of spinach leaves were deveined and ground for 3 min in a Waring Blendor with 200 ml of cold 0.01*M* Na_2HPO_4-KH_2PO_4 buffer of *p*H 7, containing 0.01*M* KCl. After filtering through cheesecloth, the filtrate was centrifuged for 2 min at 4600*g*. The supernatant was centrifuged for 20 min at 18,000*g*; the residue was suspended in buffer and centrifuged again at 18,000*g*. The final residue was made up in 0.05*M* Na_2HPO_4-KH_2PO_4 buffer of *p*H 7, containing 0.01*M* KCl. No attempt has been made to ascertain that this preparation consists solely of grana. Each reaction mixture contained grana equivalent to 4.92 mg of chlorophyll, 38.1 µmole of DPN, 500 µmole of Na_2HPO_4-KH_2PO_4 buffer of *p*H 7.05, and 100 µmole of KCl. The final volume was 10 ml. The dark control flask was wrapped with tinfoil. The anaerobic flask was evacuated continuously with a water aspirator, and the aerobic flask was open to air. The flasks were incubated for 10 min in the dark and for 60 min in the light (one 100-w bulb per flask at a distance of approximately 6 in.) with shaking at 13 to 14°C. After incubation, the samples were centrifuged to remove the grana, and the DPNH concentration in the supernatant solution was determined by measuring the decrease in optical density at 340 mµ upon the addition of acetaldehyde and yeast alcohol dehydrogenase.

6. Each reaction mixture contained grana equivalent to 4.34 mg of chlorophyll, DPN, 500 µmole of Na_2HPO_4-KH_2PO_4 buffer of *p*H 6.98, and 100 µmole of KCl. The final volume was 10 ml. The flasks were incubated aerobically for 80 min in the light with shaking at 12°C. After incubation, the samples were treated as indicated in Table 1.
7. Reduced TPN and reduced AP-DPN were estimated spectrophotometrically from their absorption at 340 mµ and 365 mµ, respectively. The extinction coefficient of reduced AP-DPN has been determined by N. O. Kaplan and M. M. Ciotti [*J. Biol. Chem.*, in press].
8. N. O. Kaplan, M. M. Ciotti, F. Stolzenbach, *J. Biol. Chem.*, in press.
9. A. San Pietro and H. M. Lang, in preparation.
10. M. E. Pullman, A. San Pietro, S. P. Colowick, *J. Biol. Chem.* 206, 129 (1954).
11. The results of this study are in preparation.
12. D. I. Arnon, *Science* 122, 9 (1955).
13. J. A. Barltrop, P. M. Hayes, M. Calvin, *J. Am. Chem. Soc.* 76, 4348 (1954).

6 April 1956

"Adenoviruses": Group Name Proposed for New Respiratory-Tract Viruses

The discovery of a new group of viruses, affecting primarily the respiratory tract, has led to the need for a meaningful, specific, and acceptable name for these agents, both as viruses and in relation to diseases with which they are associated. In the first published report of the isolation of these viruses, Rowe and his associates (*1*) used the term *adenoid degeneration agent,* abbreviated as *A.D. agent.* The 13 strains reported at that time were recovered from human adenoids removed surgically and cultivated in tissue culture. Independently, Hilleman and Werner (*2*) reported the isolation of five agents, termed *Respiratory illness* (*RI*) *agents,* during an epidemic of acute respiratory disease (ARD) and pneumonitis among recruits at Fort Leonard Wood, Mo. One of these agents (strain RI-67) was shown by complement-fixation and neutralization tests to be etiologically associated with the epidemic disease (*2*). Confirmation and expansion of their findings soon followed (*3–5*). Further information was rapidly acquired (*6–22*), indicating that these viruses comprised a family or group and that they were related to several clinical syndromes. Huebner and his associates (*6*) proposed the term *adenoidal-pharyngeal-conjunctival* (*APC*) agents or viruses as the group name.

