The Nuclear DNA Content of Lampreys

The DNA values for 2C nuclei of various species of reptiles, birds and mammals lie between 1.7 and 9.9 pg[1–4]. Within this relatively narrow range, mammals tend to have the highest values and birds the lowest. Values for fishes and amphibians are, however, much more varied, with diploid nuclei of one teleost having as little as 0.8 pg of DNA while those of an amphibian and a lungfish contain as much as 167 and 212 pg respectively[1–3]. Much of the variation that cannot be attributed to numerical differences between chromosome complements, reflects the presence of differing amounts of repetitive, and possibly other types of DNA, whose roles are currently being studied intensively[5].

However, comparisons between the DNA values of 2C nuclei of various species of vertebrates are made difficult by the fact that the data have not always been obtained by the same method[1]. Furthermore, the values are often expressed in relative terms, usually as a percentage of the amount of DNA found in the nuclei of man[6]. Even in recent studies, however, when an attempt has also been made to convert such information into quantitative values, disagreement exists as to whether the latter nuclei should be regarded as containing 6 or 7 pg of DNA[2,3]. In this paper, the relative data, both of ourselves and other workers, have been converted into picograms using the former and much quoted of these values based on the work of VENDRELY and VENDRELY[7].

Unlike other vertebrate classes with living representatives, the jawless vertebrates or Agnatha (lampreys and hagfishes) have been largely neglected in studies of vertebrate DNA content. Two values have been published for lampreys. According to an early estimate[8], *Petromyzon marinus* nuclei contain about 5 pg (i.e. approximately 92% of the value the same authors obtained for human cells) and in a second report[6] *Lampetra planeri* is cited as containing considerably less than half that amount. In view of the marked similarity of the karyotypes of all lampreys apart from *Mordacia spp.*[9], we obtained nuclear DNA values for over a quarter of the known species (representing all 3 Families) to ascertain whether the pattern exhibited by these data paralleled those shown in terms of chromosomal constitution.

Nuclear DNA values are given for 5 genera and 9 species of lampreys obtained from different geographic localities and different life cycle stages (Table). Lamprey tissues were dabbed on coverslips before application of control cells (human female leucocytes from appendix and tonsil). The composite preparations were stained by a Feulgen procedure and the nuclear DNA content of the lamprey erythrocytes and control lymphocytes measured in arbitrary units using an integrating microdensitometer with a crushing condenser[10]. The nuclear DNA content of the lamprey was expressed as a percentage of that found in the human female leucocyte and then converted into picograms.

A considerable degree of similarity exists between the mean DNA content of 8 of the 9 species with values for these lying within the narrow range of 2.2 to 2.6 pg. *Petromyzon marinus* is the exception with a value of 3.6 pg. The similarity extends from species which may have diverged as recently as the end of the Pleistocene[11] (e.g. the so-called 'paired species' *Lampetra fluviatilis* and *Lampetra planeri*) to the different genera which undoubtedly separated very much earlier.

[1] A. MORESCALCHI, Boll. Zool. *37*, 1 (1970).
[2] M. G. MANFREDI ROMANINI, in *Cytotaxonomy and Vertebrate Evolution* (Eds. A. B. CHIARELLI and B. CAPANNA; Academic Press, London 1973), p. 39.
[3] S. OHNO, *Evolution by Gene Duplication* (Allen and Unwin, London 1970).
[4] H. REES and R. N. JONES, Int. Rev. Cytol. *32*, 53 (1972).
[5] The Eukaryote Chromosome Conference, Canberra, Australia, May 1974.
[6] N. B. ATKIN and S. OHNO, Chromosoma *23*, 10 (1967).
[7] R. VENDRELY and C. VENDRELY, *L'acide desoxyribonucléique (ADN) substance fondamentale de la cellule vivante* (Legrand, Paris 1957).
[8] A. E. MIRSKY and H. RIS, J. gen. Physiol. *34*, 451 (1951).
[9] I. C. POTTER and E. S. ROBINSON, in *Cytotaxonomy and Vertebrate Evolution* (Eds. A. B. CHIARELLI and E. CAPANNA; Academic Press, London 1973), p. 179.
[10] N. B. ATKIN, in *Introduction to Quantitative Cytochemistry* (Eds. G. L. WIED and G. F. BARR; Academic Press, London 1970), vol. 2, p. 1.
[11] M. W. HARDISTY and I. C. POTTER, in *The Biology of Lampreys* (Eds. M. W. HARDISTY and I. C. POTTER; Academic Press, London 1971), vol. 1, p. 249.

