supplies of local manures and fertilizers (which can not be much expanded). If artificial fertilizers were used only on soils where they were likely to be needed (on the soils which gave significant responses in these experiments), it would be possible to increase the total production of crops in China by between one third and one half, using the rates of application mentioned above. (The variability of the estimate depends on the weights to be applied to different crops and regions.) This estimate may be taken as applying to the part of China covered by Buck's "Land Utilization in China," with the exclusion of his Spring Wheat Area. The increase in production would be much greater in the Rice Region (about one half increase over present production) than in the wheat region (about one fifth increase).

Taking economic factors into consideration, and using the 1937 farm prices in east and north China as a basis, it can be said that if all farmers whose soils needed fertilizer applied what was necessary, at the standard rate, then on the average individual farmers would have a two-to-one chance of making a profit (*i.e.,* one farmer out of three would be likely to lose money). If only those farmers applied fertilizer whose soils were likely to give an economic response, on the basis of the field experiments, total crop production in China could still be increased by at least one quarter. Supposing that China developed her own fertilizer industry and that fertilizers could be sold at prices comparable with those in the United States in 1937, then these estimates would be considerably increased. If all farmers with deficient soils used the necessary fertilizers, then each farmer would have at least a five-to-one chance of making a profit from his expenditure; if only those farmers used fertilizers who were likely to secure an economic response, total crop production in China could be increased by at least one third.

The bearing of these results on the population, food and economic problems of China needs no emphasis. While it may not be possible to take much action on them under present conditions, for the future they are equivalent in increased production to adding four or five new provinces to the 17 or 18 provinces for which these estimates may be expected to hold good. In connection with the reclamation and resettlement of the poor soils of southwest China, too, the use of fertilizers is likely often to make the difference between success and failure.

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ON THE NATURE OF VIRUS ADAPTATIONS

FILTERABLE viruses are now generally recognized as highly specialized intracellular parasites. They not only are adapted to life within protoplasm, but also show specialized adaptations as to the kinds of cell that they invade and the species of animal in which they produce disease. The several adaptations appear to be distinctive for each individual virus and also to have a range of variation that is characteristic of each virus. Variations of the adaptations, within their ranges, are common in viruses occurring naturally; and by selection of the variations under experimental conditions, modified viruses of different kinds can be produced. Such terms as *neurotropic, dermatotropic* and *epitheliotropic* have been used to designate viruses that have special affinities for certain tissues. The term *pantropic* is used to describe a virus that invades a number of tissues without having a specialized affinity for any one of them.

There seem to be three fundamental adaptations of a virus as a parasite. The primary adaptation is to an existence within living protoplasm. It is this adaptation to growth within protoplasm that I have presented as basic to the transformation of visible microbes into ultramicrobes[1] by the process of retrograde evolution under conditions of parasitism. From the primary adaptation a virus obtains its fundamental characters in relation to a host-cell, such as growth only within the cytoplasm or the nucleus, the production of inclusion bodies before necrosis, the production of necrosis without inclusion bodies and stimulation of the host-cell to proliferation. This adaptation might be termed *cellular adaptation, protoplasmic adaptation* or *cytologic adaptation.* Inasmuch as the study of the cell is known as cytology, the most accurate term for adaptation of a virus to the cell would probably be the last named, *cytologic adaptation.*

Quite distinct is the adaptation of a virus to the type of host-cell[2] in which it grows. An expression of this specialization of a virus is seen in such terms as *neurotropic* and *dermatotropic.* The specialization does not seem to be an adaptation to a tissue or an organ, but specifically to a kind of cell which may, wholly or in part, make up a tissue or an organ. For example, the fox encephalitis virus produces a clinical encephalitis in foxes, but it is not a neurotropic virus, if this term indicates that the virus grows in nerve cells. It grows to the greatest extent in the cerebral vascular endothelium, to a less extent in the hepatic cells and not at all in nerve cells. In general, a virus appears to become adapted to grow best in one kind of specialized cell, but to a less extent it will grow in certain related specialized cells and also in more embryonic types of cell. This second adaptation might be called *organ-* or *tissue-specialization,* but this does not seem satisfactory because a virus grows in types

[1] R. G. Green, SCIENCE, 82: 443–445, 1935.
[2] R. G. Green, "Proceedings of the International Assembly of the Inter-State Postgraduate Medical Association of North America" (October 13–17, 1941, Minneapolis, Minnesota), pp. 80–85. 1941.

of cells regardless of their distribution in organs and tissues. It would seem that *histologic adaptation* best expresses the specialization of a virus with regard to the kind of cell in which it grows, since histology is the science of kinds of cells.

