OBSERVATIONS ON THE ULTRASTRUCTURE OF CHROMOPLASTS IN *CELASTRUS SCANDENS**†

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ABSTRACT

The structure of chromoplasts in the aril of ripe fruit of *Celastrus scandens* was studied with the electron microscope. A remarkable regularity was observed in respect of shape and internal structure. Pigments were associated with large spindle-shaped bodies analogous to grana in chloroplasts and which were interconnected by striated, fibre-like filaments. It is suggested that chromoplasts may arise from proplastids directly and not necessarily by unidirectional ontogenesis from chloroplasts or leucoplasts.

INTRODUCTION

Investigations of the ultrastructural anatomy of plastid organelles have been devoted almost exclusively to chloroplasts, and only in comparatively recent years have contributions been concerned with the chromoplast (e.g. Frey-Wyssling and Kreutzer, 1958; Thomson, 1965; Kirk and Juniper, 1967.) Perhaps this may be ascribed to the relatively minor position in the hierarchy of plastid ontogeny to which the chromoplast has been relegated: a monotropic development is assumed from initials through proplastids and leucoplasts, with an irreversible ontogenesis from chloroplast to chromoplast (Frey-Wyssling and Mühlethaler, 1965.) Alternately, compared with chloroplasts, chromoplasts appear to be somewhat functionless organelles.

MATERIALS AND METHODS

Epidermal peels, stripped from the crimson aril of *Celastrus scandens* at the stage of opening of the enclosing loculicidally dehiscent orange capsules, were fixed in glutaraldehyde, 3% with respect to 0·05 M phosphate buffer, pH 6·8. The tissue was then postfixed in 2% osmium tetroxide (OsO_4)| and prepared for electron microscopy by dehydration, infiltration with and embed-

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ment in a plastic mixture, and thin-sectioning. Sections were not stained prior to viewing in the electron microscope.

Separate pigment extractions were made of the arils and the enclosing capsules according to the method described by Kirk and Juniper (1967) and their respective absorption spectra determined spectrophotometrically.

Results and Discussion

The cells of the epidermal and cortical tissues of the aril contain numerous (from a few to 20 and more), long (up to 30μ) lanceolate to acicular chromoplasts. These organelles are the most conspicuous feature of the cells (Fig. 1, C.) Figure 2, which is a low-magnification electron micrograph, shows the cells as being highly vacuolated (V) with chromoplasts (C), mitochondria and nuclei (N) in a cytoplasm (CY) parietally appressed against the cell walls. The protoplasts of adjoining cells are interconnected through prominent plasmodesmata (P). Except for their unusual length and the apparent disarray of the grana-fretwork system there is, at this magnification, little morphological distinction between chromoplasts and chloroplasts.

The probable direct ontogeny of chromoplasts in *Celastrus* from proplastids is supported by Fig. 3. A prolamellar body (PB) is identified in a differentiating proplastid—in this case a prochromoplastid since there is no evidence of chloroplasts in the tissue at this stage of fruit development. At a higher magnification (Fig. 4) the double membrane (DM) is in evidence. Numerous osmiophilic homogeneous globuli (OG), probably indicative of the advanced state of liphanerosis (Frey-Wyssling and Mühlethaler, 1965), are scattered throughout the plastid.

Yellow, carotenoid-containing structures, circular in transverse section, may be observed in the chromoplasts of ripening *Celastrus* fruits. These are here termed spindle-shaped bodies (SB), and appear equivalent to the spindle-shaped bodies and swellings on fibres in *Capsicum* described by Frey-Wyssling and Mühlethaler (1965) and Kirk and Juniper (1967), respectively.

Figure 5 shows the elongated nature of the chromoplast and, as compared with chloroplasts, the rather disorganised lamellar system. The spindle-shaped bodies (Fig. 6, in longisection; Fig. 7, in cross-section) have the appearance of dilated grana. They are interconnected by thin, striated, fibre-like filaments (F),

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Figs. 1—4: Chromoplasts in *Celastrus scandens*.

Fig. 1: Photomicrograph showing lanceolate to acicular shape of chromoplasts in subepidermal cells of aril. Mounted in glycerin.