The problem of terminology was discussed informally for some months by investigators and others interested in the field at the National Institutes of Health, at Walter Reed Army Institute of Research, at several universities both in this country and abroad, and by members of such groups as the Scientific Advisory Committee of the Common Cold Foundation. These discussions culminated in a meeting in New York City on 25 May 1956 of the undersigned representatives of the early investigators in the field and others interested in seeking a satisfactory solution to the problem.

Agreement was reached on the term *adenovirus group,* which suggests a characteristic involvement of lymphadenoid tissue (*23*), as well as the tissue of the first reported isolation, and is in accordance with the proposals concerning nomenclature of the Subcommittee on Viruses of the International Nomenclature Committee (*24, 25*). For the present, members of the group would be indicated by serotype numbers in accordance with the classification of Huebner *et al.* (*6, 9*). Thus far, 12 types have been reported from human and two from simian sources (*9*). Information is not yet available to permit a completely detailed description of the adenovirus group. The viruses at present included in this group, however, have the following characteristics. (i) They produce acute infection of respiratory and ocular mucous membranes with associated follicular enlargement of submucous lymphadenoid tissue in these areas and also of the regional lymph glands. Virus has frequently been isolated from adenoid or tonsillar tissues from persons without clinical signs of acute illness. (ii) Multiplication in tissue culture of certain types of human and simian cells takes place readily and leads to increased acid formation and distinctive cytopathic changes. As is shown by electron micrographs, the nuclei of virus-infected cells may contain symmetrical arrays of virus-like particles. (iii) An antigen unique to this group, demonstrable in the complement-fixation test, is shared by members of the family. (iv) Antigenic type specificity is demonstrable by the neutralization test. (v) No strain as yet has produced manifest illness in commonly used laboratory animals.

With respect to terminology of the diseases caused by these viruses, it is proposed that the usual practice be followed of employing a clinical diagnostic term followed by etiological identification, such as, for example, acute respiratory disease (ARD) caused by adenovirus type 4; pharyngitis or pharyngoconjunctival fever caused by adenovirus type 3; follicular conjunctivitis caused by adenovirus type 6; keratoconjunctivitis caused by adenovirus type 8; or pneumonitis or atiypical pneumonia caused by adenovirus type 7. The use of such terminology will eliminate confusion that might arise from the facts that a single serotype can produce clinically different diseases and, conversely, that clinically similar illnesses may be produced by different adenovirus serotypes as well as by unrelated agents.

In making the foregoing proposals regarding terminology, the undersigned realize that they have no official status conferred by any national or international body dealing with nomenclature. They have, however, found that the term *adenovirus group* is acceptable among the investigators most concerned. Accordingly, it is suggested that this designation be generally employed in the interest of avoiding further confusion in the literature until ultimately a satisfactory nomenclature can be established for viruses.

JOHN F. ENDERS, *Chairman pro tem.*
Children's Medical Center,
Boston, Massachusetts

JOSEPH A. BELL
National Institutes of Health,
Bethesda, Maryland

JOHN H. DINGLE
Western Reserve University,
Cleveland, Ohio

THOMAS FRANCIS, JR.
University of Michigan, Ann Arbor

MAURICE R. HILLEMAN
Walter Reed Army Institute of
Research, Washington, D.C.

ROBERT J. HUEBNER
National Institutes of Health,
Bethesda, Maryland

A. M.-M. PAYNE
World Health Organization,
Geneva, Switzerland

References and Notes

1. W. P. Rowe *et al.*, *Proc. Soc. Exptl. Biol. Med.* 84, 570 (1953).
2. M. R. Hilleman and J. H. Werner, *ibid.* 85, 183 (1954).
3. J. H. Dingle *et al.*, *Trans. Assoc. Am. Physicians* 67, 149 (1954).
4. H. S. Ginsberg *et al.*, *J. Clin. Invest.* 34, 820 (1955).
5. M. R. Hilleman *et al.*, *Am. J. Public Health* 45, 203 (1955).
6. H. J. Huebner *et al.*, *New Engl. J. Med.* 251, 1077 (1954).
7. W. P. Rowe *et al.*, *Am. J. Hyg.* 61, 197 (1955).
8. M. R. Hilleman, J. H. Werner, M. T. Stewart, *Proc. Soc. Exptl. Biol. Med.* 90, 555 (1955).
9. W. P. Rowe, J. W. Hartley, R. J. Huebner, *ibid.* 91, 260 (1956).
10. R. H. Parrott *et al.*, *New Engl. J. Med.* 251, 1087 (1954).

