the forms of evolution of sex differentiation in fishes as compared with amphibians.

S. S. Chetverikov, V. P. Efroimson, and B. L. Astaurov are engaged in researches into the genetics and phenogenetics of the complicated phenomenon of voltinism in mulberry and oak silkworms.

Problems of the phenogenetics of behavior and instinct are being studied on dogs by L. V. Krushinsky, on birds by A. N. Promptov, and on *Drosophyllum* by R. A. Mazing. The majority of this work is being conducted in the Institute of Genetics of Nervous Activity, founded by I. N. Pavlov.

A new synthesis of genetics and evolutionary teachings is presented in various published papers by I. I. Shmalhausen. Highly interesting, also, are the experiments on correlation and selection, carried out in the laboratory of I. I. Shmalhausen and M. M. Kamshilov. The question of the evolutionary importance of nonhereditary variability is being studied in great detail by I. I. Shmalhausen, V. S. Kirpichnikov, I. I. Lukin, G. F. Gause, and others. All these researches are building up a genetic foundation for Morgan's idea that adaptive modification paves the way to evolution. Shmalhausen's general teachings on the ways of the evolutionary process throw a new light on the conception of the importance of reactive correlative systems, the most important peculiarity of which is the ability for modificatory adaptations.

As has been shown in this short review, Soviet biologists are devoting much attention to the problems of genetics, which are among the most important confronting modern science. We are confident that we shall achieve further great progress in genetics in the near future.

Ultrashort Application Time of Penetrating Electrons:

A Tool for Sterilization and Preservation of Food in the Raw State[1]

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DURING THE LAST SEVERAL YEARS, in an attempt to determine the selective effects of ultrashort time exposures as compared with prolonged radiation periods, we have exposed a number of drugs and other chemical compounds, foodstuffs, and cultures of microorganisms to the action of penetrating, negatively charged particles (electrons), which were released during a time period of about 1/1,000,000 of a second. The electronic intensity applied during such short radiation impulses amounted to about 30,000–50,000 amperes.

It is a well-known fact that all chemical reactions need a certain starting time, and it remained to be seen if various desired biological effects could be exercised ahead of undesired chemical side reactions (*5*).

There exists today no convenient method of preserving foodstuffs in their fresh, raw state, and our experiments were in part directed to this need. Another aspect of the work involved the use of this radiation method in the field of bacteriology and medicine to determine whether we had at our disposal a more differentiated tool than was heretofore available in the treatment of microorganisms—as, for example, attenuation.

Actually, the experiments indicate that ultrashort exposure times are a vital factor in differentiation and in suppressing undesired side reactions.

Theoretically, it would appear relatively easy to avoid undesirable side reactions, such as oxidation, by removing the air as far as possible and by irradiating either in a partial vacuum or by replacing the oxygen with inert gas; but it must be kept in mind that this can be achieved only to a limited degree, since foodstuffs per se contain so much water that the vacuum reduction cannot proceed below the evaporation point, if dehydration and subsequent changes in texture are to be avoided. Even under inert gases, the water remaining in the target would still interact with the electrons and lead to harmful changes in flavor and appearance.

To determine the over-all extent of side reactions, such as the formation of oxidation products during exposure to high-speed electrons of ultrashort duration, distilled and tap water were irradiated, and it was found that with dosages comparable to those causing complete sterilization, the hydrogen peroxide formation amounted to less than .005 per cent. These experiments were conducted at room temperature. Subsequently, we repeated the experiments with the same dosages but with progressive reduction of the temperature to −100° C., and found a continuous decrease of hydrogen peroxide formation, the final percentage being only about 1/10 that formed at room temperature. Thus, a second method became

[1] The authors are grateful to M. P. Davidson, W. S. Wasserman, and A. A. Strelsin for making available the funds which supported these experiments. Richard Sencer has assisted considerably with the building of the radiation laboratory.

available to suppress undesired side reactions. In combination with the ultrashort exposure times, it provided the necessary means to preserve a number of raw foodstuffs, without noticeable changes in appearance, taste, and odor. Generally, it was found that the combination of these two factors suppressed not only oxidation but also all other processes, except for the most rapidly occurring chemical and biological reactions.

