bumin fractions can take place in both alkaline and acid buffer systems (*p*H 5.9). There is some further indication that the major bands in the FF and FS phenotypes are each composed of two bands, but we have not always obtained separation of these.

The other phenotype, FS, was found in only one individual, a woman living in southern Norway. Her albumin type appears as two major bands with a very weak one in front. Compared to the zones of the FF phenotype, the FS type shows about half the staining intensity and thickness of bands.

These results indicate a theory of two codominant alleles. The very rare heterozygote is most probably the same as the bisalbuminemia already described. We consider this heterozygosity to be a quite normal condition and another example of a polymorphic serum protein system of which many are now known in the animal kingdom. We prefer to call the two alleles Al^F and Al^S (F, fast; S, slow). This nomenclature will have advantages over A_1 and A_2 (*2*) and A and B (*3*) if additional alleles are found.

GEORGI EFREMOV
MIKAEL BRAEND

Department of Medicine,
Veterinary College of Norway, Oslo

References and Notes

1. H. Bennhold, T. Ott, G. Scheurlen, *Verhandl. Deut. Ges. Inn. Med.* **64**, 279 (1958); F. Wuhrmann, *Schweiz. Med. Wochschr.* **89**, 150 (1958); H. J. Nennstiel and T. Becht, *Klin. Wochschr.* **35**, 689 (1957); G. Franglen, N. H. Martin, T. Hargreaves, M. J. H. Smith, D. I. Williams, *Lancet* **I-1960**, 307 (1960); P. L. Adner and A. Redfors, *Nord. Med.* **65**, 623 (1961).
2. M. Knedel, *Clin. Chim. Acta* **3**, 72 (1958).
3. D. P. Earle, M. P. Hutt, K. Schmid, D. Gitlin, *J. Clin. Invest.* **38**, 1412 (1959).
4. M. Braend and G. Efremov, *Proc. Intern. Congr. Animal Reproduction and Artificial Insemination, 5th*, Trento, Italy, September 1964.
5. C. Stormont and Y. Suzuki, *Proc. Soc. Exptl. Biol. Med.* **114**, 673 (1963).
6. W. M. McIndoe, *Nature* **195**, 353 (1962).
7. M. D. Poulik, *ibid.* **180**, 1477 (1957).
8. We thank O. Hartmann (State Institute for Public Health), K. J. Lindqvist (Veterinary Institute), and P. Lund Larsen, all of Oslo, for providing samples. Supported in part by grants from the Agricultural Research Council of Norway. One of us (G.E.) is on leave from the Department of Physiology, University of Skopje, Yugoslavia, with a scholarship from the Royal Norwegian Ministry of Foreign Affairs.

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Purine and Pyrimidines in Sediments from the Experimental Mohole

Abstract. *Cytosine, adenine, guanine, and thymine, but not uracil, have been detected in core samples taken from various depths of the experimental Mohole. The following quantities of bases were found in the deepest core samples available (approximately 25 × 10⁶ years old): cytosine, 2.5 μg/5 g; adenine, 0.9 μg/5 g; guanine, 0.2 μg/5 g; thymine and uracil, 0 μg/5 g.*

The existence and composition of organic compounds of biological origin in fossils, sediments, and sedimentary rocks provide clues for the understanding of biological evolution and the origin of life. Most reports on biogeochemical analysis have been concerned with hydrocarbons, amino acids, sugars, and porphyrins (*1*). Although the role of nucleic acids as the genetic material in all known forms of life is clearly established, the quantities of nucleic acid residues as paleobiochemicals have not previously been reported. Nucleic acid residues have been qualitatively found in recent sediments and various fossils (*2*). I report here an analysis of purine and pyrimidine bases in core samples obtained from the experimental Mohole drilling during March and April 1961 off Guadalupe Island, Mexico (*3*). The deepest core sample available, EM 7-3, has been estimated to be 25×10^6 years old (*4*). A detailed study of the biogeochemistry of sediments in the experimental Mohole has been reported (*5*).

