may be a function of the density of the nucleons in a volume of the order involving the Compton wavelength of the meson.

There is other recent evidence of the failure of conventional interactions and models. In particular, one may cite the work of Chamberlain, Segrè, and Wiegand (*5*) on *p-p* scattering from 120 to 345 mev. These authors have found that all theoretical investigations so far, based on static potentials, including the work of Christian, Jastrow, and others, have failed to explain their experimental results. Thus, the experimental evidence of both Bernardini *et al.* and Chamberlain *et al.* points to the possible operation of nonlocalizable, velocity-dependent forces of the many-body type.

Osborne (*6*) has presented experimental evidence of pluromultiple meson production in high-energy cosmic-ray showers. He points out that, although the events in light nuclei are not inconsistent with a single collision model, the heavier nuclei events cannot be described by this model. In view of the probable nature of nuclear forces as indicated by the evidence from the scattering experiments cited above, it is the author's opinion that the simple picture of pure plural meson production by individual nucleon-nucleon encounters is quite likely not valid. What in the past have been taken for examples of pure plural meson production in cosmic-ray showers by individual nucleon-nucleon encounters probably involve multiple production in one single act by nucleons acting as nuclear subunits or groups. These groups of nucleons may be those outside the nuclear core, which is consistent with evidence presented by R. F. Mozley (*7*) and R. D. Miller (*8*) on photonuclear stars, which indicates that only the surface nucleons are effective in producing π-mesons. In the phenomenon of pluromultiple production there may be more than one such group involved. Although it is not unlikely that there may be no such phenomenon as pure plural meson production, there seem to be two types of multiple meson production: the type ordinarily encountered involving nucleonic groups and the type first observed by Lord, Fainberg, and Schein (*9*), wherein the nucleonic volume involved in these extremely high-energy interactions is so small as to preclude the presence of groups of nucleons, but nevertheless may be the site of the excitation of the nucleon-antinucleon field, the heavy nuclear quanta fields (embracing mesons of the τ and V type) and the surrounding pion field.

The volumes of interaction discussed above suggesting the nonlocalizability of nucleonic interactions may be termed "elementary volumes" and may be identified as functions of the elementary lengths. Thus, there is more than one elementary length, and in this context they may be interpreted as not so much imposing limitations to the behavior of natural phenomena as the natural constants c, e, and h do, but rather as serving to define the application of various physical models and concepts. For instance, in the experiments of Bernardini *et al.* the elementary length involved (the mesonic Compton wavelength) limits the application of the free nucleon model of the nucleus, as well as the concept of the static potential (*10*). On the other hand, the elementary length (probably the protonic Compton wavelength) involved in the phenomenon of the multiple production of particles involving single nucleon volumes may limit, if one is permitted to speculate, the unambiguous application of the elementary concepts of particle and field.

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A Rapid Titrimetric Method for Determining the Water Content of Animal Tissues[1]

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The most widely used method for determining the water content of animal tissues is that whereby the material is dried to a constant weight in an oven. This method is subject to certain disadvantages, notably the danger of decomposing some of the complex organic compounds if too high a temperature is employed and the time consumed in drying and weighing. These difficulties are to a great extent obviated by the use of the Karl Fischer reagent and the titrimetric estimation of water.

This procedure is fully described in the recent book by Mitchell and Smith (*1*) and has been widely utilized in industrial laboratories for the determination of the water content of many substances such as paper, reagents, and foodstuffs. We have encountered no record of its adoption by physiologists and biochemists, but we believe that it would prove of considerable value to these investigators.

For determining the water content of blood we first weigh a capillary tube approximately ½ in. in length.

[1] This investigation was carried out under contract N7onr29544 between the Office of Naval Research and the University of California.

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Having nicked the tail of a rat so as to expose a small drop of blood, the latter is touched with the end of the tube, which then fills by capillarity. The tube holding the blood is again weighed and dropped into a 100-ml glass-stoppered volumetric flask containing about 20 ml of a mixture of the Fischer reagent and methyl alcohol. This mixture has previously been brought to a light cherry color so as to match a color standard. The capillary tube is cracked open while in the reagent by tapping with a glass rod. The water decolorizes the Fischer reagent, and this is back-titrated with more reagent to the original color. The operation takes about 3 min and the end point is definite.