1/1,000,000 of a second. The law of absorption (*8*) and the possibility of an exact dosage are factors in favor of artificially produced electrons, which, furthermore, can be handled and directed much more easily and safely. Finally, with electrons accelerated by tensions up to 10,000,000 volts, the danger of formation of radioactive by-products in the irradiated substances is negligible, whereas the contrary is true of neutrons.

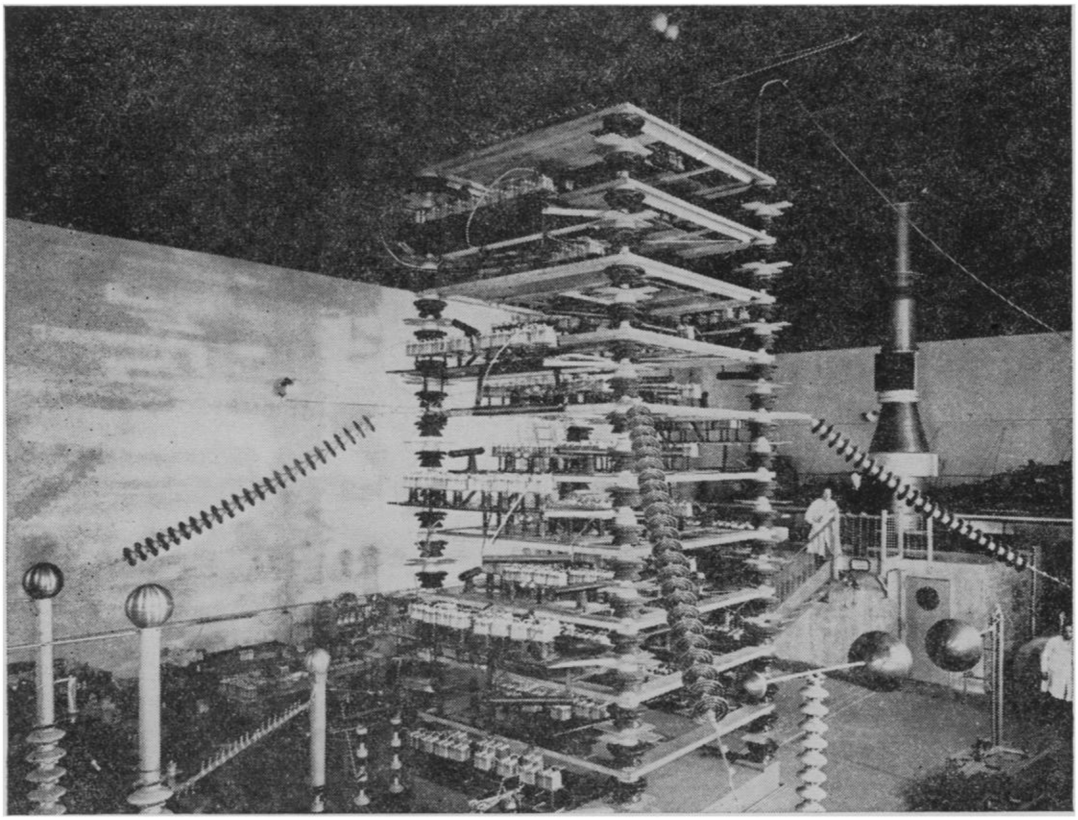

FIG. 1. The Capacitron built by Electronized Chemicals Corporation in their laboratories in Brooklyn, New York. It produces ultrashort electrical impulses of very high voltages and amperages which, in a specially designed discharge tube, are converted into correspondingly short bursts of electrons. Such bursts make it possible to bring out the true effects of radiation by suppressing certain side reactions. Therefore, the Capacitron will be used particularly in the sterilization of foodstuffs in the raw state, in the preparation of new therapeuticals, and in radiation therapy.

