Histological Studies on the Genus *Fucus*

I. Light Microscopy of the Mature Vegetative Plant

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With 9 Figures

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Introduction

The genus *Fucus* offers much of interest to both the plant and animal histologist. The developing embryos of these plants are widely recognized as providing an almost ideal system for the study of the establishment of polarity and anisometry in plant cells. In the course of a study of the histology and fine structure of *Fucus* embryos it was found necessary to examine also mature plants since many of the findings with the embryos were uninterpretable in the absence of histological and fine structural details of the mature tissue.

Quite unexpectedly the cells and tissues of the mature *Fucus* plant have proven of interest in their own right and it is with this work that the present paper is concerned.

A section of mature *Fucus* thallus is remarkable in its resemblance to a section of animal cartilage. This resemblance is more than superficial. In both cases the cells are embedded in a massive, biphasic matrix composed of rigid, oriented fibres and amorphous polysaccharide. The fibrous components of cartilage and of tissues of the *Fucus* thallus are of course quite different, being the protein collagen in cartilage and the polysaccharides cellulose and alginic acid in *Fucus*. However, the amorphous polysaccharides of the matrices are remarkably similar; both are sulphated polysaccharides, chondroitin sulphate in cartilage and fucoidin in *Fucus*.

Recent work shows that some polysaccharides both of animals (Godman and Lane 1964, Berendes 1965) and of plants (Northcote Protoplasma, Bd. LXII/4 20
and Picket-Hepha 1966) are polymerized into units of large molecular weight which are contained within membrane-bounded vesicles in the cells. These polysaccharides are probably secreted from the cells by a reverse pinocytosis process in which the vesicle membrane is incorporated into the plasma membrane. It is of interest to know if the extracellular polysaccharides of Fucus are also polymerized within the cells and similarly secreted as macromolecules.

There is as yet no histological evidence in either plant or animal tissue for the secretion of different polysaccharides of high molecular weight from the same cell. Mature Fucus tissue is ideal material in which to look for such a multiple secretion since the two polysaccharides alginic acid and fucoidin can be distinguished histochemically (McCullly 1965). As a system for the study of the production of extracellular material the Fucus thallus has the advantage of having continuous apical growth. Such a growth pattern is useful since it gives both a temporal and a spatial sequence of matrix formation within an individual plant.

Algal polysaccharides such as alginic acid, fucoidin, carrageenin and agar make up a large proportion of the mass of the algae in which they are produced as extracellular material. Because these algal polysaccharides are of considerable economic importance there has been much investigation of their chemistry (see reviews by Kreger 1962, O'Colla 1962) and studies have also been made on the influence of the environment on their production (Moss 1948, MacPherson and Young 1952, Black et al. 1955). No studies have been made on their origin or mode of secretion. The absence of such work is especially surprising in view of the light which such a study would throw on the production of extracellular materials in general.

In addition to the obvious advantages of Fucus tissues for the study of matrix formation, the cellular components of this material are also of interest. Microscopical examination of cells teased out of a piece of fresh Fucus thallus reveals a confusion of intracellular components. Of these only the plastids are easily identified by their pigment. In some cases the large nuclei can be seen, but in general the cells are so crammed with vacuoles and inclusions that even the nuclei cannot be distinguished. Although the exact nature of the various cellular inclusions has not been described, it is known from the earlier work that many of these contain polyphenolic materials (see Frtisch 1945). Recently there has been considerable interest in these substances. It has been shown that intact Fucus plants secrete large amounts of polyphenolic material (Craigie and McLachlan 1964a) and there are strong suggestions that these secreted materials are of considerable ecological and physiological significance. In this regard Craigie and McLachlan (1964b) have demonstrated differential antibiotic effects of these substances on pure cultures of various algae, and Provassoli (1965) has shown that the secreted polyphenols from Fucus have marked morphogenetic effects on cultures of Monostroma. The origin and mode of secretion of these polyphenolic materials of Fucus are therefore of considerable interest as is also the nature of the various