The third type of virus adaptation is related to the species of animal which the virus invades or in which it produces a disease. This adaptation, like the others, appears to be distinctive for each virus. The rabies virus is broadly adapted in this respect, being capable of invading probably all species of mammals and birds. The distemper virus, which is more restricted, produces a disease only in members of the weasel family, the raccoons and the Canidae. The virus of the oral papillomatosis of dogs appears to be capable of invading only the dog. The adaptation to growth in a host-species or in a range of host-species might well be termed the *zoologic adaptation* of a virus.

While the cytologic adaptation of a virus seems to undergo little or no variation, the histologic and the zoologic adaptations seem to be subject to extensive natural variation. Within the ranges of the latter two adaptations, great experimental change can be effected in a virus by the selection of the species of animal injected and by the choice of tissue used as virus in serial host-to-host transfers. The distemper virus may be highly adapted to ferrets by host-to-host passage, becoming highly virulent for that animal and at the same time becoming a harmless, immunizing agent for members of the canine family. Distinctly different, artificially modified distemper viruses are produced by ferret-passage, depending upon whether the virus is passed serially through ferrets by subcutaneous injection and the use of spleen as inoculum; by intracranial injection and the use of brain tissue as transmission material; or whether it is passed by skin-to-skin inoculation. Such viruses are identical in their zoologic adaptation but differ in their histologic adaptation. A clear separation of these adaptations seems essential to qualify the nature of both natural and experimental viruses.

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URETHANE: ABSENCE OF PARALLELISM WITH THE ANTI-SULFONAMIDE ACTION OF p-AMINOBENZOIC ACID

THE demonstration by Johnson[1] that urethane (ethyl carbamate) exerts an anti-sulfanilamide effect on systems involving luminous bacteria led to the assumption that urethane should exert an anti-sulfonamide action by inhibiting the *in vivo* protective action of sulfonamides against streptococcal or other infections. That this assumption is not correct has been demonstrated in this laboratory.

p-Aminobenzoic acid (0.5 grams per kilo) completely inhibits the protective action of sulfanilamide (2.0 grams per kilogram) against a streptococcus infection (produced by the injection of 0.1 cc of a 24-hour broth culture of Strep. hemolyticus). Urethane (0.5 grams per kilogram) fails to inhibit the anti-streptococcal action of sulfanilamide (2.0 grams per kilogram). Approximately 500 mice were used to establish this point.

The failure to demonstrate an anti-sulfanilamide action by urethane in an *in vivo* system involving protection against streptococcus infections limits the applicability of data obtained from the study of luciferase systems to the broader aspects of sulfonamide action. The basic mechanisms involved in the luciferase system are not necessarily those involved in the anti-bacterial action of sulfonamides generally.

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[1] SCIENCE, 95: 104, 1942.

BLUEBERRY STORAGE

DURING 1941 the Maine Agricultural Experiment Station conducted blueberry storage studies under controlled atmosphere and controlled temperature. These studies showed a great variation in the keeping quality of the different clones of low-bush blueberries and varieties of high-bush blueberries. The low-bush showed the greatest variation, as some of the clones with poor flavor when they were put in storage had good flavor when the storage period was completed. With other clones the reverse was observed. The fully mature and overripe berries did not keep well in storage and while they appeared good when removed from storage they became soft and wet before the berries could be retailed. In these experiments, the named varieties of high-bush blueberries did not store as well as some of the high-bush selections made in Maine.

The blueberries which were stored at 5° C and in an atmosphere with an oxygen content of 5 per cent. or slightly less were in the best condition at the end of the experiment. Carbon dioxide contents of from 13 to 15 per cent. in the atmosphere were not detrimental in these studies. These conditions are similar to those used by Van Doren *et al.*[1] in the storage of cherries, and the temperature was slightly higher than that recommended by Levine *et al.*[2] for the storage of

[1] A. Van Doren, M. B. Hoffman and R. M. Smock, *Proc. Amer. Soc. Hort. Sci.*, 38: 231–238, 1941.

[2] A. S. Levine, C. R. Fellers and C. I. Gunness, *Proc. Amer. Soc. Hort. Sci.*, 38: 239–242, 1941.