In principle, all kinds of chemically active rays can be used under proper conditions for sterilization and preservation purposes (*7*), although X-rays and ultraviolet are not usable for practical purposes, for obvious reasons.

The development of the atomic pile has made available unlimited quantities of neutrons which theoretically could be used for sterilization and preservation (*6*). It would seem, however, that the size of the neutron and, therefore, the relatively high amount of ionization (*4*) exercised by each individual particle would lead to a greater amount of side reactions than would be tolerable. Furthermore, it will not be easy to construct neutron sources that operate effectively during impulses of

Moreover, highly accelerated electrons release more intensity below the surface and have an absolutely defined penetration range; thus they fulfill in an ideal way the fundamental demands of radiation therapy regarding subsurface intensity and range control.

In order to use to the fullest extent the therapeutic possibilities of highly accelerated electrons, it will be necessary often to deviate from the pattern developed in the application of hitherto used radiations such as X-rays. The biological intensity ot penetrating electrons is about 500,000–1,000,000 times greater than that obtainable with X-rays. It is therefore possible to carry therapeutically sufficient amounts of radiation through very small evacuated channels—for instance, injection needles. Thus, through such a needle can be carried enough radiation intensity for the application of therapeutic doses to diseased areas far below the surface without harming the overlying or surrounding tissues. Deep-seated cancers in rabbits were reached and eliminated by this procedure.

of a comparable density an irradiation from both sides is possible, the total penetration range thus being increased to about 24 mm. At present consideration is being given to enlarging our equipment to a practical penetration range of 70 mm., making it possible to sterilize with one impulse about 20 liters of material of the specific gravity of water. If one assumes an average discharge frequency of only 30 impulses per minute, this would be equivalent to a capacity of 600 liters per minute or 36,000 per hour, provided that the diameter of the exit device is increased to 50 mm.

TABLE 1*

Product	No. of impulses	Original contamination	Sterility	Container	Remarks
Spore-forming G.N.B. in oil	2	25 B./cc.	Sterile	Petri dish	30-cc. sample; no morphological change
Diphtheria antitoxin	1	Unknown	"	Ampule	No loss of potency
Whole blood	1	"	"	"	No hemolysis or decrease of O_2 uptake
Human plasma	2	"	"	"	10-cc. sample; no protein denaturation up to 12 impulses
Protein hydrolysate	2	G.N.B., GPC	"	Al. foil	10-gram sample
Novocaine solution	2	G.N.B.	"	Ampule	No chemical changes
Distilled water	3	Pyrogen	"	"	Free of pyrogen
Penicillin powder	2	Unknown	"	Al. foil	No change in potency
Brewers' yeast	3	Weevil eggs	"	" "	No change in yeast
H. pertussis	2	20 B./cc.	"	Petri dish	No change in antigenicity
Whole bran	2	Unknown	"	Al. foil	No change in growth-promoting properties
Trypsin	3	"	"	" "	No inactivation
Cholinesterase	2	"	"	" "	" "
Ground raw beef	2	"	"	Pliofilm bag	30-gram sample; no change in appearance
Fluid milk	1	"	"	Petri dish	50-cc. sample; no change in appearance
Pork meat patty	4	*S. marcescens* *B. subtilis*	99.9%	" "	Samples 0.6–2.5 cm. thick
Potato "	4	"	93.3%	" "	Samples 1.2–2.5 cm. thick

* All experiments were carried out with a 3,500,000-volt Capacitron; the impulse duration was about 1×10^{-6} second. The samples were usually irradiated within a distance of 7.5 cm. from the exit window.