Figs. 2—4: Electron micrographs at increasing magnifications. C, chromoplast; CY, cytoplasm; DM, double membrane; M, mitochondrion; N, nucleus; OG, osmiophilic globule; P, plasmodesmata; PB, prolamellar body; SB, spindle-shaped body; TB, tannin body; V, vacuole; W, cell wall.


C
C
C
10 μ
1
N
V
CY
V
C
TB
P
OG
1μ
2
M
C
V
PB
W
1μ
3
SB
OG
DM
W
1μ
4

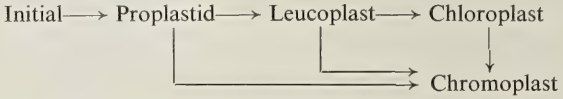
frequently forming dense filament packets (FP). The spindle-shaped bodies have diameters of up to 300 mμ as compared with 100 mμ of equivalent structures (swellings on fibres) in *Capsicum* (Kirk and Juniper, 1967). The osmiophilic globuli with diameters of up to 85 mμ, are rarely found within the spindle-shaped bodies; they appear to occur between them. The filament packets of the fibre-like filaments appear to be osmiophilic but it is doubted whether in fact they are the osmiophilic globuli. Rather, they appear to be concentrations of lamellae high in lipid content. The stroma (S) appears to have lost its granularity.

The absorption spectra of the carotenoid pigments extracted from arils and capsules in hexane are shown in Fig. 8.

The spectra are quite similar with the capsules having somewhat less carotenoids than the arils. Complete chromatographic separation and determination of the pigment components is not reported here. Absorption maxima of approximately 443 and 470, and 447 and 474 mμ for yellow and red fruits of *Capsicum* respectively, have been reported by Kirk and Juniper (1967).