Since the usual methods of extracting nucleic acids from biological materials and determining the base composition were not applicable to the largely inorganic core samples, the following procedure was developed. The purine and pyrimidine bases were extracted from the sediments after hydrolysis in 12*N* perchloric acid at 100°C for 1 hour. The bases were separated from the highly saline extracts by adsorption onto activated charcoal-celite and eluted with 2 percent (by volume) of concentrated ammonium hydroxide in 50 percent (by volume) aqueous ethanol. The extracts were further purified and characterized by two-dimensional chromatography on Whatman No. 40 paper by the descending technique, the chromatogram being developed first with a mixture of isopropanol and hydrochloric acid (*6*), and then with *n*-butanol and ammonia (*7*). The bases were identified, and the quantities were estimated by the characteristic ultraviolet absorption spectra in both acid and alkali. The degree of ultraviolet-absorbing materials in all the reagents used was established by appropriate controls. To determine the efficiency of the analytical procedures, radioactive bases were added prior to hydrolysis of the sediment. The recovery of each base was established from the fraction of initial radioactivity found in the isolated base (*8*). This method does not distinguish the free bases from those present as nucleosides or nucleic acids.

Table 1 shows the quantities (uncorrected for losses) of the five naturally-occurring bases found in core samples taken from various depths. If corrected for recovery, the quantities of pyrimidines in the core samples would be approximately twice those reported in Table 1. The corrected quantities of adenine and guanine in the sediments are difficult to estimate accurately because of the low recovery of these purines. Although recovery of all three pyrimidines was more than 40 percent, only cytosine was found at all depths.

Table 1. Quantities of purines and pyrimidines in the experimental Mohole sediments (μg/5 g dry weight). The average recovery (percent) of base was as follows: cytosine, 43; adenine, 10; guanine, 5; thymine, 45; uracil, 49. The quantities reported have not been corrected for losses during the analytical procedures.

Sample	Depth (m)	Cytosine	Adenine	Guanine	Thymine	Uracil
L–66	0	5.2	3.5	6.5	1.2	0
EM 7–7	0	2.3	2.0	3.5	1.0	0
EM 6–2	76	3.2	0.6	2.5	0	0
EM 8–11	101	0.8	2.5	0.5	0	0
EM 8–14	129	1.2	0.5	0.5	1.4	0
EM 7–3	170	2.5	0.9	0.2	0	0

Since the addition of cytosine-2-C^{14} to the sediment prior to hydrolysis with perchloric acid did not result in the formation of radioactive uracil, no oxidative deamination occurred under the conditions employed. The failure to find uracil, the only base unique to RNA, is difficult to explain. Perhaps RNA and its component parts are rapidly and selectively removed soon after deposition. In addition to the naturally-occurring purines and pyrimidines, other ultraviolet-absorbing and fluorescent compounds were observed on the paper chromatographs. These compounds have not been identified.

A report (*9*) on the aerobic decomposition of these five bases in the solid phase suggests that, at 25°C, adenine and cytosine have half-lives of approximately 10^6 years, guanine and uracil have half-lives of between 10^4 and 10^5 years, whereas thymine has a half-life of less than 10^3 years. The data in Table 1 are consistent with the relative stability of these bases.

Although the estimation of half-lives from extrapolations of laboratory experiments may be valuable as a measure of relative thermal stability and as first approximations to stabilities under natural conditions, their use should not be restrictive. For example, the half-life of alanine at 25°C (solid phase, aerobic, 1 atm) has been calculated to be 20,000 years (*10*). Although this amino acid should not be detectable beyond 5 or 6 half-lives, if originally existing in quantities similar to those in present-day sediments, nevertheless alanine was found in sample EM 7–7 (2.5 μg/g of dry weight); in fact alanine has been found in samples over 10^8 years old (*11*). Therefore, it would not be unreasonable to find the purine and pyrimidine bases in samples much older than their calculated half-lives.

EUGENE ROSENBERG
Department of Bacteriology, University of California, Los Angeles

