nating differences in the sugar ring pucker (*18*).

There is considerable utility in presenting idealized coordinates for the two forms of Z-DNA. These can be used for energy calculations to assess the stability of the different conformations; they can also be used in a quantitative analysis of the NMR spectrum as they provide detailed information concerning the environment of various protons in the molecule. The coordinates can also be used to calculate the unique circular dichroism associated with the high-salt form of poly(dG-dC) (*14*). It should be pointed out that these coordinates differ in a significant way from coordinates generated by a study of fiber diffraction patterns. Coordinates from fiber diffraction patterns are generated by making a number of assumptions about the molecule, including the assumption that all repeating units are equivalent; further, conformational details are never visualized in fiber diffraction studies since the analysis is far from atomic resolution. This limitation is important, especially in trying to evaluate NMR spectra, in which small changes in the molecular environment produce considerable changes in the resonance spectrum.

The material presented here suggests that Z-DNA exists not as a single structure but rather as a family of structures which are broadly similar to each other but differ in certain specific ways that result in slightly modified conformations. It is quite likely that changes in local conformation are not confined to Z-DNA alone, but may also be found commonly in the more familiar right-handed B-DNA. Thus local changes in the environment due to ions or proteins are likely to produce changes in conformation, many of which will be sequence-dependent. These changes in conformation may be a significant aspect of the biology of the nucleic acids and may help to define some of the specificity of their interaction with proteins and other molecules.

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4. Abbreviations used in this report: d, deoxy; C, cytosine; p, phosphate; G, guanine; A, adenine, and T, thymine.
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19. To generate the complementary dimer, use the equation

$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix} * \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

To generate the nth neighboring dimer, use

$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} \cos[n*(-60°)] & -\sin[n*(-60°)] & 0 \\ \sin[n*(-60°)] & \cos[n*(-60°)] & 0 \\ 0 & 0 & 1 \end{pmatrix} * \begin{pmatrix} x \\ y \\ z \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ n*7.43 \end{pmatrix}$$

Where x', y', z' are the new coordinates in angstroms and x, y, z are the original coordinates in angstroms.
20. The dihedral angles are defined as

$$\begin{matrix} & \alpha & \beta & \gamma & \delta & \epsilon & \zeta \\ \text{O3'-P-O5'-C5'-C4'-C3'-O3'-P-O5'} & & & & & & \end{matrix}$$

χ is the angle about the glycosidic bond.
21. This research was supported by grants from the National Institutes of Health, National Science Foundation, National Aeronautics and Space Administration, American Cancer Society, and Netherlands Organization for the Advancement of Pure Research (ZWO).

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Unmyelinated Axons in the Posterior Funiculi

Abstract. *Electron microscopy of the dorsal funiculus in the rat reveals that most axons in this pathway are unmyelinated. These axons have not previously been counted, nor are they considered in modern studies on the organization of the dorsal funiculus. Because of the importance of this pathway in somatic sensation, it is important to understand that these fibers exist and that they are present in greater numbers than the well-studied myelinated axons.*

The mammalian posterior funiculus is an important somatic sensory pathway in the spinal cord. Textbooks state that the axons in this pathway are predominantly myelinated primary afferent fibers (*1*), and although other fiber types are known, conduction velocities indicate that these others are also myelinated. Furthermore, published histograms of axonal diameters in the posterior funiculus do not mention unmyelinated axons (*2*). Thus it was surprising to find large numbers of unmyelinated axons in each posterior funiculus of the rat. Since the unmyelinated fibers outnumber the myelinated axons in this pathway, it is necessary to ascertain their existence and numbers.

Normal rats were anesthetized with sodium pentobarbital and then perfused through the heart with normal saline. As soon as the right auricular effluent was

Table 1. Number of myelinated and unmyelinated axons in the dorsal funiculus of the S_2 to S_4 segments of the rat spinal cord. The dorsal funiculus proper is that part of the dorsal funiculus that does not include the corticospinal tract.

Rat	Segment	Dorsal funiculus proper		Corticospinal tract		Total	
		Myelinated	Unmyelinated	Myelinated	Unmyelinated	Myelinated	Unmyelinated
1	S_2	5,232	4,609	1,662	2,590	6,894	7,199
2	S_2	5,457	6,452	2,380	2,871	7,837	9,323
3	S_3	3,654	4,338	1,695	2,880	5,299	7,218
4	S_3	3,818	5,214	1,568	2,794	5,386	8,008
5	S_4	2,162	4,702	1,035	3,541	3,197	8,153
6	S_4	3,219	8,186	1,614	3,893	4,833	12,079
Average		3,924	5,584	1,659	3,080	5,574	8,663

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free from blood, the perfusate was changed to a mixture of 3 percent glutaraldehyde, 3 percent paraformaldehyde, and 0.1 percent picric acid in 0.1*M* cacodylate buffer at *p*H 7.4. After perfusion, the spinal cord was sectioned (500 μm), and the appropriate slices were fixed in 1 percent osmium tetroxide and 1.5 percent potassium ferricyanide in 0.1*M* cacodylate buffer at *p*H 7.4 (*3*). The slices were then stained with 1 percent aqueous uranyl acetate, dehydrated, and embedded in a mixture of Epon and Araldite. Thin sections of the posterior columns were placed on single-hole grids covered by a Formvar film, and all myelinated and unmyelinated axons were counted.