We used as an electron accelerator (*2*) a modified impulse generator constructed according to the design first developed by E. Marx. Thereby a number of capacitor banks are charged in parallel over charging resistances and discharged in series over adjustable spark gaps. The end voltage is determined by the number of the capacitor banks as well as the charging voltage applied to each individual bank. In our installation, we used a powerful charging equipment which permits charging the condenser tower to its full capacity 50–100 times per minute. The discharge time of such an impulse generator can be varied by adjustment of the charging resistances between 10^{-4} and 10^{-7} second.

The discharge tube, immersed in a special lubricating oil, is of the laminated disc type first described by Brasch and Lange (*1*). Orthodox glow filament cathodes can hardly be used for our purposes, since it is necessary to handle currents of the magnitude of many thousand amperes during a split second. Therefore, a special gas cathode was developed which can be regulated within the necessary limits.

The electrons penetrate into the open through a window device, 15 cm. in diameter.

An apparatus of the above or a similar design will henceforth be referred to as a "Capacitron."

By various methods we have determined that the practical penetration range of the present Capacitron is approximately 12 mm. in water. In solid materials

So far we have been able to sterilize a wide variety of medicinals, therapeutics, and foodstuffs with penetrating electrons of ultrashort duration, as emitted from the Capacitron. The compounds, in tightly sealed containers, were either contaminated per se or had been contaminated by the addition of bacteria.

Table 1 shows some representative results of these tests. Such items as suspensions of spore-forming, gram-negative bacteria, diphtheria antitoxin, whole blood, blood plasma, protein hydrolysate, penicillin, novocaine solution, brewers' yeast, bran, proteolytic and diastatic enzymes, as well as foodstuffs such as meat, sea foods, dairy products, vegetables, and fruits, were sterilized with electrons without impairment, provided the proper conditions were used. In the case of sodium-penicillin powder, sterilization is achieved with two impulses without any detectable deterioration of potency. A similar result is obtained with brewers' yeast contaminated with weevil eggs. Whole human blood as well as human and bovine plasma were completely sterilized with one to two impulses in a distance of 10 cm. from the exit window. The whole blood showed no change in oxygen uptake, as evidenced by a Van Slyke determination, and a red cell count identical with that of the control. Thus treated, it could be stored in closed containers over considerable periods of time without showing any noticeable changes. It is interesting, however, to note that the exposure of whole blood to excess impulses causes partial hemolysis and conversion of the hemoglobin into methemoglobin. That the sterilization of bovine plasma was not accompanied by the formation of toxic degradation products, such as peptones, was shown by injecting into a dog 50 cc. of an isotonic solution twice in an interval of six minutes without resulting change in blood pressure.

We find that the dosages necessary for sterilization have so far caused no detectable morphological changes in the microorganisms. Hence, it seems probable that bacterial death is caused by inhibitory changes in one or more of the most unstable enzyme systems essential for survival of the organism. Denaturation of structural protein is generally not detectable with electron dosages adequate to cause complete sterilization. Partial and even complete protein denaturation can, however, be achieved, the degree of denaturation depending upon the number of impulses and the stability of the native protein molecule. On the basis of these results, it seems that electrons of ultrashort duration can be adapted to serve as a satisfactory tool for the attenuation of bacteria in a graded and rigidly controllable way. Thus, it would be possible, by the change of the number of impulses as well as of the duration of the individual impulse, to reach and stabilize the various interphases between the native and the denatured state of any particular, biologically active protein. We have already been able to determine that, in the case both of diphtheria toxin and *Hemophilus pertussis*, detoxification can be obtained by exposure to high-speed electrons under suitable conditions. These examples were selected purposely, since in both cases detoxification usually is obtained by chemical means, affording a comparison of the degree of attenuation possible with electrons. Viruses are more resistant to electrons, requiring several times the dose necessary to inhibit the multiplication of most bacteria.[2]

