inexpensive and easy to construct to make it suitable for classroom work.

The apparatus consists chiefly of an air pump (A)

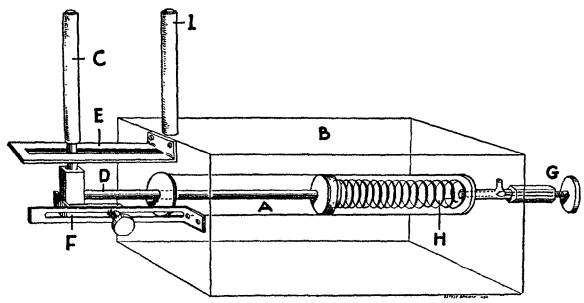

FIG. 1.

of the type used for inflating football bladders. This pump is mounted horizontally in a wooden box (B), each end of the pump being flush with the outside surface of each end of the box. A vertical metal rod (C) runs in a slotted guide (E), its excursion being limited by the adjustable stop (F). To the outlet nozzle of the pump is attached a needle valve (G). A coil spring (H) of suitable strength and an upright rod (I), attached to the box, complete the apparatus.

To operate the apparatus the forearm rests on the top of the box and the rubber (tubing) covered rods are grasped in the hand, the size of the grip being adjusted with the stop (F). When the grip is exerted, air is forced out of the pump through the needle valve (G) the adjustment of which controls the resistance to be overcome and therefore the required force. The outlet of the needle valve may be connected by rubber tubing to a suitable recording device for graphic registration. When the grip is relaxed, the coil spring (H) returns the piston to its resting position.

The work done may be calculated from the product of the number of strokes, the distance moved per stroke and the force required. The number of strokes may be recorded or counted; the distance moved per stroke is measured. The force required to bring the rod (C) into apposition with the rod (I) can be measured by performing that operation with a simple spring balance.

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SPECIAL ARTICLES

ACTIVE IMMUNIZATION IN MONKEYS AGAINST POLIOMYELITIS WITH GERMICIDALLY INACTIVATED VIRUS[1]

IN my previous work it was shown that sub-infective doses of active virus or virus-serum[2] combinations[3] may produce immunity against the virus of poliomyelitis. The former method, however, is attended by the danger of giving the disease during the course of immunization, whereas the latter method entails considerable difficulty in reaching the proper virus-serum combination. An excess of virus in the mixture may produce the disease, while an excess of serum reduces the immunity considerably.

Although the use of germicidally inactivated virus for the production of active immunity has been reported successful in the virus conditions, such as Borna disease, cattle plague, dog distemper, foot-and-mouth disease, fowl plague, herpes, psittacosis, rabies and yellow fever, the experimental results in the case of poliomyelitis, up to the present, have been both contradictory and indefinite.

Therefore, an attempt was made to produce active immunity against poliomyelitis in *Macacus rhesus* monkeys, using as antigen virus inactivated by either formalin or phenol.

It was shown that active poliomyelitis virus inactivated with formalin is antigenic. Virus treated with phenol did not prove as effective as formalized virus; besides, the concentration necessary to render the virus non-infective made it too irritating for convenient use. The monkeys were injected intracutaneously with a 10 per cent. virus suspension. Either one or two inoculations were given. In the latter case, the interval between the two doses was from 10 to 20 days.

The optimum antigenic dose was determined as being approximately ½ gram of cord tissue. This was based upon the results of the following experiments.

Tissue immunity was shown by only one of three monkeys which had received 2.5 cc of a 10 per cent suspension. One of these three had had one inoculation and the others, each two injections. Poliomyelitis antibodies were found in all three serums. Some tissue immunity was demonstrable in ten monkeys of a series of twelve animals, 3 of which were given one inoculation consisting of 5 cc of a 10 per cent. suspension and 9, two such inoculations. In seven of the ten, which showed tissue immunity, the degree of immunity was comparable with that of animals given similar treatment with active virus. Virus neutralizing substances were found in all their serums.

[1] This research was aided by grants from the New York Foundation and the Rockefeller Foundation.

[2] M. Brodie, *Proc. Soc. Exp. Biol. and Med.*, 30: 1238, 1933; *Jour. of Immun.*, in press.

[3] M. Brodie and A. Goldbloom, *Jour. of Exp. Med.*, 53: 885, 1931; M. Brodie, *idem.*, 56: 493, 1932.

