comes relatively simple and straightforward. For example, the pyridine analogue would be called pyridine-adenine dinucleotide, which might be abbreviated to PAD if desired. The deaminated form is at present called "desamino-diphosphopyridine nucleotide," but this term gives little idea of its nature, since the part of the molecule which is deaminated (the adenine) is not mentioned in the name. The obvious name for it is nicotinamide-hypoxanthine dinucleotide (NHD). The analogue of TPN in which the phospho- group is attached to the 3′-position instead of the normal 2′-position is at present called "3′-triphosphopyridine nucleotide," a name which surely cannot be taken as indicating only one phosphate group attached to the 3′-position. The new system would give the natural name nicotinamide-adenine dinucleotide 3′-phosphate, perhaps abbreviated to NAD3P. Other analogues should cause no great difficulty. Abbreviations for the analogues are not being officially suggested; these are merely given as personal suggestions to illustrate the great advantages of the NAD system.

Possible objections. It remains to consider whether the names now proposed for the coenzymes are in strict accordance with chemical terminology.

"Nucleotide." Can NMN and FMN strictly be termed nucleotides? If the definition of a nucleotide is restricted to substances that can be obtained from nucleic acids (that is, to purine and pyrimidine nucleotides), they cannot, because of the different bases present. Probably, however, nobody would wish to narrow the definition in this way, and it is much more reasonable to use the term to denote the chemical structure:

base—pentose—phosphate

Clearly NMN qualifies as a nucleotide.

The case of FMN is not so clear, for two reasons. In the first place, it contains not ribose but ribitol, so that the —CHOH— group in position 1 of the ribose is represented by a $—CH_2—$ group in the flavin. However, the term "nucleotide" is also applied to the deoxyribonucleotides, in which the —CHOH— group in position 2 of the ribose is replaced by a $—CH_2—$ group. It is not unreasonable, therefore, to make the term cover both modifications, although the change in the 1-position is the more important, since it prevents ring formation. In actual fact, the flavin compounds have been universally called nucleotides for well over 20 years, and there is no suggestion that their nomenclature should be changed.

In the second place, the term "flavin" includes not only the base but the ribitol as well. Therefore the term "flavin nucleotide" must be understood as referring to a nucleotide containing flavin, rather than a nucleotide "of" flavin in the sense in which NMN is a nucleotide of nicotinamide.

"Dinucleotide." Finally, can NAD and FAD be strictly termed dinucleotides? A purist might hold that the term implies that the two mononucleotides are linked in the same way as the nucleotides in nucleic acid, by a 3′-5′-linked phosphate group. However, it would seem reasonable to consider a compound formed by the simple union of two mononucleotides to be a dinucleotide, particularly since the two classes of dinucleotides differ only in the point of attachment of a single bond.

"Dipeptide" has been cited as an analogy where the term implies a definite point of linkage, but the analogy is not a valid one. A dipeptide is not formed by the union of two monopeptides, and the name is clearly based on different principles. A truer analogy would be "disaccharide," which is used for a compound formed by joining two monosaccharides, without respect to the point of attachment.

Substances of the FAD type have been called dinucleotides ever since their first discovery, and it is the only name available. It has probably appeared far more often in the literature in this sense than in the sense of the 3′-5′-linked compounds, and it would be unreasonable now to restrict its use to the latter type.

Conclusion. Such are the reasons which have led the Enzyme Commission of the International Union of Biochemistry to recommend the use of NAD and NADP. The Biological Chemistry Nomenclature Commission of the International Union of Pure and Applied Chemistry has also decided, after considering the possible alternatives, to recommend these names in place of the existing systems. Preliminary experience has shown that, even by those whose first reaction is to express a preference for the retention of DPN, the new names are very quickly found to be attractive and satisfactory. It is hoped that when they become the official recommendations of both international unions, journals will give a lead in their adoption.