Our early experiments in the field of foodstuffs demonstrated that sterilization could be achieved, although the mechanism of enzyme inhibition was then not well enough understood to obtain products which were unaltered in taste, odor, and appearance. In the meantime, we have found that the solution of this problem lies, in addition to the factors already discussed, in a rigid dosage control of the penetrating electrons, which allows selective enzyme inhibition without attacking the other constituents of the food sample. With trypsin, for example, we found that five impulses within a distance of 5 cm. from the exit window caused 16 per cent inhibition. In this particular case, an inhibition of 92 per cent was obtained with 16 impulses. However, some enzymes of the oxydase group seem to be particularly resistant to the inactivation with accelerated, ultrashort-time electrons.[3]

On the basis of these and similar results on other enzyme systems we proceeded to apply electrons in graded impulses to a wide variety of meats, sea foods, dairy products, vegetables, and fruits. In general, it can be said that with impulse dosages 3–15 times the sterilization dosage, enzyme inhibition, and therefore preservation, was obtained in practically all the tested foods without any deep-going changes in the taste, odor, and appearance of the material. Although a number of these experiments are still more or less in an exploratory stage, it can already be said that a manifold increase of preservation time over the controls is possible, provided that the food samples are exposed in sealed containers and under appropriate conditions, such as the addition of an inert gas and, if necessary, cooling, during the time of the irradiation.

Table 2 shows the experimental data obtained with some representative food samples under these conditions. It will be seen that lean beef, poultry, and eggs, are the most easily preserved in the series of proteinous foods, whereas in the case of vegetables, green peas, mushrooms, and tomatoes gave satisfactory results. An irradiated steak, for instance, was unchanged for all practical purposes after storage in the incubator at 37.5° C. for 12 days. The same was true for whole eggs, as well as egg yolks and dehydrated eggs. Whole pigeon eggs, irradiated bilaterally with three impulses each, were absolutely fresh after storage for 10 weeks at room temperature. Preservation of fluid milk without changes in taste proved to be of considerable difficulty, but was finally achieved after deaeration and irradiation at low temperatures. But generally milk products and cheeses are highly susceptible to changes in taste.

Irradiation at room temperature caused changes in the *red* color of many of the treated food samples. In the case of meat products, the color changed frequently from red to dark purple, whereas in products such as strawberries, carrots, etc., a definite bleaching took place. We have preliminary proof that, in meat products, the change in color is due to a change in the hemoglobin similar to that occurring during the irradiation of whole blood, whereas in vegetable products, the carotenoids are changed either by oxidation or by rupture of the olefinic chain. Cooling of these foodstuffs to temperatures of −40° C. and lower during the irradiation period usually eliminated color changes without interfering with degree of sterilization and enzyme inhibition.

After exposure to high-speed electrons, sea foods such as salmon, shrimps, oysters, and lobsters were stored at elevated temperatures for periods of from 4 to

[2] This work is being carried out in cooperation with Dr. U. Friedemann and his associates, of the Brooklyn Jewish Hospital, Brooklyn, New York, and will be published in detail at a later date.

[3] A detailed study of this problem will be the topic of a later publication.

12 days and were found to be fully satisfactory except for a slightly smoky taste, which developed after about 5 days and which may indicate the incomplete inhibition of certain very resistant enzyme systems. We would like to underscore at this point that no preservatives or antioxidants were added in any of these experiments.

A peculiar effect is the obvious sensitivity of vegetable cells to the impact of high-speed electrons. We observed repeatedly that irradiation with overdosages of electrons caused partial destruction of the cell walls, combined with a structural breakdown and an oozing out of the cell contents. This is particularly noticeable with fruit slices such as apples, pears, and strawberries, while whole fruits such as grapes, blueberries, and cherries were considerably more stable. This effect may be explained by the less pronounced elasticity of the plant cell as compared to the animal cell.

