Columns V, VI, VII and VIII are similar to columns I, II, III and IV, respectively, and give the results of observations made upon the same preparation during the constant intravenous infusion of adrenalin (1-25,000).

In this experiment the refractory period of normal auricular excitations was found to lie between 0.1338 sec. and 0.1367 sec. The refractory period of extrasystoles induced 0.1439 sec. to 0.1501 sec. after normal excitations was between 0.1044 sec. and 0.1092 sec. The same ratio obtained when the cardiac rate was accelerated by the constant intravenous infusion of adrenalin. The refractory period of normal excitations lay between 0.0922 sec. and 0.0978 sec. while the refractory period of early extrasystoles was between 0.0716 sec. and 0.0746 sec.

In a series of 19 animals it has been demonstrated that the refractory period of a premature systole is considerably (20-30%) shorter than that of a normal spontaneous excitation. Moreover, the earlier the extrasystole is induced in the normal diastole, the shorter is its refractory period.

Complete results of the other observations, and the significance of these findings with relation to certain ectopic rhythms, will be discussed in a subsequent communication.

7180 P

Reversible Inactivation of Bacteriophage by KCN.

A. P. KRUEGER AND S. ELBERG.

From the Department of Bacteriology, University of California, Berkeley.

It has recently been shown that the complete inactivation of phage following treatment with $HgCl_2$ can be reversed by precipitation of Hg^{++} with restoration of the phage to its original titre.[1, 2] The phenomenon is interesting in that reactivation occurs after exposure to very concentrated $HgCl_2$ solutions for long periods of time, conditions which produce irreversible loss of the growth function in even the most resistant spore forms of bacterial life. The suggestion was advanced[2] that this behavior spoke for the enzyme concept of phage rather than for the view that phage is composed of living protoplasm.

[1] Krueger, A. P., and Baldwin, D. M., *J. Gen. Physiol.*, 1933, **17**, 129.

[2] Krueger, A. P., and Baldwin, D. M., *J. Gen. Physiol.*, 1933, in press.

Further work seemed indicated to determine whether the reversible inactivation of phage with $HgCl_2$ represented a special case or whether, as seemed likely, it was merely one example of a general property of phage. We wish to summarize here certain experiments on the cyanide-phage reaction.

1. *Inactivation.* Standard antistaphylococcal phage[3] suspended in beef infusion broth of pH 7.6 was mixed with an equal volume of 1/5,000 KCN (M/325) solution. The mixture was kept at room temperature for 24 hours after which time the following samples were taken: (a) 1 ml. immediately diluted 1/1,000 with broth for determination of residual [P]. (b) 10 ml. for reactivation.

2. *Reactivation.* To 10 ml. of inactivated phage was added 1 ml. of 2.74% $AgNO_3$ and 2 ml. of 1% KCN, the purpose being to remove the CN ions from their union with phage and to combine them in the complex double ion $Ag(CN)_2^-$. The latter ion does not form insoluble compounds with the cations present and therefore obviates the dangers of phage adsorption on a precipitate. Dilutions of 1 part of the reactivated mixture to 1000 parts of broth were made at once for subsequent titration.

3. *Controls.* (a) Equal volumes of various phage concentrations and 1/5,000,000 KCN (M/325,000) solution were mixed together. These solutions were titrated along with the inactivated and reactivated series to detect any possible influence of 1/10,000,000 KCN upon the titration system. (b) The reactivated solutions themselves served as an adequate means of observing the effects of $Ag(CN)_2^-$ ions on the titration set up. It was found that neither the CN^- ions nor the $Ag(CN)_2^-$ ion in the concentrations employed altered the Bacterium-Bacteriophage reaction utilized in the quantitative determination.

4. *Titration.* All titrations were performed according to the procedure developed by Krueger for the quantitative determination of phage.[3, 4] In this method an activity unit having the general dimensions of a velocity constant is employed and as in certain enzyme determinations the results of each individual experiment are referred to a standard solution (containing in phage work $1x10^{10}$ such units).

Results. In 4 separate experiments it was found that the inactivation of phage by exposure to M/650 KCN for 24 hours could be completely reversed by converting CN^- to $Ag(CN)_2^-$. The yields were respectively 78%, 100%, 86%, and 98%, of the initial phage.

[3] Krueger, A. P., *J. Gen. Physiol.*, 1929, **13**, 557.

[4] Krueger, A. P., *Science*, 1930, **72**, 507.

While inactivation in these experiments appears to be complete the method of carrying out the test involves the possibility of a small residuum of active phage escaping detection, for the inactivated solution is diluted 1:1000 with broth before titrating it. This step is necessary in order to bring the KCN concentration down to a level (1/10,000,000) which will not interfere with the titration reaction. However, even should some phage not be inactivated the maximal theoretical amount that might be overlooked would be very small indeed; at most not more than two hundred thousandths of one per cent of the original phage titre.

Conclusions. 1. The inactivation of antistaphylococcal bacteriophage suspended in infusion broth at pH 7.6 by CN^- can be completely reversed by converting CN^- to $Ag(CN)_2^-$. 2. The previously reported reversible inactivation of phage by Hg^{++} therefore appears to be not a special case but rather one example of a more or less general property of phage.

7181 P

Effect on Total Thyroidectomy on Response to Adrenalin.

EUGENE C. EPPINGER AND SAMUEL A. LEVINE. (Introduced by E. C. Cutler).

From the Medical and Surgical Clinics, Peter Bent Brigham Hospital, Boston.

The following observations have been carried out as a part of the study concerning the therapeutic value of total thyroidectomy in angina pectoris. It was noted a few years ago[1] that intramuscular injections of adrenalin, when given to patients suffering with angina pectoris would provoke attacks of anginal pain. As a result of clinical observation, it was found that when total thyroidectomy was performed in patients who were having daily attacks of angina, these attacks disappeared immediately following the operation and long before any changes had taken place either in the basal metabolism or in the rate of blood flow. It was therefore suspected and, in fact, predicted[2] that removal of the thyroid gland might be producing a fundamental alteration in the response of the circulation to

[1] Levine, S. A., Ernstene, A. C., and Jacobson, B. M., *Arch. Int. Med.*, 1930, **45**, 191.

[2] Levine, S. A., Cutler, E. C., and Eppinger, E. C., *New Eng. J. Med.*, 1933, **209**, 667.