in the diet is important in the production and prevention of experimental dental caries in rats. Eighty-eight per cent. of rats fed a diet containing 0.23 grams of phosphorus per 100 grams of diet show dental caries at the end of 140 days of feeding. One hundred and forty rats fed diets containing 0.410 grams of phosphorus per 100 grams of diet show a percentage incidence of caries of 5 per cent.

The studies of McCollum, Simmonds, Park and Shipley, on bone growth and calcification, demonstrated the great importance, for the deposition of calcium salts in the osseous tissues, of certain ratios between these elements. The studies of Howland and Kramer, and others, have demonstrated the dependence of calcification on the inorganic phosphorus content of the blood, and especially on the product of the concentration of calcium and phosphate ions in the blood. We have found that a similar relation exists between blood composition and the incidence of dental caries. Using available data[5] on the composition of rat blood on diets unbalanced in calcium-phosphorus, we have been able to calculate that a critical level of blood phosphorus exists ($10.5 \pm .5$ mg) under which rats develop caries and above which rats are immune from dental caries.

Blood phosphorus concentration is determined in great measure by total calcium, total phosphorus and total vitamin D intake. Therefore the maintenance of a level of blood phosphorus above the caries-immunity level ($10.5 \pm .5$) is dependent upon these three factors. The level of phosphorus intake which will maintain the caries-immune level of blood phosphorus increases with increasing calcium intake and decreases with increasing vitamin D intake.

SUMMARY

(1) Estimations of the phosphorus content of diets reported to produce caries in rats indicate that rations containing 0.4802 grams of phosphorus per 100 grams of diet, or less than 0.4802 grams of phosphorus per 100 grams of diet, tend to induce dental caries in rats if Ca intake is 0.3424 per cent.

(2) Estimations of the phosphorus content of diets reported to produce rats immune to dental caries indicate that such diets contain 0.5282 or more grams of phosphorus per 100 grams of diet and 0.4012 or less grams of calcium per 100 grams of diet.

(3) Experimental evidence is presented which indicates that the level of phosphorus in the diet is an important factor in producing caries-susceptibility and caries-immunity in rats.

(4) We have also found that a relation exists between blood composition (phosphorus) and the incidence of dental caries in rats. Caries arises in rats whose blood phosphorus falls below a critical level (about $10.5 \pm .5$ mg[6] of phosphorus per 100 grams of serum), while those rats whose blood phosphorus concentration is $10.5 \pm .5$ or above are immune from dental caries.

(5) It is indicated that this blood figure is dependent upon the level of phosphorus, calcium and vitamin ingested in the diet.

In a forthcoming paper we shall present the results of an extensive review of the recorded observations of our own and other laboratories on the relation between diet and susceptibility to dental caries in the rat and our conclusions from examining these data in the light of the working hypothesis (blood phosphorus critical level) here presented.

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## ON THE ULTRA-VIOLET PHOTOMICROGRAPHY OF LIVING CELLS

AN important advantage of the ultra-violet microscope in biology is its ability to photograph directly many cell structures which ordinarily are seen only in fixed and stained preparations. In this way one can study these structures without fear that they may be coagulation artifacts. To do this with complete assurance, however, it is often necessary to work with living and not merely with fresh material. All the ultra-violet photographs thus far published have been made with the original microscope of Köhler (Zeiss)[1] or the modification due to Barnard (as built by Beck)[2]. These instruments, though well suited to the photography of fixed preparations, require exposures which are too long for living cells both because of the highly injurious action of the ultra-violet light and because of the loss of fine detail through Brownian movement and protoplasmic streaming.

It has been found that only simple modifications are required to give photographs with the immersion

[5] Benjamin Kramer and J. Howland. In press.

[6] This figure is obtained by relating the calcium, phosphorus and vitamin D intake and percentage incidence of caries of the Hoppert, Webber and Canniff rats, with the blood calcium and phosphorus values of Kramer and Howland.

[7] Research fellow supported by grants from the American Dental Association and the Dental Staff of the Johns Hopkins Hospital.

[1] A. Köhler, *Zeit. f. wiss. Mik.*, 21: 129, 273 (1904); *ibid.*, 24: 360 (1907); A. Köhler and F. Togby, *Arch. f. Augenheilk.*, 99: 263 (1928); E. Grawitz and Grüneberg (photography by A. Köhler), "Die Zellendes menschlichen Blutes im ultraviolettem Licht" (Leipzig, 1906); H. v. Schrötter, *Virch. Arch. f. Path. Anat. u. s. w.*, 183: 343; F. F. Lucas, *Proc. Nat. Acad. Sci.*, 16: 599 (1930); *J. Morph.*, 52: 91 (1931).