In order to emphasize further the distinct difference between impulse irradiation of extremely short duration and continuous or semicontinuous irradiation, we submit a few of many chemical experiments that were carried out to illustrate this point. Highly purified olefinic monomeres are known to be particularly prone to polymerization under mild conditions. Smooth polymerization of such compounds with electrons from various sources has been described repeatedly (*3*). On exposure of such representative compounds as propylene, isobutylene, vinylacetate, and styrene, at room temperature, to electron impulses of extremely short duration, we found that no significant degree of polymerization was detectable, although the kinetic energy which had been released was many times in excess of the amount required to start the chain reaction. The number of impulses used in these experiments varied from 3 to 25, the samples (10 grams each) being within a distance of 4 cm. from the exit window. Similarly, the drying and the polymerization effect of ultraviolet on vegetable oils (*7*) such as linseed, castor, and cotton-seed oil cannot be duplicated by even extended exposures to high-speed electrons. Viscosity, specific gravity, and iodine number remain unchanged after exposures up to 20 impulses at room temperature.

TABLE 2*,†

Raw foodstuffs	No. of impulses	Storage temperature (°C.)	Storage time (days)	Appearance	Taste‡	Odor	Notes
Animal origin:							
Lean beef	8	37.5	12	Good	Good	Good	Tenderized; purple color
Ground pork	8	"	6	"	"	"	Purple color
Calves' liver	6	"	5	Fair	"	"	Brownish color
Chicken breast	8	27	12	Good	"	"	
Chicken liver	6	"	7	"	Fair	"	Slightly bitter taste; discoloration
Chicken heart	8	"	7	"	Good	Fair	Slightly stale odor
Oyster	6	37.5	5	"	Fair	Good	Slightly cooked and rancid taste
Salmon	14	"	12	"	"	"	Slightly cooked taste
Shrimp	12	"	8	"	Good	"	
Lobster	10	26	10	"	"	"	No change in color
Whole pigeon egg	12	27	49	"	"	"	
Egg yolk (chicken)	6	28	12	"	"	"	
Fluid milk	6	37.5	6	"	"	"	Vacuum deaerated with nitrogen; cooled to −30°C.
Fluid cream	8	"	6	"	"	Fair	Heavy offtaste unless irradiated under special conditions
Powdered cream	6	"	20	"	"	"	
Cream cheese	12	26	12	"	"	"	
Plant origin:							
Tomato, sliced	10	27	10	Fair	"	Good	Texture slightly mushy
Peas	12	27	16	Good	Fair	"	Some loss of flavor
Carrots	14	37.5	10	Fair	Good	"	Texture good, but bleached
Mushrooms	8	"	10	"	"	"	Brown discoloration
Asparagus	12	27	8	Good	Fair	"	Sour taste
Apple, sliced	10	25	13	Fair	Good	"	Soft texture
Pear, sliced	10	"	"	Poor	"	"	Poor texture
Peach, sliced	8	"	8	Fair	"	"	Soft texture; some discoloration
Strawberry, whole	12	28	10	Good	"	"	Irradiation at −30°C.; irradiation at room temperature causes bleaching
Grapes, whole	14	37.5	12	"	"	"	
Cherries, whole	16	28	14	"	"	"	
Blueberries, whole	8	34	8	"	"	"	
Pineapple, sliced	10	28	8	"	Fair	"	Slightly sour
Orange, sliced	10	28	8	"	"	"	

* All experiments were carried out with a 3,500,000-volt Capacitron. The impulse duration was about 1×10^{-6} second. The samples were about 0.6–1.2 cm. thick and not more than 12.5 cm. in diameter.

† All controls were handled in exactly the same manner as the irradiated samples. Changes in appearance, taste, or odor were manifest in all instances during the first 4–18 hours of storage.

‡ The taste tests were performed either on the raw material or, in some cases, both on the raw and the cooked samples.

It is quite remarkable that, with a time element of too short a duration for the initiation of a reaction, there also seems to be no accumulation factor for many chemical compounds.