The dorsal white funiculi in the rat are two large bundles of white matter that lie between the dorsal horns. At the light microscopic level, the most prominent components of these tracts are the myelinated axons, but capillaries and radial glial processes are also evident. The corticospinal tracts, which are located in the dorsal white column in the rat (*4*), are clearly indicated as small areas of closely spaced, fine, myelinated axons.

In the electron microscope, the above features are seen with greater clarity. In addition, the unmyelinated fibers can be seen (Fig. 1). In cross section, these axons have circular or oval profiles with diameters of 0.3 to 1.0 μm (Fig. 1). The organelles in these axons consist of neurofilaments, microtubules, and occasional mitochrondia (Fig. 1). The unmyelinated axons occur singly or in bundles of two to ten, and they are scattered throughout the funiculus and are not concentrated next to the gray matter or in the corticospinal tract. There are more unmyelinated than myelinated axons, both in the corticospinal tract and in the rest of the funiculus (Table 1). From these data, it can be calculated that 60 percent of the axons in the posterior funiculus of the rat are unmyelinated.

The fiber types that are known are (i) ascending myelinated primary afferent axons that are generally believed to be the predominant axonal type in the pathway, (ii) descending myelinated primary afferent axons located in the fasciculus interfascicularis (comma tract of Schultze) and septomarginal band (*5*), (iii) corticospinal fibers, which form a circumscribed bundle of axons in the ventromedial part of each posterior funiculus in the rat (*4*), (iv) propriospinal fibers (*5*), (v) fibers descending from cells in the nuclei gracilis and cuneatus (*6*), and (vi) second-order ascending cells (*7*).

It is possible that the unmyelinated axons also belong to one of these categories. Unmyelinated fibers outside of the corticospinal tract were mentioned by Nageotte (*8*), who noted a few unmyelinated fibers near the gray matter and in the median septum. The fact that the unmyelinated axons are spread throughout the funiculus suggests that they are not restricted to corticospinal or propriospinal systems, and it would be interesting to find unmyelinated primary afferent fibers in the posterior funiculi. The cell bodies that give rise to the unmyelinated axons can be located by various types of experimental surgery. Presumably an understanding of the unmyelinated fiber systems of the posterior funiculus will provide further insights into the organization of somatic sensory systems.

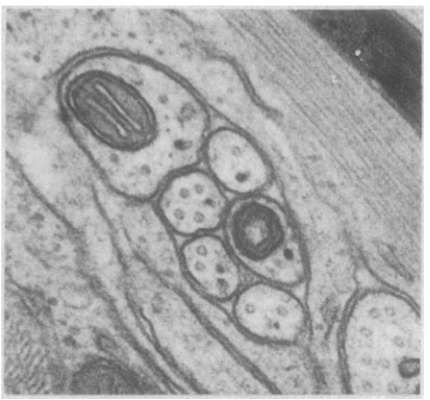

Fig. 1. A group of six unmyelinated fibers in the dorsal white colume (×90,000).

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Assessment of Pharmacological Treatment of Myocardial Infarction by Phosphorus-31 NMR with Surface Coils

Abstract. *Phosphorus-31 nuclear magnetic resonance (NMR) measurements with small surface coils have been used to observe phosphorus metabolism of perfused hearts within localized regions. The method allows for direct, noninvasive, sequential assessment of the altered regional metabolism resulting from myocardial infarction and its response to drug treatment, which cannot be observed by conventional techniques.*

A central issue in the study of most disease states is the correlation between the pathophysiology and the metabolic competence of the region that incurs injury or exhibits an abnormality. This problem is of particular importance for conditions that involve compromised blood flow to and oxygenation of an organ or part of an organ. Myocardial infarction and cerebrovascular occlusion (stroke) are two examples. Key elements in the clinical treatment of infarction and stroke are the determination of the location, size, and extent of the injury and learning the time course of metabolic impairment and the onset of irreversible damage. Techniques based on x-rays, ultrasound, and nuclear medicine may be used to determine the size and location of injury, but there has been no clinical method for directly and noninvasively assessing the metabolic competence of an injured site. A method for noninvasively determining metabolic function would be extremely useful for characterizing the extent of deterioration and monitoring the efficacy of therapies.

Nuclear magnetic resonance (NMR) techniques can provide information on the molecular level about structural, motional, and thermodynamic properties of many naturally occurring nuclei of biological interest (*1*). The ^{31}P nucleus is useful in metabolic studies involving

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