from BIOL. JOURN., 5 (2) 5-8 (1965)

New Cytological Observations of *Spirogyra*. The Structure of the Cytoplasmic 'Bridles.'

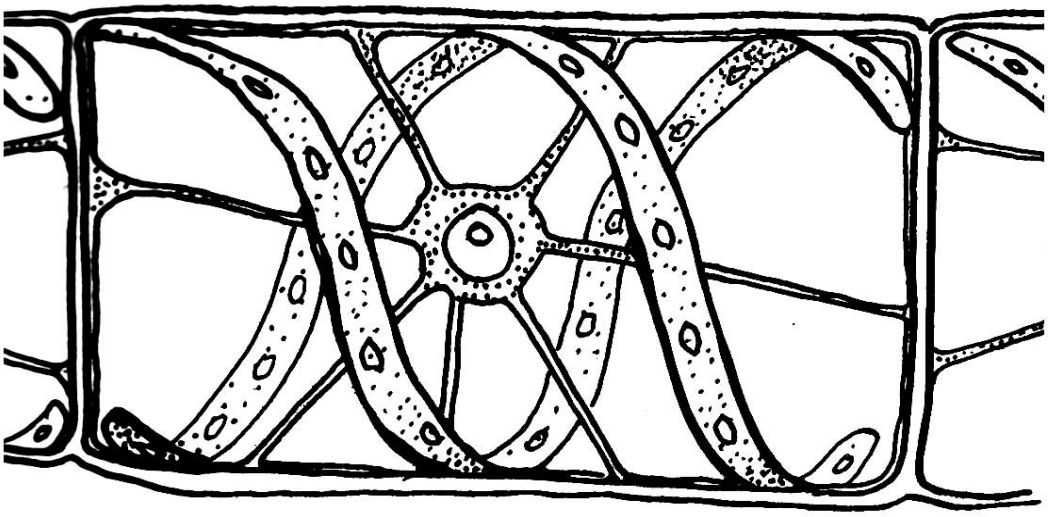
By BRIAN J. FORD

Introduction: *Spirogyra* is studied as a 'type' Chlorophyte in secondary and advanced schools in many countries. It is the main filamentous genus studied in Britain and features in the GCE 'O' and 'A' level examinations, and is studied on the continent and in many states of the U.S.A. It is drawn by many thousands of scholars each year in the course of their academic work, yet recent observations have shown that the structure of the alga is at variance with the descriptions seen in textbooks. The purpose of this paper it to describe these differences and to resolve the structural configuration of *Spirogyra*.

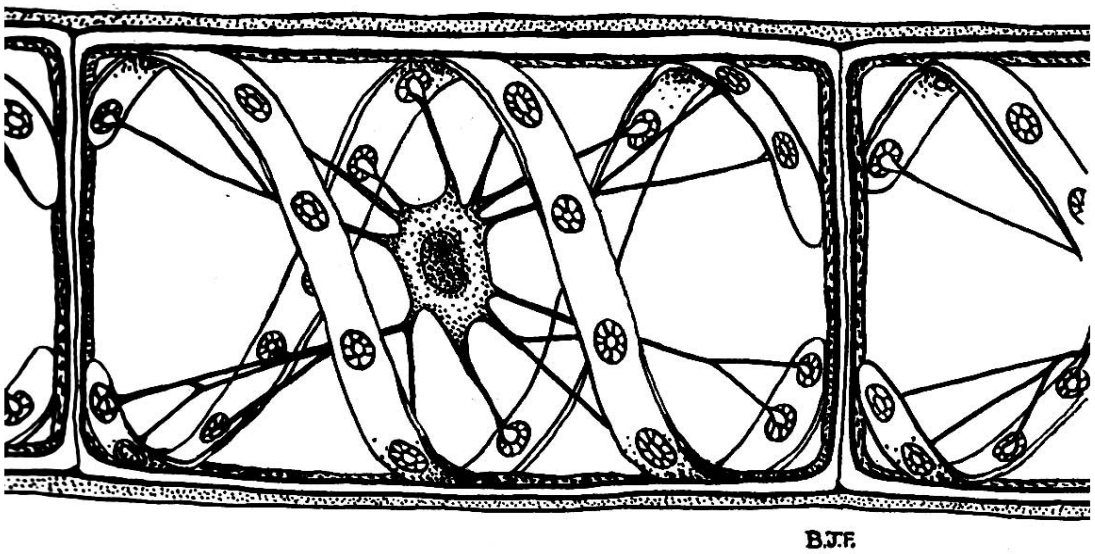
Previous Descriptions: The cytoplasmic strands which support the nucleus at the centre of the vacuolar cavity have been given the name 'bridles.' They are described in similar terms in most available textbooks, e.g. Murray (1960) states that the nucleus 'is attached by cytoplasmic threads to the peripheral cytoplasm lying against the cell-wall'; Hentschel and Cook (1960) state it is suspended by the strands'; Cook *et al* (1960) speak of 'bridles running from the lining of cytoplasm'; and Lowson (1962) accompanies a series of very inferior drawings with the mention of 'protoplasmic strands running across the vacuole to the centre.' Nelson (1962) describes the cells thus: 'From the peripheral cytoplasm delicate strands run out to the centre, where the nucleus is placed'; Priestley & Scott (1955) mention: 'strands radiating (from the nucleus) to the layer of cytopalsm which lines the wall'; Small (1937) does not appear to mention them but published an inaccurate drawing; Maclean and Ivemey-Cook (1952) describe the chloroplast as 'T-shaped in section, with threads running from the central stem of the T to the centre'; and Vines & Rees (1964) state the 'chloroplast is connected to the nucleus by strands.'