[2] J. E. Barnard, *Lancet*, 2: 117 (1925); *J. Roy. Mic. Soc.*, 47: 253 (1926); R. W. G. Wyckoff and A. L. Ter Louw, *J. Exp. Med.*, 54: 449 (1931).

objectives in from $\frac{1}{25}$ to $\frac{1}{5}$ of a second. Resolution approaching the theoretical maximum has been reached in pictures of living cells made under these conditions. We have furthermore observed that many kinds of cells if carefully shielded from all extraneous radiation are seemingly unhurt by the amount of ultra-violet light necessary to photograph them. Consequently it has been possible to prepare serial photographs which show many single cells and simple organisms passing through successive stages in their life histories. As would be expected from the conspicuous absorption of formed chromatin, this "motion picture" procedure has proved especially instructive in studies of cell division.

The microscope used is a Barnard instrument adapted to take Zeiss optics and modified in various minor details of its construction. Reduced exposure and irradiation times have been achieved (1) by employing as source a sufficiently powerful condensed spark discharge (between cadmium electrodes), (2) by refining mechanical features so that the correct focal plane for the ultra-violet light can *always* be reached after applying an empirical correction to the setting for green light and (3) by photographing on fine grained motion picture film at moderate initial magnifications and enlarging from the negatives. It should be remarked that after these modifications ultra-violet photographs can be made with practically the same ease and certainty that attend ordinary photomicrography with visible light.

This apparatus and the "slow motion picture" technique which it makes possible are being applied to the study of a number of biological problems. With A. H. Ebeling photographs[3] have been made of various tissue cells in mitosis. We have also photographed the growth of yeast, several steps in the reduction divisions leading to the production of grasshopper sperm and some stages in the life cycles of typical protozoa. These will be published at a later date, together with a detailed description of the microscope itself.

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## ELEMENT 87

THE isolation of element 87, reported in the press on October 15, 1931, offers another opportunity to test the validity of the periodic classification. The accompanying curves indicate certain properties of the alkali elements, and have been extended to cover the properties of element 87 by extrapolation. The values so obtained are subject to the usual objections common to extrapolated figures, but it will be interesting to see how closely they will conform to the observed properties of element 87 when the element has been completely studied.

Figs. 1, 2, 3 and 4 represent, respectively, the

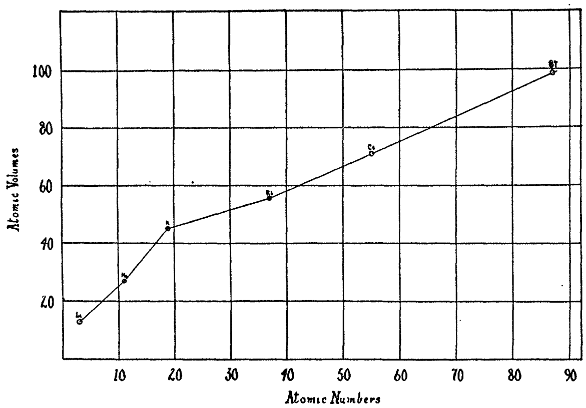


FIG. 1. Atomic volumes of the alkali elements plotted against their atomic numbers, with the value for element 87 extrapolated.

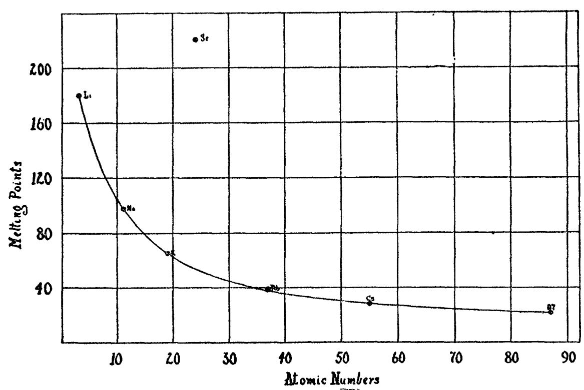


FIG. 2. Melting points of the alkali elements plotted against their atomic numbers, with the value for elements 87 extrapolated.

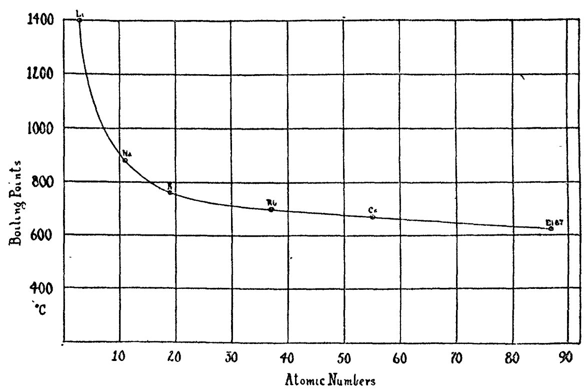


FIG. 3. Boiling points of the alkali elements plotted against atomic numbers, with the value for element 87 extrapolated.

[3] A few of our earliest photographs will appear in a forthcoming number of the *Journal of Morphology*.