The DNA content of lamprey nuclei

Family and Species	Geographical Locality	Life cycle stage	No. of cells	DNA content	
				%	pg
Petromyzonidae					
Ichthyomyzon fossor	Great Lakes, United States	Larva/Adult	29	38.4 + 0.75	2.3
Ichthyomyzon gagei	Southern Unites States	Larva/Adult	30	37.4 + 1.08	2.2
Ichthyomyzon bdellium	Southern United States	Adult	15	41.3 + 2.28	2.5
Petromyzon marinus	Great Lakes, Canada	Larva/Adult	36	60.7 + 3.47	3.6
Lampetra lamottenii	Great Lakes, Canada	Larva/Adult	30	40.0 + 1.25	2.4
Lampetra planeri	Southern England	Larva/Adult	32	40.5 + 2.65	2.4
Lampetra fluviatilis	Northern England	Larva	15	41.3 + 1.29	2.5
Geotriidae					
Geotria australis	Tasmania	Larva/Adult	31	44.0 + 2.95	2.6
Mordaciidae					
Mordacia mordax	Southeastern Australia	Larva	61	40.7 + 1.09	2.4

Values are expressed as a mean percentage (+ 1 S.E.) of that found in the human female leucocyte and in picograms on the assumption that the diploid nucleus of man contains 6 pg[7].

The Northern Hemisphere genera *Ichthyomyzon*, *Petromyzon* and *Lampetra* have very similar karyotypes[9]. The higher DNA value for *Petromyzon* is therefore not the result of an increase in chromosome number or size. The proposed intermediate taxonomic position of *Petromyzon* between *Ichthyomyzon* and *Lampetra*[12] requires that DNA increase in *Petromyzon* was a somewhat isolated event and occurred during or after the evolutionary differentiation of *Petromyzon*. There is no palaeontological evidence to suggest when this actually took place, nor is there any cytochemical evidence that the extra DNA is of a particular type such as repetitive or spacer DNA[4,13].

Since the Southern Hemisphere genus *Geotria* possesses a chromosome number[9] and DNA content typical of those of other Holarctic genera, it is karyologically similar to Holarctic forms. However, the other Southern Hemisphere genus, *Mordacia* has a much lower chromosome number[14] and karyotype size than other lamprey genera but retains a similar DNA value. Centric fusions may have occurred in the evolution of *Mordacia* but fusions alone cannot account for the distinctly different karyotypes. Although the *Mordacia* karyotype has been described as the most distinct of the lamprey genera[9], this distinctness clearly does not extend to the amount of DNA present in nuclei.

Our results confirm the suggestion (based on the DNA value for a single species, *Lampetra planeri*) that lampreys typically possess DNA values of approximately 40% of that found in man. However, an examination of the chromosomes of a variety of lampreys reveals that close similarity of karyotype may be accompanied by differences in DNA content (e.g. *Petromyzon*) and, conversely, marked differences in karyotype may be accompanied by similarity in DNA value (e.g. *Mordacia*). Since parallel examples have been recorded for insects[15] and mammals[12], they emphasise the need for restraint when predicting relationships based solely on a few exact DNA values.

Résumé. Nous avons trouvé que le contenu en ADN nucléaire varie peu chez les lamproies. Dans les 3 familles principales ce contenu représente en moyenne le 40% de celui de l'homme. Il existe une corrélation entre le contenu en ADN et le caryotype dans presque tous les genres.