Many phenomena which have been attributed to the action of radiation proper represent in reality merely the cumulative effect of rays together with nonspecific, radiation-caused, side reactions. The latter include elevation of temperature, oxidative processes on the surface—and within the target—as well as a multitude of other chemical reactions. In consequence, the suppression of by-effects will illustrate automatically what may be called "the pure radiation principle" and will facilitate the more intimate understanding of the fundamentals involved. The Capacitron carries sufficient intensities into the targets in such short times that most chemical reactions can be eliminated while the effective biological impact is maintained. Therefore, a detailed study from this specific angle seems to be indicated, and for principal reasons an even further shortening of the exposure time to about 10^{-8} second must be considered.

Although a great deal of exploratory and developmental work is yet to be done, there can be no doubt that a process which, among other things, permits preservation in a raw state and causes chemical and biological effects of such a highly differentiated nature, will be found useful in many applications beyond those reported here. An important consideration, for practical purposes, will be whether or not the operating costs of such a device are prohibitive. Detailed estimates show that such expenditures will not materially increase the final price of the treated product, provided that the output of the Capacitron is adapted to the desired purpose.

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NEWS *and Notes*

A meeting of the Inter-Society Committee for a National Science Foundation has been called for 10:00 A.M., Sunday, February 23, in Washington at Hotel 2400 by Kirtley F. Mather, who is chairman of the Council Committee arranging for the organization. Since the Boston meeting, at which a resolution calling for this action was adopted, invitations have been extended to a large number of national scientific and educational groups asking for the appointment of delegates to the Washington meeting. The response was immediate, so that some 60 delegates are now receiving instruction from their group.

About People

Wendell M. Stanley, Rockefeller Institute for Medical Research, Princeton, New Jersey, and 1946 Nobel Prize winner in chemistry, addressed the Detroit Section of the American Chemical Society January 15 on the subject of influenza vaccines. Vaccine separated from chick embryonic fluid by centrifuging, Dr. Stanley said, consists almost exclusively of purified virus, while other types, prepared by elution, alternate freezing and thawing, or precipitation with chemicals, include as impurities as much as 80 per cent of chick proteins and other material containing nitrogen. Carl F. Graham, Research Department, Wyandotte Chemicals Corporation, chairman of the Section, presided at the meeting.

William Walter Greulich, professor of anatomy, Stanford University School of Medicine, and director of the Brush Foundation, has returned to the United States after three months in Australia and New Zealand, where he visited universities and medical schools and lectured to chapters of the British Medical Association in all principal cities of the two countries.

Saul B. Arenson has been made professor emeritus of inorganic chemistry at the University of Cincinnati. Since August 1946, he has been convalescing from a heart attack at 1884 Laurel Canyon Boulevard, Los Angeles 46, California.

W. S. Flory, Jr. has been appointed professor of experimental horticulture and vice-director of the Blandy Experimental Farm, University of Virginia. His new work, effective February 1, follows service as horticulturist of the Virginia Agricultural Experiment Station.

Percy Williams Bridgman, 1946 Nobel Prize winner for work in physics, was honored at a dinner given in Boston January 11 by Dean of the Faculty of Arts and Sciences Paul H. Buck, Harvard University. Speakers were I. I. Rabi, Columbia University, who received the Nobel award in physics in 1944; Theodore Lyman, director, Jefferson Physical Laboratory, Harvard; John Clarke Slater, chairman, Physics Department, Massachusetts Institute of Technology; and James B. Conant, president of Harvard. Guests included George R. Minot and William P. Murphy, Harvard Medical School, who won the prize in physiology and medicine in 1934; Manuel S. Vallarta, Mexican physicist and representative on the U. N. Atomic Energy Commission; A. W. Hull, General Electric Company; Harvey N. Davis, president, Stevens Institute of Technology; George A. Campbell, telephone research engineer of Upper Montclair, New Jersey; Gordon F. Hull, Dartmouth College; and Karl K. Darrow, Columbia University.

Sven Wingquist, inventor of the spherical ball bearing and founder of the SKF ball-bearing industry, on December 10 celebrated his 70th birthday by donat-