Falk and others upon different material. If we assume that the alkalinity of the tissue is slowly changed to acid reaction, it is difficult to see how low hydrogen ion concentration can operate to render the tissues more digestible, whereas a high degree of acid, such as we have found developed in the liver in the present study, may well be imagined to exert a profound influence upon the character of the proteins of the liver, for this concentration resembles that of gastric juice, especially that of the young subject,[1] where proteins are digested rapidly.

Since the above statements were written, the electrometric method has been checked by the Sørensen colorimetric method supplemented by the indicators of Clark and Lubs. Practically identical results have been obtained with both liver and kidney. The details of the method, with results and discussion, will be given in another place under the following title: "Further Studies on the Reaction of Dying Tissues," by Withrow Morse and R. Goldberg. The question will be raised therein, whether the suggestion made by Paul Erlich ("Die Aenaemie") that the reaction of the nucleus is acid, is applicable here.

16 (1763)

The cure of infantile rickets by sunlight as demonstrated by a chemical alteration of the blood.

By ALFRED F. HESS and P. GUTMAN.

[*From the Department of Pathology, College of Physicians and Surgeons, Columbia University, New York City.*]

It has been shown by one of us (A. F. H.) that the rickets of infants can be cured merely by frequent exposures to the sun's rays.[2] Animal experiments carried out in this laboratory confirmed these clinical observations. They clearly demonstrated that rickets could be either prevented or brought about in rats fed a standard diet, according to whether they were subjected for

[1] McClendon, J. F., *Amer. J. Physiol.*, 1915, xxxviii, 191.

[2] Hess, A. F., and Unger, L. J., PROC. SOC. EXPER. BIOL. AND MED., 1921, xviii, 298.

Hess, A. F., and Unger, L. J., *J. A. M. A.*, 1921, lxxvii, 39.

short periods to the sun's rays or were kept at all times in the dark. The present report adds substantiation from the chemical side to the clinical and anatomical evidence brought forward in the previous papers.

In a recent article Howland and Kramer[1] have shown th he inorganic phosphorus of the serum of infants suffering from active rickets is reduced, and that during the process of healing, especially upon the administration of cod liver oil, the phosphorus content gradually rises to normal. In view of the marked clinical improvement following sun treatment, it seemed of interest to ascertain whether this procedure was accompanied by a chemical alteration of the blood. For this purpose the rapid colorimetric method of Bell and Doisy[2] was used, in which the color is developed in protein-free filtrates through the reduction of phosphomolybdic acid by hydroquinone in alkaline sulphite solution. Special attention was paid to the inorganic phosphorus of the blood, although in many instances the so-called acid-soluble and total phosphorus was also estimated. It will be seen from the accompanying chart that the normal figures for inorganic phosphorus are sufficiently constant to render this test of clinical value (Table I).

TABLE I.

BLOOD PHOSPHORUS IN NORMAL INFANTS.

Name	Age, Mos.	Inorganic.	Acid Soluble.	Total.	Name.	Age, Mos.	Inorganic.	Acid Soluble.	Total.
		Mg. P. per 100 c.c. Blood.					Mg. P. per 100 c.c. Blood.		
M.K.	6	4.40	14.5		P.D.	10	4.48	18.5	45.8
B.S.	3	4.33	16.2	38.3	S.D.	10	4.31	17.2	46.3
F.M.	15	4.60	17.8	41.6	B.H.	12	4.60	18.1	53.5
B.S.	3	4.42	17.2	56.8	A.M.	11	4.76	13.0	37.8
H.H.	11	4.80	25.9	43.0	H.M.	7	4.10	16.0	68.2
G.H.	8	4.69	16.4	34.3	B.F.	6	4.00	18.9	
M.D.	4	4.65	17.2	37.5	A.R.	13	4.44	18.7	52.5
J.F.	18	4.44	16.0	49.6	D.B.	9	4.17	18.5	39.4
B.R.	11	4.39	16.8	43.6	H.R.	13	4.61	19.6	40.5
W.L.	8	4.10	14.9	67.1	S. F.		4.00		
J.R.	6	4.10	15.3	63.5	H. B.		4.40		
B.B.	6	4.05	17.5	—	L. S.		4.00		
A.S.	6	4.25	15.0	54.7	S . B.		4.80		
A.A.	2	4.17	15.9	35.0	M. G.		4.34		
M.C.	11	4.14	18.7	—					
T.S.	10	4.20	18.3	41.4					

[1] Howland, J., and Kramer, B., *Am. J. Dis. Child.*, 1921, xxii, 105.