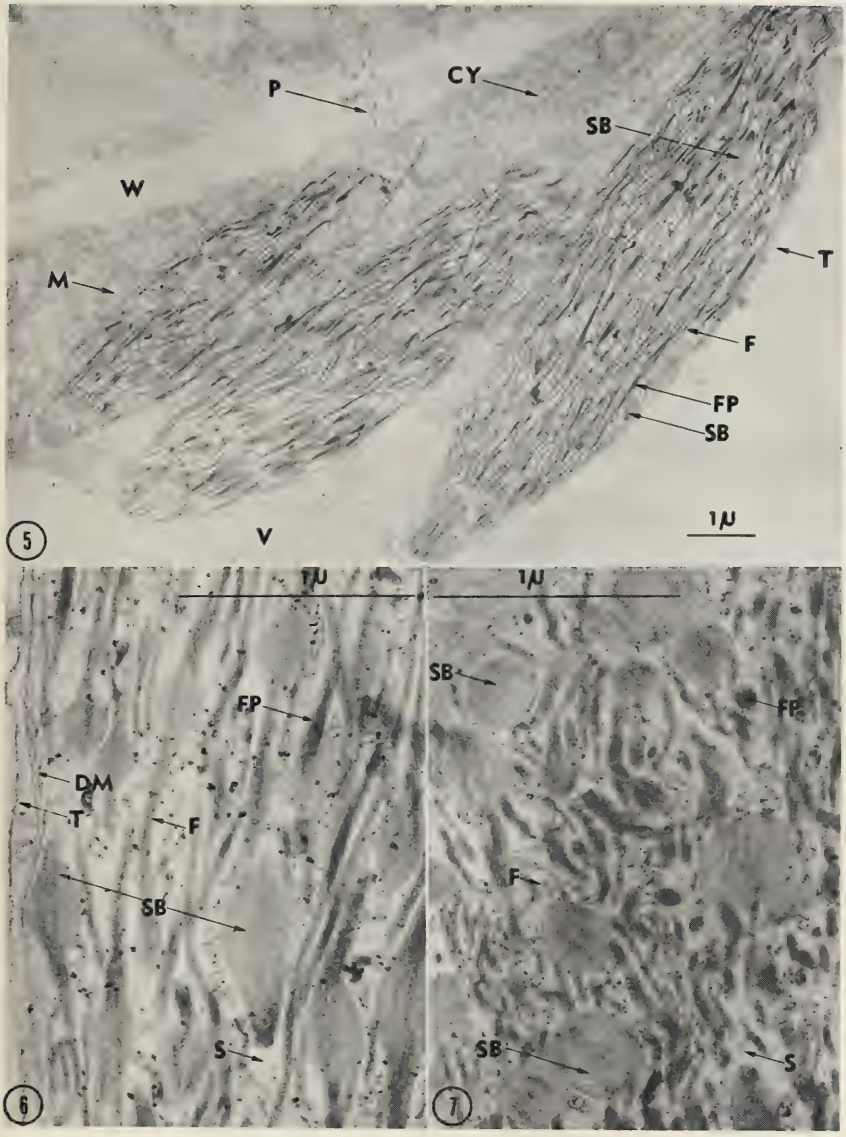
Conclusions

The results of this investigation—which is limited in that only fully ripe fruits were used—show a number of similarities and differences with those previously reported. The chromoplasts maintain a remarkable regularity in shape in contrast to those in Navel oranges (Thomson, 1965). The ontogeny of the pigment bodies, although not followed sequentially, appears to correspond to Frey-Wyssling's and Kreutzer's (1958) *Capsicum* type, that is, culminating with the development of spindle-shaped bodies. Although ontogenesis from leucoplasts and/or chloroplasts is not excluded, the chromoplasts in *Celastrus* probably also arise from proplastids directly:



In order to determine whether this is the case an ontogenetic study of chromoplasts in the developing fruit coupled with an analysis of the carotenoids is under way.

Figs. 5—7: Electron micrographs of chromoplasts.
Fig. 5: Organisation of spindle-shaped bodies and lamellar system.
Fig. 6: High magnification in longisection.
Fig. 7: High magnification in transverse section. CY, cytoplasm; DM, double membrane; F, filament; FP, filament packets; M, mitochondrion; P, plasmodesmata; S, stroma; SB, spindle-shaped body; T, tonoplast; V, vacuole; W, cell wall.


P
CY
SB
W
T
M
F
FP
SB
5
V
1μ
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T
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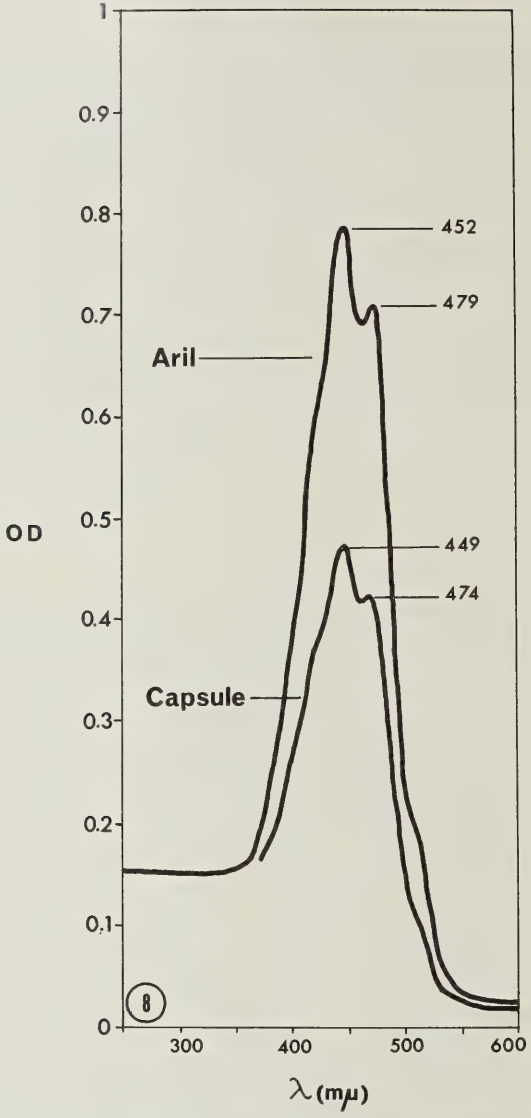

FIG. 8: Absorption spectra of *Celastrus* aril and capsule pigments.

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