MALCOLM DIXON
Department of Biochemistry, Cambridge University, Cambridge, England

References

1. O. Hoffmann-Ostenhof and R. H. S. Thompson, *Nature* **181**, 452 (1958).
2. F. G. Fischer, *Ergeb. Enzymforsch.* **8**, 186 (1939).
3. F. Schlenk, *Advances in Enzymol.* **5**, 207 (1945); N. O. Kaplan, in *The Enzymes*, P. D. Boyer, H. Lardy, K. Myrbäck, Eds. (Academic Press, New York, ed. 2, 1960), vol. 3, p. 105; M. Dixon and E. C. Webb, *Enzymes* (Longmans, Green, London; Academic Press, New York; 1958), p. 395.
4. O. Warburg and W. Christian, *Biochem. Z.* **287**, 291 (1936).
5. A. Kornberg and W. E. Pricer, *J. Biol. Chem.* **186**, 557 (1950).
6. N. O. Kaplan and M. M. Ciotti, *ibid.* **221**, 823 (1956).

11 October 1960

Sustained Swimming Speeds of Dolphins

Abstract. Observations of four large groups of dolphins suggest that they are able to swim at a sustained speed of 14 to 18 knots. The blackfish are able to maintain speeds of about 22 knots, and one killer whale seemed able to swim somewhat faster. This implies that the apparent coefficient of surface friction remains approximately constant for dolphins from 6 to 22 ft long, as is the case for rigid bodies.

Since Gray (*1*) called attention to the anomalously high speed of dolphins (or porpoises) in 1936 and presented the case of a dolphin clocked at 33 ft/sec (about 19.7 knots), there have been a number of reports of similar high speeds of swimming. However, very little information on the sustained speeds of which these animals are capable has been published. On the basis of the various assumptions made, the speeds reported indicate a work rate per pound of muscle between 5 and 10 times that measured for terrestrial mammals, including man and the horse. However, data for terrestrial mammals (*2*) show that such mammals, by going into oxygen debt, can sustain work rates up to 100 times the basal metabolic rate for very short periods of time, and there seems to be a good possibility that many of the observations reported were of dolphins doing the equivalent of a 100-yard dash.

The lack of information in the scientific literature on the sustained speed capability of dolphins prompted us to have observations made through the cooperation of the Matson Navigation Company and Alexander Anderson, navigating officer of the S.S. *Monterey*. Printed forms were provided the observers for recording the time and location of observations, the speeds and relative positions of ships and dolphins, and the duration of sightings. Also included were seven sketches of species likely to be encountered on the trip from California to Australia, together with common names and lengths at maturity.

Most of the observations were made in the Southern Hemisphere while the ship was traveling at between 19.6 and 21 knots. Many observations of short duration were made on 1 to 30 dolphins at a time as they were swimming with the ship, but after about 2 minutes at these speeds they dropped behind; this suggested that to sustain such swimming speeds was beyond their capability. Four large groups of dolphins were observed in calm seas, swimming at 14 to 18 knots for periods of 8 to 25 minutes. Details of these observations are given in Table 1. In at least two of these sightings the dolphins never came close to the ship or seemed to be deflected from their course by the presence of the ship. These data support the conclusion that dolphins 6 to 8 ft long can swim at a sustained speed of about 18 knots.

William Von Winkle, of the U.S. Navy Underwater Sound Laboratory, reported (*3*) that a school of blackfish (probably *Globicephala melana*) had been observed circling a Navy vessel, which was cruising at 22 knots, for several days at a time. They would pass the ship, go way out in front, and go back in the wake to look for food. They were 12 to 15 ft long. On the basis of model similiarity, a dolphin of this size, twice the length of the smaller animals, should have a muscle weight (and presumed power output), per square foot of surface area, twice as great. If the coefficient of surface drag were constant, this would lead to a speed $2^{1/3}$ (= 1.26) times as great, since the propulsive power increases as the cube of the speed; 1.26 × 18 knots (the sustained speed of the smaller, common dolphin) equals 22.7 knots, which comes very close to the speeds maintained by the blackfish.