11. J. A. Bell *et al.*, *J. Am. Med. Assoc.* 157, 1083 (1955).
12. M. R. Hilleman, A. J. Tousimis, J. H. Werner, *Proc. Soc. Exptl. Biol. Med.* 89, 587 (1955).
13. H. S. Ginsberg *et al.*, *Am. J. Public Health* 45, 915 (1955).
14. M. R. Hilleman *et al.*, *Am. J. Hyg.* 61, 163 (1955).
15. M. R. Hilleman *et al.*, *ibid.* 62, 29 (1955).
16. T. O. Berge *et al.*, *ibid.* 62, 283 (1955).
17. T. G. Ward *et al.*, *Science* 122, 1086 (1955).
18. E. Jawetz *et al.*, *ibid.* 122, 1190 (1955).
19. F. A. Neva and J. F. Enders, *J. Immunol.* 72, 315 (1954).
20. L. Kjellen, *Arch. ges. Virusforsch* 6, 45 (1955).
21. L. Kjellen *et al.*, *Nature* 175, 505 (1955).
22. C. G. Harford, A. Hamlin, E. Parker, *Soc. Am. Bacteriologists Proc. 1955*, p. 64.
23. Older usage applied the term *adenoid* to a variety of glandlike lymphatic or lymphoid tissues in addition to the nasopharyngeal adenoids.
24. Report of the Subcommittee on Viruses, *Intern. Bull. Bacteriol. Nomenclature and Taxonomy* 4, 109 (1954).
25. C. H. Andrewes, chairman of the Subcommittee on Viruses of the International Nomenclature Committee has signified to us his approval of the name *adenovirus*, indicating that it offers a great advantage and can be readily integrated with the proposed system of the Committee for Virus Nomenclature.

19 June 1956

Encoding Nonintegers in a General p-adic Number System

Without doubt the most common number system in use is the decadic system, which is more often called the decimal system and in which ten basic numbers (*base* or *radix* ten) 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 are used. But the decadic system is by no means the only possible number system. In fact, it is not even necessary that the radix of a number system be equal to or less than ten; it can be greater than ten. As an example, consider the number system with radix 11. Here a new symbol, say α, must be created as the eleventh basic number in addition to the ten in the decadic system, making the new list of basic numbers as follows: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, α. If one wishes to express the number 360 in this new system, one would have: $(360)_{10} = (2\alpha 8)_{11}$. We will call the number system with a radix p a p-adic number system.

Methods of converting integers in the decadic system to expressions in other number systems and vice versa by means of Euclid's algorithm are well known. However, little information seems to be available for converting nonintegers, numbers with decimal places in the decadic system. This note presents ways for encoding an arbitrary nonintegral number and a rational fraction in a general p-adic system.

Suppose it is desired to encode a nonintegral number in the decadic system into one in a p-adic system. The integral and decimal parts (parts preceding and following the decimal point, respectively) of the number must be converted separately. Euclid's algorithm or the continued division process can be applied to both parts, but the methods of application are different. For the integral part, the process is to perform successive divisions by p and collect the remainders in the reverse order; for the decimal part, it is necessary to perform successive divisions by p^{-1} and collect the remainders in the forward order. As an example, assume that $(7.3125)_{10}$ is to be encoded in the diadic system (radix 2). We will find that

$$(7)_{10} = (111)_2$$

and

$$(0.3125)_{10} = (0.0101)_2$$

Hence

$$(7.3125)_{10} = (111.0101)_2$$

It may also be proved that this conversion is unique.