References and Notes

1. I. A. Breger, in *Organic Geochemistry*, I. A. Breger, Ed. (Macmillan, New York, 1963), p. 50.
2. A. A. Prashnowsky, *Neues Jahr. Geol. Paleontol.* **118**, 103 (1963).
3. American Miscellaneous Society Committee, *Natl. Acad. Sci.–Natl. Res. Council Publ.* **914**, 183 (1961).
4. W. R. Riedel, H. S. Ladd, J. I. Tracey, M. N. Bramlette, *Bull. Am. Assoc. Petrol. Geolog.* **45**, 1793 (1961).
5. S. C. Rittenberg, K. O. Emery, J. Hulsemann, E. T. Degens, R. C. Fay, J. H. Renter, J. R. Grady, S. H. Richardson, E. E. Bray, *J. Sediment. Petrol.* **33**, 140 (1963).
6. G. R. Wyatt, *Biochem. J.* **48**, 581 (1951).
7. W. S. MacNutt, *ibid.* **50**, 384 (1952).
8. The details of the method will be published elsewhere.
9. A. Minton and E. Rosenberg, *Geochim. Cosmochim. Acta*, in press.
10. D. Conway and W. F. Libby, *J. Am. Chem. Soc.* **80**, 1077 (1958).
11. P. H. Abelson, *Science* **119**, 576 (1954).
12. Supported by NASA grant NsG-672. I thank D. Chandler for technical assistance, Prof. S. C. Rittenberg for valuable suggestions, and Prof. W. R. Riedel for providing various core samples for analysis.

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Allergic Encephalomyelitis: A Hyperacute Form

Abstract. *The hyperacute form of allergic encephalomyelitis is characterized by its short incubation period, 100 percent incidence, overwhelming severity, and high mortality and by the massive quantities of polymorphonuclear neutrophils, fibrin, and edema fluid which infiltrate the central nervous system. The hyperacute form has been produced with the aid of aqueous pertussis vaccine as an adjuvant. This is the first reproducible laboratory model for human acute necrotizing hemorrhagic encephalopathy.*

Experimental allergic encephalomyelitis (EAE) is an inflammatory, autoimmune disease of the nervous system characterized by perivascular infiltrates of mononuclear cells. Usually, it is produced by injecting an emulsion of myelinated nervous tissue in Freund's complete adjuvant (killed mycobacteria, mineral oil, and emulsifying agent). It has been shown that *Bordetella pertussis* organisms can be substituted for the mycobacteria in the oily adjuvant (*1*). Further, it is known that intraperitoneal vaccination with aqueous suspension of pertussis organisms enhances the encephalitogenic effects of nervous tissue injected later by a different route (*2*). Therefore, it was no surprise to find that aqueous pertussis vaccine mixed with aqueous nervous tissue homogenate had an adjuvant effect. Completely unexpected, however, were the discoveries that this aqueous mixture produced EAE much more rapidly than the usual water-in-oil emulsions, that the disease was much more severe, and that it exhibited a qualitative difference in its histopathology.

The disease was produced in Lewis or Fischer-344 rats by intraperitoneal injection of 200 mg (wet weight) of guinea pig or rat spinal cord homogenate mixed with 0.6 ml of commercial pertussis vaccine and diluted to 3.0 ml with saline. Six to nine days later (usually 7 or 8 days), the rats developed clinical signs of EAE. The incidence was 100 percent. Loss of tail tonus progressed rapidly over a few hours to hind limb weakness, paraplegia, and quadriplegia. Most animals died in 1 or 2 days; only a few survived 3 to 7 days. At necropsy, the spinal cord, medulla, nerve roots, cerebellum, and forebrain contained lesions whose intensity and frequency decreased in the order listed. The spinal cord was peppered with perivascular lesions in all the animals. The inflammatory infiltrate contained enormous numbers of polymorphonuclear neutrophils, many monocytes, and relatively few lymphocytes, an order of frequency quite the opposite of that seen in "ordinary" EAE. The inflammatory cells were present in the lumens and walls of veins and capillaries, in perivascular spaces, in perivascular parenchyma, and in meninges. Confluence of inflammatory lesions led to broad fields, especially in the conus medullaris, where the neutrophil exudate obscured all other tissue elements. Vessel walls and perivascular parenchyma were infiltrated with fibrin. Perivascular tissue was edematous and demyelinated. Hemorrhages, focal necrosis, and myelomalacia were seen often. In advanced cases, many vessels were thrombosed (Fig. 1).

An experimental disease of this histopathologic character has not been produced previously in a reproducible manner, although several investigators have described lesions in occasional animals that had some or all of the features described above (*3*). However, a similar condition occurs in man as "acute hemorrhagic necrotizing encephalopathy" (*4*).

We have designated this syndrome "hyperacute" because of the unprecedented severity of the lesion and because of the short incubation period. A few rats developed mild clinical and histologic signs as early as 6 days after inoculation, and some asymptomatic rats also had lesions at this time. The latent period was shortened further by bilateral adrenalectomy on the day the injection was given. All of these rats died or developed clinical signs of EAE 5 or 6 days after injection. However, the pathogenic agent