The one killer whale (*Orcinus orca*)—actually a dolphin—that was observed from the *Monterey* traveled at speeds of 20.6 to 30 knots. If we assume that it was of average length, it should have been about 3 times the length of the 5- to 8-ft dolphin. On the basis of model similarities, this killer whale should be able to swim $3^{1/3}$ times faster than the 18 knots, or 1.44 × 18, or 26 knots. This value is about the speed at which the whale swam around the ship but less than the 30 knots at which it approached the ship. After playing around the ship for 20 minutes at a sustained speed greater than the 20.6 knots at which the ship was sailing, the killer whale continued on its original course at about the speed of the ship.

We suggest that under the assumption of a constant ratio of muscle power to muscle weight, the sustained speeds that have been observed imply that the coefficient of surface friction remains approximately constant for dolphins from 6 to 22 ft long. It seems probable that the capacity of these mammals for sustained work can be estimated more closely than their capacity for short-term high rates of work. Such estimates, together with the speed data of Table 1, should provide an improved basis for calculating the value of the surface drag coefficient.

Table 1. Observations made from the *Monterey* on sustained swimming ability of dolphins.

Approx. No. of dolphins	Date (1958)	Speed of dolphins (kn)	Length of time at observed speed (min)	Position of ship	Speed of ship (kn)	Comments
50	2 Nov.	18	8	32°S, 176°W	19.6	Some dolphins rode the bow wave. Large and small dolphins in group. Smaller ones came closest to ship.*
500	25 Oct.	14–16	20	34°S, 158°E	19.5	Group was traveling in same direction as ship when it was overtaken and passed. Group was about 0.25 mile away at closest approach.*
200	31 Oct.	18	10	34°10′S, 167°05′E	21	Some of the dolphins approached side of vessel but stayed 200 yd off.*
200–300	31 Oct.	17–18	25	34°15′S, 167°45′E	21	Dolphins were sighted several miles ahead of ship in calm sea. They remained about 0.5 mile away from vessel but swam on same course as vessel.*
1	12 Oct.	20.6–30	20	03°30′S, 141°45′W	20.6	Killer whale (about 20 to 25 ft long) approached ship at about 30 kn, swam back and forth around bow, veered away at about speed of ship.

* Dolphins were white-sided and about 6 to 8 ft long.

CARL L. JOHANNESSEN
Department of Geography, University of Oregon, Eugene

JAMES A. HARDER
Department of Civil Engineering, University of California, Berkeley

References and Notes

1. J. Gray, *J. Exptl. Biol.* **13**, 192 (1936).
2. S. Brody, *Bioenergetics and Growth* (Reinhold, New York, 1945).
3. W. Von Winkle, personal communication to J. A. Harder, 9 Jan. 1959.

12 July 1960

Interpeduncular Nucleus and Avoidance Conditioning in the Rat

Abstract. Rats trained to make a jumping response to the onset of a visual stimulus lost the habit after damage to the interpeduncular nucleus of the midbrain. It was noted, however, that the majority of the operated animals showed perfect retention of the "fear" response to the conditioned stimulus.

Thompson and Massopust (*1*) have demonstrated that damage to the interpeduncular nucleus of the mesencephalon abolishes a previously established brightness discrimination in the rat. More recently it has been found that this nucleus also participates in mediating a kinesthetic discrimination as well as an auditory habit (*2*). Because of the paucity of anatomical, physiological, and psychological data related to the interpeduncular nucleus, its function in learning and retention is unknown. Some enlightenment was obtained in the study reported here, in which the effects of lesions in the interpeduncular nucleus on retention of an avoidance response were studied (*3*). Of particular interest was the finding that although damage to this nucleus profoundly disturbed the subsequent performance of the avoidance response, the fear-producing properties of the conditioned stimulus were spared.

Nineteen adolescent albino rats were trained to make a jumping response to the presentation of a visual stimulus. The apparatus, which consisted of an enclosed box made of Plexiglas, was located in a light-proof, sound-attenuated room. The box measured 6 inches on either side and was 10 inches high. The floor of the box was made into a grid composed of bronze rods. A space of ½ inch existed between the top of the walls and lid of the box.