It is clear that for integral numbers, the maximum number expressible with n digits in the decadic system is $(10^n - 1)$; this maximum number is $(2^n - 1)$ in the diadic system and $(3^n - 1)$ in the triadic system, and so forth. There is no simple relationship between a decimal number of a given number of digits in the decadic system and the number of necessary digits to express the same number in another system; it depends on the desired accuracy. For example,

$$(3.1416)_{10} = (11.00100100001111111110\ \ldots)_2$$

All *fractionals* (numbers less than one and signified by a fractional point placed at the left of the number) that terminate or repeat cyclically can be expressed as proper rational fractions. Conversely, it is also true that all proper rational fractions can be written as fractionals which terminate or repeat cyclically; the period or cycle of repetition may sometimes be very long. These statements hold for the conventional decadic system as well as for the general p-adic system. Let it be desired to encode the rational fraction $(A/B)_{10}$, where A and B are integers prime to each other and $A < B$, in the diadic system. It is of course possible first to express the integral numerator and denominator, A and B, both in the binary code and then to divide. Division in the diadic system is similar to the operation in the decadic system except that only two basic numbers, 0 and 1, are involved in the former system. However, straightforward division may prove to be a laborious and discouraging process because one does not know when to expect periodicity or how long the period of repetition is, which can indeed be very long. Several important relationships are pointed out in the succeeding paragraphs which will greatly facilitate the encoding process. Reference to the diadic system is not to be taken as a limitation of the relationships.

1) If the denominator B is expressible as an integral power of 2, then the fraction $(A/B)_{10}$ when written as a fractional in the diadic system will terminate. This is easily seen, because if $(B)_{10} = 2^n$, then $(B)_{10} = (1000\ \ldots\ 0)_2$, 1 followed by n zeros in the diadic system. Hence

$$\left(\frac{5}{16}\right)_{10} = (0.3125)_{10} = \left(\frac{5}{2^4}\right)_{10} = \left(\frac{101}{10000}\right)_2 = (0.0101)_2$$

2) If the denominator B is expressible in the form $(B)_{10} = 2^k \cdot \mathrm{m}$, where k is any positive integer including zero, and m is prime to 2, then the fraction $(A/B)_{10}$ when written as a fractional in the diadic system will repeat cyclically and indefinitely. This statement can be proved by the use of Euler's theorem on the congruence of numbers in number theory. It can be shown (*1*) that if integer p is relatively prime to integer m, then there are positive exponents s for which

$$p^s = 1 \pmod m$$

This expression means that $(p^s - 1)$ is divisible by m. In the language of number theory, one would say that p^s and 1 are congruent modulo m. Rules exist for the determination of the smallest value of the exponent s and the period of the remainders. It suffices to say here that since m is prime to 2, it is possible to determine the smallest value of the exponent s such that $(2^s - 1) = Cm$.

$$\left(\frac{A}{B}\right)_{10} = \frac{A}{2^k \cdot m} = \frac{AC}{2^k(2^s - 1)} = \frac{AC}{2^{k+s}}\left(\frac{1}{1 - 2^{-s}}\right)$$

The last expression can be easily written in the diadic notation; and the appearance of the second factor indicates clearly the existence of an infinite geometric progression with ratio 2^{-s}. As an example, suppose one desires to express the rational fraction $(5/14)_{10}$ as a fractional in the diadic system. Now

$$B = 14 = 2^1 \cdot 7$$

whence $k = 1$ and $m = 7$. It is obvious here that the exponent of 2 modulo 7 (smallest value of s to make 2^s and 1 congruent modulo 7) is 3. Hence $2^3 - 1 = 1 \cdot 7$ with $C = 1$, and

$$\left(\frac{5}{14}\right)_{10} = \frac{5 \cdot 1}{2^{1+3}}\left(\frac{1}{1 - 2^{-3}}\right) = \frac{2^2 + 2^0}{2^4}(1 + 2^{-3} + 2^{-6} + 2^{-9} + \ldots)$$

It follows directly that

$$\left(\frac{5}{14}\right)_{10} = \frac{101}{10000}(1 + 0.001 + 0.000001 + 0.000000001 + \ldots)_2 = (0.0101\mathit{101}101101\ \ldots)_2$$