Three of eleven animals received one 10 cc dose; the remaining 8 were given two such doses. Of the entire group, nine showed some tissue immunity, which is evidenced by the animals' resistance to direct intracerebral inoculation of active virus. Unlike those receiving 5 cc amounts, the tissue immunity of these animals was lower than that of monkeys receiving similar doses of active virus. Too, the degree of immunity was lower than that developed by the animals in the foregoing series of twelve animals. Nine of the eleven had humoral antibodies.

Comparing formalized non-infective virus with active virus, as to antigenic value, the following facts were derived:

(1) In the case of active virus, the dose and the subsequent degree of immunity were directly proportional. Using formalized virus, however, the optimum dose was found to be 5 cc.

(2) With formalized cord tissue, the humoral immunity was usually better than the tissue immunity, but decidedly lower than that developed when active virus was used, even though with 5 cc amounts of formalized antigen, the tissue immunity obtained using either antigen was quite comparable. In some instances, humoral immunity was present in the absence of demonstrable tissue resistance and *vice versa*. To be able to say definitely that there is a correlation between tissue and humoral immunity in the case of active virus, but no such correlation using formalized virus, more work must be carried out concerning the relationship between neutralizing substances in the serum (humoral immunity) and resistance to direct intracerebral inoculation (tissue immunity) of virus. Toward this end, and also to determine whether a non-specific neutralizing substance destroyed by formalin was present in the nerve substance, two monkeys received some non-virus-containing-tissue intracutaneously. Neither of the two developed any antiviral substances.

(3) Using active virus, two inoculations given 10 to 20 days apart were more efficient than one inoculation, but with inactivated virus this did not seem so.

A comparison between the immunity produced due to the injection of inactivated virus and that of convalescent monkeys showed that, using the inactivated antigen, the tissue immunity was sometimes about equal to, but that the humoral immunity was lower than, the corresponding immunities in the case of recovered animals.

The inactivated antigens used in this work produced no reaction whatsoever upon combined inoculations of large doses both intracerebrally and intraperitoneally; for neither temperature increase nor cerebro-spinal fluid pleocytosis were demonstrable. Whether immunity developed from either a killed or highly attenuated antigen can not be definitely stated. If immunity was due to a small quantity of residual virus or to virus of very low virulence, then one must suppose that the stimulation brought about by less than one intracerebral infective dose gave immunity. However, since less than 120 intracerebral infective doses of active virus produced no demonstrable immunity, it is not likely that immunity was due to a sub-infective quantity of virus.

To further investigate this possibility, a series of 8 animals were given, intracutaneously, formalized virus suspension of sufficient infectivity to produce only a mild reaction upon combined intracerebral and intraperitoneal inoculation. Though still viable, the virus failed to give better immunity than did virus rendered non-infective. This again argues against the probability that non-infective material immunized by means of a slight amount of residual virus of extremely low infectivity.

It was found during the course of this work that the majority of the immune animals showed increased erythrocytic sedimentation rates at some time during the development of immunity. There seemed to be a definite relationship between immunity and changes in erythrocytic sedimentation rate.

This work indicates that definite immunity can be developed against the virus of poliomyelitis using virus rendered non-infective by formalin. However, in the concentration used, the formalin gave considerable skin irritation. Therefore, in the present work virus suspensions are being inactivated with lower concentrations of formalin.

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COMPARING SOIL FUNGICIDES WITH SPECIAL REFERENCE TO PHYMATOTRICHUM ROOT ROT[1]

Phymatotrichum omnivorum (Shear) Duggar, the fungus that causes the highly destructive root-rot disease, attacks the roots of plants from a few inches to several feet deep in the ground. For this reason, none of the chemicals customarily used as soil fungicides have proved effective in eradicating this fungus even from small infested areas. Recent work has shown that a group of volatile chemicals,[2] relatively insoluble in water, have strongly fungicidal properties and appear of particular promise for use against this fungus and other soil organisms.

In preliminary evaluation of these and other possible fungicides, the direct toxic effect was tested as

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[2] The writers are indebted to the Roessler and Hasslacher Company (now R. and H. Chemicals Department, E. I. du Pont de Nemours and Co., Inc.) for furnishing many of the chemicals tested.