The preparation of solid material is likewise simple. A small piece of tissue (muscle, liver, brain) weighing from 100 to 250 mg is excised and placed upon a tared slip of filter paper. After rapid weighing the paper and tissue both are dropped into the flask containing the reagent. In order to facilitate the extraction of the water, the tissue mass is crushed with a glass rod. Titration then follows. A blank for the water in the filter paper is secured by extracting and titrating a plain piece equal in weight to that used in the experiment.

In order to test the method we examined both whole blood and tissues of normal adult laboratory rats. Samples of blood were taken from 55 rats and titrated with the Fischer reagent. The values for water showed a range of 77–80%, with a mean of approximately 79%, values which correspond very closely to those found by numerous previous investigators who used the standard drying methods.

For tissues we used muscle, liver, and brain. Three rats were sacrificed. From each we took two samples of the tissues mentioned. The water content of one sample of each pair was determined by the titration method. That of the other sample was determined by placing the tissue in an oven at 90° C and drying to constant weight. For the three rats the results were as shown in Table 1, expressed as percent of water.

TABLE 1

Tissue	Percentage water found by	
	Titration	Drying
Muscle	74.1	74.4
	74.1	74.7
	74.6	74.6
Liver	72.1	72.1
	73.2	74.2
	72.4	72.6
Brain	79.2	78.3
	77.1	77.5
	79.1	76.3

The slight variation in estimate of water content found by the two methods appears to be purely random in character. Their accuracy therefore is substantially equal. The advantage of the titrimetric method lies in the rapidity with which the determinations may be made. With it one may not only secure immediately the data pertaining to an extensive array of samples but he may also follow changes in the water content of blood or tissue almost as soon as they occur. The procedure thus lends itself particularly neatly to periodic blood tests or biopsies performed with laboratory animals or even man.

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Bone Implantation as a Means of Studying Vitamin D Action[1, 2]

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The specific action of vitamin D in the body economy is still to be determined; in fact, there is still no agreement as to the locale of its action. In 1924 Shipley (*1*) demonstrated calcification *in vitro,* using nonrachitic serum as a calcifying medium. Fischmann (*2*) noted that rachitic serum would not calcify osteogenic tissue and failed to compensate for the deficiency by addition of calcium and phosphorus. This suggests the possibility that healing of rickets is dependent on the presence of vitamin D or some derivative thereof. Sobel and co-workers (*3*), however, showed that calcification took place *in vitro* without the presence of vitamin D.

It would appear as a result of these excellent *in vitro* investigations that vitamin D exerts its influence on the environment from which bone receives its mineral. An attempt to test the above observations with *in vivo* studies was carried out by using the intact animal as the culture medium.[3]

Tibiae were taken from 1-day-old chicks, and one of each pair was placed under the skin of a 2-week-old rachitic or nonrachitic chick. The bone was inserted alongside the ribs through a small incision, which was immediately sewn up. The host chicks were fed AOAC rachitogenic diet without vitamin D or with 1 unit vitamin D/g of feed throughout the experiment.

After 4 days the implanted tibia was removed and the Ca content compared with that of its nonimplanted mate. The results are shown in Table 1. In the rachitic host the bone lost calcium, whereas in the nonrachitic host a slight amount was gained, indicating the presence of a pathological change in the composition of the body fluid of a rachitic animal.

It should be noted that the loss or gain of Ca shown in Table 1 is the resultant of the amount of Ca that entered and the amount that left the bone through ex-

[1] Presented at the Congress of the International Union of Pure and Applied Chemistry, New York 1951.

[2] Contribution No. 214 of Division of Chemistry, Science Service.

[3] The assistance of L. J. Carter and P. M. Richard with the care and treatment of the animals is gratefully acknowledged.