Microphotographs of the L929 fibroblast cells grown in contact with the polyurethane (PU) and the PU–PVP IPN as well as control cells are depicted in Figure 1 *a–c*. The control cells (Figure 1 *a*) are spindle-shaped, uniformly and thickly spread out, and have a glistening appearance characteristic of a normal and healthy condition. The cells in contact with the degrading PU membrane (Figure 1 *b*) have lost their spindle shape and become round, indicating cell lysis. Some of the cells were observed floating in the medium. The PU membrane used in this case is definitely not supportive of cell growth or adhesion. Figure 1 *c* depicts the L929 cells in contact with the IPN membranes. The profuse cell growth that is uniformly spread as in the control cell population is clearly seen. The spindle shape and the glistening appearance of the cells are also evident. These studies therefore indicate that by IPN formation, the degrading PU membranes could be made more bioresistant and highly supportive of cell growth and adhesion. This IPN membrane may, therefore, be eminently suitable for encapsulation of living cells in the fabrication of artificial internal hybrid organs such as artificial pancreas and liver.

Clinical indication of any deficiency in biocompatibility as far as the performance of a material is concerned is best brought out by studies of local tissue response. Histological studies[12] of the local tissue response on implanting the PU and PU–PVP IPN membranes had indicated better compatibility for the IPN. This response was further confirmed by quantifying the response using specific immunostaining techniques and computer-aided image analysis[14].

The image analysis studies, utilizing monoclonal antibodies for specific staining, could recognize the absence of T cells, B cells and neutrophils and the predominance of ED2 macrophages. Macrophages are known to play several roles in the inflammatory response. One of the roles of the macrophage is to phagocytose cellular and molecular debris and also to detoxify and/or sequester toxic materials.

The polyurethane membrane induced an initial inflammatory response evidenced by a maximum number of ED2 macrophages, i.e. 366, in one month. With the stabilization of the response at three months, the macrophage number dropped down to 161. The distribution of these macrophages even at the end of 3 months was uniformly spread out and higher at the implant interface (Figure 2 *a*).

In contrast, the ED2 macrophages were 210 in number at one month at the IPN interface and this had dropped to a mere 21 isolated cells in the vicinity of the implant (Figure 2 *b*), at the end of 3 months. The IPN membrane can, therefore, be considered as a very biocompatible material.

In conclusion, interpenetrating polymer networks of polyurethane have been synthesized with desired physicochemical properties. The materials are, therefore, ideal candidate materials for encapsulating pancreatic cells or hepatocytes for the fabrication of artificial internal hybrid organs. Ongoing work in progress is concerned with establishing the permeability characteristics of these membranes to metabolites and other components of extra cellular matrix for effective functioning of the hybrid organ.

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ACKNOWLEDGEMENT. I acknowledge the assistance of DST, India, for the award of a BOYSCAST Fellowship at the University of Liverpool, UK, under which a part of this work was carried out.

Received 9 February 1995; accepted 28 March 1995

Fractal relation of perimeter to the water body area

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The relation between the fractal dimension of the perimeter and the area of a water body is given. The fractal dimension of the water bodies arrived through perimeter–area relationship is tallied with their actual fractal dimensions. The fractal dimension of the water bodies under study is very close to that of the Brownian mountain lakes.

THE relation of water body area A to the perimeter P of the water body is one of the important hydrologic

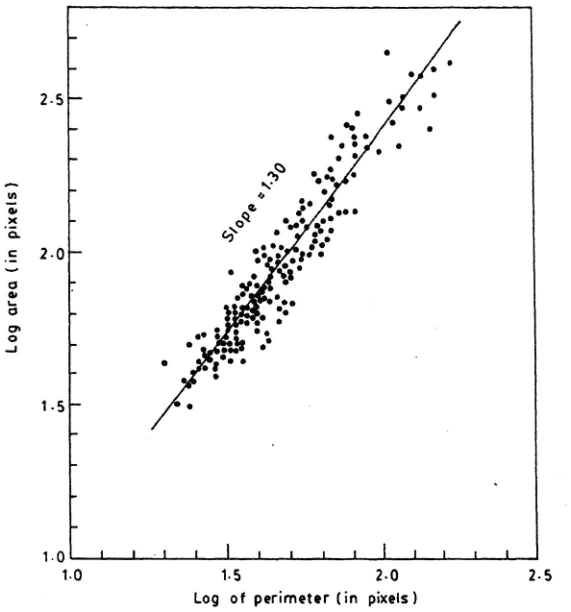

Figure 1. Logarithm of water body area vs logarithm of perimeter.

Table 1. Fractal dimensions of four surface water bodies

Fractal dimension D	$\alpha = 2/D$	Error*
1.51	1.32	0.03
1.49	1.34	0.05
1.49	1.34	0.05
1.46	1.37	0.08

*The fractal dimension of the perimeters of water bodies as predicted through perimeter–area relationship is 1.538 ($D = 2/1.3$).

characteristics. According to Euclidean law, the area–perimeter relation should be

$$A \sim P^2. \tag{1}$$

If the water body having the fractal dimension of exactly 1, which indicates that the water body has a smooth outline circular in shape, then the relationship shown in equation (1) is satisfied. But in nature, no water body has a smooth outline. Hence, they are also self-similar fractals.

Mandelbrot[1] demonstrated the applicability of the power function relating perimeter to area of nondifferentiable functions or bounded curves of infinite length. In another study[2] he proposed the concept of statistical self-similarity for the boundary between the sea and the land. The water body outline too is, in a sense, a boundary between land and water body. Hence, this study.

As demonstrated by Mandelbrot[1], the power value is not 2 for nonstandard shapes (fractal shapes), so the relation between P and A is taken in the form

$$A \sim P^{\alpha}, \tag{2}$$

where $\alpha = 2/D$ is an exponent that fits to the data. Empirical studies[3, 4] predict α value to be less than 2.

To show the fractal relation of perimeter to area of a water body, a large number of water bodies situated between the geographical coordinates of 18°00–18°30′N latitudes and 83°15′–83°45′ E longitudes were traced from Landsat (TM) data (30 mts resolution) acquired in November 1986, post-monsoon, when the water bodies generally attain equilibrium stage (areal extent may be the highest compared to the other periods). The traced water bodies were digitized through a digital Pulnix camera. This was done to keep the data noise-free. The digital data were binarized by giving specific grey value as threshold to separate water bodies from no-water body regions. Then the area A was determined simply by counting the number of pixels and the perimeter P by measuring the length of the water body boundary. The sizes of water bodies range from 0.05 km^2 to 0.8 km^2. Figure 1 shows a double logarithmic plot of area versus perimeter for 200 water bodies. The data are well fitted by the power law $A \sim P^{1.3}$, implying that the perimeter of water bodies are self-similar. The fractal dimension D of the perimeters of the water bodies equals $2/1.3 = 1.53$, which is close to that of the fractal dimensions computed for four selected water bodies (Table 1) from 200 water bodies. This value is also close to that of the Brownian mountain lakes, $D \sim 1.5$ (ref. 1, 5).

It is concluded that for the water bodies under study, during post-monsoon season the perimeter has to be raised to the power $2/D = 1.3$ to predict the water body's area from its perimeter. The fractal dimension of water bodies under study is very close to that of the fractal dimension of the Brownian mountain lakes.

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ACKNOWLEDGEMENTS. The Research Associate fellowship granted by the Council of Scientific and Industrial Research, India, is gratefully acknowledged by the first author. The facilities provided by ISRO, Bangalore, India, under RESPOND project are also gratefully acknowledged by the authors.

Received 17 October 1994; revised accepted 24 March 1995