[2] Bell, A. F., and Doisy, E. A., *J. Biol. Chem.*, 1920, xliv, 55.

The infants were placed in the direct sunlight for a half hour to several hours, the period varying according to the intensity of the sun and the sensitiveness of the skin. Previous to treatment the majority of infants showed the usual clinical symptoms of mild rickets and the characteristic signs on x-ray examination. Such, however, was not invariably the case; it has been our experience that infants may manifest the classical signs of rickets, accompanied by a low inorganic phosphate content of the blood, and, nevertheless, show apparently normal epiphyses at the wrists and other joints. In the course of the sun treatment the babies became markedly tanned, the rachitic signs diminished or disappeared, and the general condition improved.

The accompanying table, which shows successive examinations of the blood, requires little interpretation (Table II). It will be

TABLE II.

BLOOD PHOSPHORUS OF RACHITIC INFANTS TREATED WITH SUNLIGHT.

Name.	Age (mos.).	Inorganic P.					Acid Sol.[1]	Total.[1]
		6/22	7/21	8/11	9/16	10/18		
F.R.....	7	2.80	3.75	4.14	4.13		15.7	43.6
P.F.....	5	3.7	3.4	4.16	4.22		23.0	41.0
I.A.....	13	2.77	2.75	3.53	4.		15.2	43.6
M.L.....	8	3.1	3.18	3.75	4.28		15.0	36.0
R.M.....	15	3.0	3.02	3.16	3.87		14.5	44.6
C.M.....	37	3.4			3.77	4.3	19.3	52.0
T.M.....	7	3.0			3.9	4.0	16.6	38.5
M.E.....	18		4.0			3.77[2]	15.2	56.8
H.G.....	15	4.6				3.69[2]	15.9	39.0

seen that the inorganic phosphorus of the rachitic infants steadily increased from month to month, starting generally below 3.5 mg. per 100 c.c. of blood and gradually being restored to the normal level which must be considered about 4.0 mg. On the other hand, the results of the determinations of "acid-soluble" and of total phosphorus are not sufficiently definite to warrant deductions. There were no alterations in the diet throughout these periods, the infants receiving the usual milk formulas; all were given orange juice daily, the older children getting cereal in addition.

It is evident that sunlight not only brings about a cure of the rachitic lesions, but in so doing occasions chemical changes in the

[1] Tests made with blood used for the first inorganic P. determination.

[2] Previous to treatment.

blood similar to those noted when the cure is effected by cod liver oil. This is of interest as affording testimony that the curative process occasioned by these divergent therapeutic agents is fundamentally the same. These observations establish a chemical basis for heliotherapy in rickets. They furnish also, as far as we know, the first definite evidence of metabolic change in the animal body brought about by the solar rays.

17 (1764)

Dissociation of microbic species.

II. Mutation in pure-line strains of the bacillus of rabbit septicemia.

By PAUL H. DE KRUIF.

[*From the Laboratories of the Rockefeller Institute for Medical Research, New York City.*]

The coexistence of two distinctly different types of microbe in cultures of the rabbit septicemia bacillus has been reported in a previous paper.[1] These varieties, once separated, appear to breed true to type for many passages. The organisms have been designated as types D and G. Type D is very virulent for rabbits, grows diffusely in liquid media, and yields highly fluorescent, rather opaque colonies on serum agar. Type G is of extremely low virulence, exhibits a granular sedimenting growth in fluid media, and grows in the form of translucent, non-fluorescing colonies on serum agar. The two types show no noticeable differences in morphology or in fermentation reactions. Immunization and agglutination reactions indicate their antigenic community.

It seemed necessary to determine whether the two varieties coexist in cultures isolated from infected rabbits or whether one variety arises from the other. Type D (virulent) is the microbe invariably obtained from the naturally infected rabbit. Type G has only been found after artificial cultivation has been carried on for some time. But since the primary isolations were made from colonies which conceivably might arise from two or more

[1] *Jour. Exper. Med.*, 1921, xxxiii, 773.