The Observations: Cells of *S. bellis*, (illustrated) *S. nitida* and several other spp. not positively identified for the purposes of this thesis, were mounted in a glycerin-phenol-lactic acid medium and examined critically under an oil-immersion lens, NA 1.30, oiled to a condenser at full aperture and studied with a X8 eyepiece at a tube-length of 180 mm. It was found that the cytoplasmic branches may divide into several secondary strands as they pass from the paranuclear cytoplasm towards the peripheral layers. They may also remain unbranched. They are seen to pass from the central region of each cell to a point directly below each pyrenoid. None were seen to reach the peripheral cytoplasm apart from in the region of a pyrenoid. In other genera of the *Zygnemetales* there

is a similar intercourse between nucleus and pyrenoid: in *Zygnema* there is a bridge of cytoplasm between the stellate chloroplasts which itself contains the nucleus and provides the contact. *Mougeotia* has a laminate chloroplast with direct cytoplasmic contact between the nucleus and the enclosed pyrenoids. It is not therefore illogical to assume similar behaviour is present in other related genera.



Spirogyra: Typical diagram of structure. From several sources.



Spirogyra: revised diagram of structure.

It is therefore correct to describe the 'cytoplasmic 'bridles' in these species of *Spirogyra* as passing 'from the nucleus and its layer of cytoplasm (the *paranuclear cytoplasm*) to the pyrenoids.' Critical examination shows that the strand itself enters the central region of the pyrenoid and appears to pass in through a number

of radiating channels. This relationship may be seen in **Plate i,** 2 & 4.

The little-used textbook White (1933) gives a more-or-less correct description, and Fischer (1922) states : ' Der Zellkern liegt meistens immitten der Spirogyra-zelle, das ihn umgebende Plasma sendt in solchen Fälen Stränge aus welche sich mit ganz besonderer Vorliche dort anheften wo ein Pyrenoid ligt . . .' It is salutary that

