their normal fellows, and that lead is found in fatigued leaded muscles. Lactic acid is the result of activity, combines with lead to form the lead phosphate in the blood to form lead lactate. As this soluble lead lactate comes into contact with inorganic phosphate at the surface of the muscle cells, the lead is reprecipitated as insoluble lead phosphate, causing alteration in the surface permeability. Efforts to show that reasonable concentrations of lead affect the conductivity of nerve were unsuccessful.

Experiments inducing Fatigue in Leaded Cats

On this basis further experiments were made on intact animals. Cats were exercised in a revolving drum and the fatigue produced was increased locally by attaching a weight to the right fore-paw. It soon became apparent that if the animals were given lead the limb most affected was the one raising the weight (fig. 82). In other words,

lead attacked the site of greatest fatigue. The weighted foot showed signs of weakness after about two weeks of exercise. The threshold of the weighted muscle to stimulation through nerve was higher than that of the opposite foot, and a similar difference was apparent with direct muscular stimulation in most of the cases tested.

Blue Line on the Gums

The well-known blue line on the gums, sometimes called the Burtonian line, was described by Grisolle in 1836 and by Burton in 1840. It consists of fine granules of pigment, arranged in the form of a dark blue stippled line, within the tissue of the gum and about a millimetre from the gingival margin (fig. 83). It is more marked round teeth having infected gingival



FIG. 83.—Microscope Drawing showing Sub-epithelial Position of Lead Line in Gum

(By courtesy of Professor J. C. Aub and the Williams and Wilkins Co., Baltimore)

troughs and occasionally may be found on the mucosa of the cheek opposite such teeth. The line is more frequently seen on the mandibular gums than on the maxillary, and in the incisor region than in the molar. If there are no teeth it does not occur. It is a precipitate of lead sulphide caused by the action of hydrogen sulphide upon the lead salts in the circulation. The gas is formed by micro-organisms in infected gingival troughs. Despite the pigment lying within the tissues, careful cleansing of the mouth and teeth often causes it to disappear. It is significant of absorption and not of intoxication. Its intensity and size provide a rough guide to the duration and severity of exposure to lead. At necropsy a broad blue line of lead sulphide may be found in the mucosa of the rectum near the anal margin.

Lead Anæmia

As early as 1831 Laennec described pallor of the tissues and thinness of the blood in cases of plumbism. The red-cell count was first found to be low in lead poisoning in the year 1840. Studies of lead anæmia are important, not only because of its clinical significance, but also because a clear understanding of the action of lead on the red blood corpuscle as an isolated cell throws considerable light on the mechanism of its reaction with other cells in the body. Chronic lead poisoning may give rise to a mild low colour-index anæmia. It is therefore of value to estimate the hæmoglobin figure in persons exposed. In differential diagnosis it is important to remember that in any case of industrial plumbism it is rare to find less than 3,000,000 red cells per c.mm.

Punctate Basophilia

Examination of the blood for punctate basophilia is of value in the prophylaxis of plumbism and, indeed, essential in the hygienic control of lead processes if the occurrence of manifest plumbism is to be avoided. The presence of basophilic stippling in the blood is not a specific sign of lead poisoning. It is seen in pernicious anæmia, leukæmia, the anæmias of carcinomatosis, in pneumonia in infants and sometimes in normal persons. However, its occurrence in these conditions is rare and slight as compared with the frequency and intensity of its appearance during plumbism. Ehrlich believed the stippling to be of cytoplasmic origin, and this view is undoubtedly correct. The basophilic granules are independent of the nuclear substance and have origin in the reticulum. Direct transition between nuclear fragments and stippling has never been observed.

Cytoplasmic Origin of Basophilic Granules

Furthermore, in marrow preparations made by sternal puncture the granules are frequently seen in erythroblasts with intact nuclei. The granules show none of the photographic or staining properties of nuclear substance. There is much evidence of the close alliance of basophil punctation with polychromatophilia and reticulation. The same fixatives and the same differential stains are effective for all three conditions. Blood films can be

prepared showing all stages between punctate basophilia and typical reticulum. This action is analogous to its effect on other young cells, the sarcoma cell. Circulation of the sarcoma cell for its attack, and in the case of the sarcoma cell are the reticulocytes (Key, 1924).

Methods of Staining and of Microscopy

Thin blood films are fixed with methylene-blue (methylene-blue parts, distilled water 400 parts). They are then immersed in a dark-ground illumination by dark-ground illumination. The red cells are seen as circles of light dots within the circle (fig. 84). Large dots denote excessive

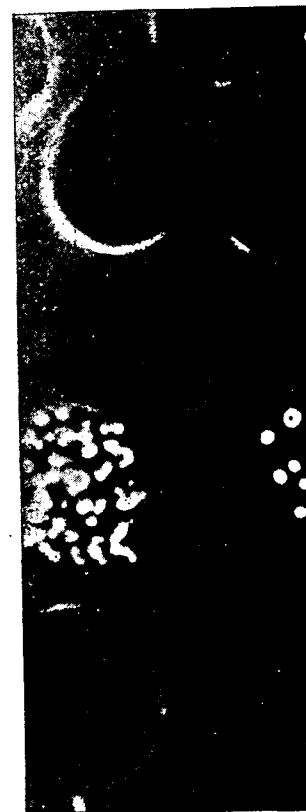


FIG. 84.—Erythrocytes showing punctate basophilia by Dark-ground illumination.
(After Professor R. E. Loefer)