E. S. Robinson[16], I. C. Potter and N. B. Atkin[17]

School of Biological Sciences, University of Bath, Bath (Somerset, England), and Department of Cancer Research, Mount Vernon Hospital, Northwood (Middlesex, England), 10 January 1975.

[12] C. L. Hubbs and I. C. Potter, in *The Biology of Lampreys* (Eds. M. W. Hardisty and I. C. Potter; Academic Press, London 1971), vol. 1, p. 1.
[13] W. Flamm, Int. Rev. Cytol. *32*, 1 (1972).
[14] I. C. Potter, E. S. Robinson and S. M. Walton, Experientia *24*, 966 (1968).
[15] D. P. Fox, Chromosoma, *27*, 130 (1969).
[16] Permanent address: School of Biological Sciences, Macquarie University, North Ryde, N.S.W., Australia.
[17] We thank F. W. H. Beamish, W. M. Howell, Jean Joss, D. Lynch, P. Manion and A. D. Pickering for material. Support was provided by the Science Research Council.

Juvenomimetic Activity in some Plants

It was reported that topical application of acetone extracts of stem or saw dust of certain plants to newly moulted 5th instar nymphs of the red cotton bug *Dysdercus cingulatus* resulted in retention of varying degrees of nymphal characters. Based on this bioassay, it was found that out of 9 plants investigated 6 had considerable juvenile hormone activity[1]. The juvenile hormone activity in the plants studied was represented as FME equivalents, i.e. juvenile hormone activity shown by the extract from 1 g of dried plant stem, equivalent to the quantity of farnesly methyl ether in µg. The present report summarizes the results of our investigations covering more plants.

Dried stem was Soxhlet extracted with acetone, and the acetone extract was studied on newly moulted 5th instar nymphs of *Dysdercus cingulatus* as reported previously[1]. 16 plants were collected locally, of which 12 showed presence of juvenomimetic activity in the extract by the method employed for the study, whereas the remaining 4 did not give any positive indication of this activity in their extracts. The plants studied, and the juvenomimetic activity present in them in terms of FME equivalents is given below: *Erythrina indica* Lam. (48 FME eqs); *Auracaria excelsa* R. Br. (77 FME eqs.); *Anona reticulata* L. (65 FME eqs.); *Peltoforum inerme* Benth. (46 FME eqs.); *Tamarindus indica* L. (11 FME eqs.); *Manihot esculenta* Pohl. (56 FME eqs.); *Phyllanthus emblica* L. (80 FME eqs.); *Eupatorium* sp. (23 FME eqs.); *Mangifera indica* L. (47 FME eqs.); *Tabernaemontana dichotoma* Roxb. (97 FME eqs.); *Macaranga peltata* Muell. (10 FME eqs.) and *Psidium gaujava* L. (5 FME eqs.). The following plants were found not to possess any appreciable juvenile hormone activity: *Millingtonia hortensis* L. f., *Careya arborea* Roxb., *Anacardium occidentale* L. and *Dalbergia latifolia* Roxb.

The present study supports our earlier presumption that juvenomimetic activity is wide-spread in plants[1]. This juvenomimetic activity may be due to the juvenile hormone-like substances in the extracts, or may be synergistic rather than intrinsically hormonal[2].

Zusammenfassung. Es wurde bei 12 von 16 untersuchten Pflanzen die juvenomimetische Wirkung in den Acetonextrakten festgestellt; die restlichen 4 zeigten keinerlei Effekte. Die juvenomimetische Wirkung wird auf juvenilhormonartige Stoffe in den Extrakten oder auf einen Synergismus zurückgeführt.

V. K. K. Prabhu and M. John[3]

Department of Zoology, University of Kerala, Kariavattom, Trivandrum (India), 12 September 1974.

[1] V. K. K. Prabhu, M. John and B. Ambika, Curr. Sci. *42*, 725 (1973).
[2] M. Slade and C. F. Wilkinson, Science *181*, 672 (1973).
[3] We thank the Indian National Science Academy for a research grant, Professor K. K. Nayar for Laboratory facilities and Mr. P. N. Chandrasekharan Nair for identification of plants.