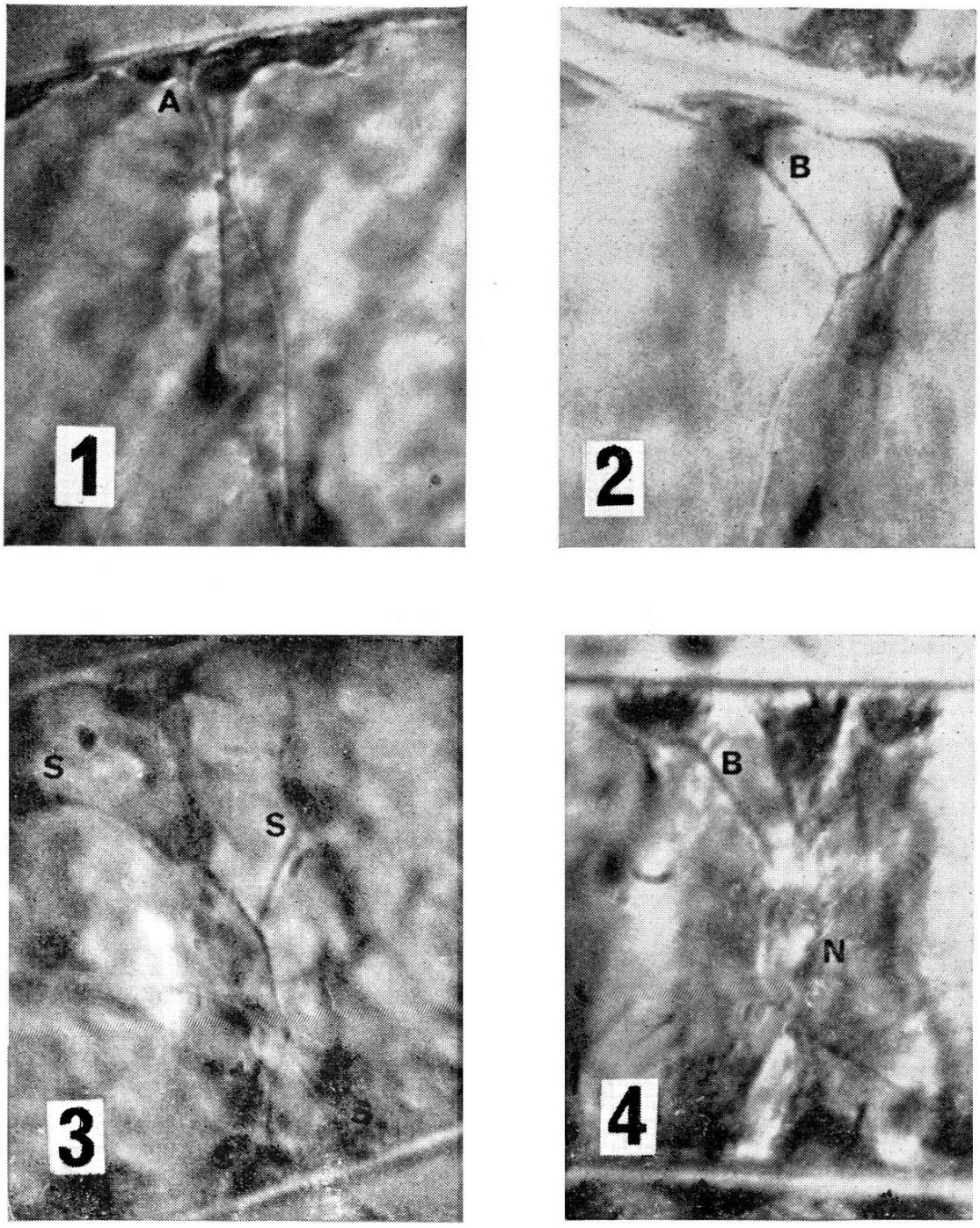


Plate i : *Spirogyra* **spp. under oil-immersion.**
(for detailed explanation see text).

these earlier, correct descriptions were superseded by factually inaccurate descriptions in the textbooks that scholars use today.

Photomicrographic Evidence : The **Plate i** shows some typical views of the *Spirogyra* cell. It is infrequent that a clear discernable ' bridle ' lies in the focal plane of the microscope throughout its entire length, though **Plate i,** 2 shows this clearly. The point of origin of the ' bridle ' in the paranuclear cytoplasm and its entry into the central medullary region of the pyrenoid is clearly visible (B). **Plate i,** 1 shows a distal bifurcation of the ' bridle ' at A. This cytoplasmic strand was initially of the appearance of reaching the cytoplasm between two closely associated young pyrenoids, but closer examination shows clearly the bifurcation and association of the two branches with individual pyrenoids that results.

Plate i, Nos. 3 & 4 were obtained by a different technique. The microscope was slowly racked down during the period of exposure in order to resolve images of bridles as they passed from the paranuclear cytoplasm to the pyrenoids. As a result the appearance of great depth of field is gained. Illustration 3 shows clearly the curling of the ' bridles ' as they cross the cell vacuole, and Illustration 4 the nucleus (N) and ' bridles ' (B) are seen in true relation to each other.

Summary : In contradiction to descriptions given in the overwhelming majority of biological textbooks, the cytoplasmic ' bridles ' of *Spirogyra* are shown to pass from the paranuclear cytoplasm to the peripheral regions of the cell at the pyrenoids, and not merely to the ' layer of peripheral cytoplasm ' or indeed to the ' region of the chloroplast.' Physiological considerations lend some anticipation of these observations, and micrographic illustrations show how a change-of-focus technique can resolve the structural configuration of the ' bridles ' throughout their length. It is hoped that this description, somewhat more significant in structural and physiological terms, may be incorporated into newer texts and so resolve a topic of some importance in the education of young biologists.