DISCUSSION

Flowering has been an area of interest to the botanists because, the processes leading to it provide useful experimental systems (methods) for the study of environmental and internal controls of development and to the rest of the mankind because agriculture is based on the control of flowering. The present study, emphasizes on the study of light and temperature as the two important environmental controls or extrinsic factors and to the growth regulator-gibberellins as an essential internal control or intrinsic factor.

As reviewed earlier, flowering has been studied extensively and a large body of knowledge, about it, has been accumulated. The major emphasis, so far and always has been on the processes affecting the initiation and early development of flowers rather than on associated or subsequent events. Hillman (1964) is of the opinion that the directions of research in the physiology of flowering are hard to predict with any accuracy, and harder still to recommend with any assurance. So, the best thing may thereby be to make a sincere attempt stepwise and to correlate the results. And the field of research will undoubtedly continue to progress, as it has in the past-through critically tested geneses appropriate choice of experimental material, perseverance, and technical advances (Hillman, 1964).

Carrot is a day-neutral biennial which requires chilling (Vince-Prue, 1975). As reviewed earlier, biennials have interested
researchers because they pose a challenge to them. The challenge has been to convert biennials into annuals by modifying their environment. This can be done only by a thorough understanding of the interactions of the various environmental factors on plants.

One of the two environmental factors studied in the present work is temperature. Temperature, whether high or low, affects metabolism and hence development. Vince-Prue (1975) reports that carrot requires chilling. To understand the role of cold temperature on early metabolism of seedlings, the results so obtained can be analysed.

Decrease in the protein content during the first four weeks of vernalization treatment (Figure 6) may be due to its breakdown into amino acids. This is supported by the data for amino acids which indicates a rise during this period. Later the reverse is observed. There was a fall in the amino acid level and a gradual increase in the protein levels. Perhaps this was because of formation of new proteins. Markowski (1962), however, found no change in protein content with vernalization. But a decrease in the levels of amino acids during vernalization was reported earlier for wheat (Trone, 1966, 1969; Pauli and Mitchell, 1960; Jones and Reinberger, 1970; Srivastava and Fuden, 1972; and Reinberger, 1975) and for rye (Grozesluk and Kulka, 1963; Thomas and Zalik, 1974). Thus, the observation in the present study supports Jones and Reinberger (1970) who suggested that total and remarkable change takes place in the
content of protein and amino acids as a direct result of vernalization.

It is likely that the high protein content in vernalized seedlings during the first week might be associated with the RNA-mediated protein synthesis. Pavlov and Aukov (1964) and Chinoi et al. (1969) also reported higher protein content in vernalized seedlings than in control ones. Altschul et al. (1966) and Danielson (1956) have indicated that globulins are the predominant reserve proteins in the seeds of dicotyleonous plants. The concentration of these proteins in dry seed is very high and it gradually drops with the advancement of germination. The results obtained by electrophoretic separation of storage soluble proteins also reveal similar patterns. The bands gradually disappear.

Osborne (1907) while classifying wheat proteins based on their solubility properties, had reported that the proteins extracted by Tris-glycine buffer at pH 2.3 should be mainly globulins and albumins. As far as the molecular weight of the proteins is concerned, Beisfeld et al. (1962) have reported that if the protein can be separated on 7.5% gel its molecular weight has to be greater than 30,000. Also from theoretical considerations of protein it can be calculated that 7.5% acrylamide gel has an average pore size of 500Å.

The disappearance of the proteins during germination is in general agreement with that reported for seeds of wheat by Barber et al. (1967). The results obtained also show that the
dry seed sample was rich in proteins and of the seven distinguishable bands, the two located on the upper part of the gel were deeply stained. These dark bands were also relatively broad and may be the dominant reserve protein since the colour intensity is known to serve as an index of the concentration of the proteins. These proteins could be significant in the later responses of the plant towards flowering. But, this could not be proved because, the vernalized seedlings could not survive in the field conditions. It is likely that the lack of certain proteins made them susceptible to high temperature devernalization.

The sharp fall in the aminoacid levels may be due to their rapid utilization by seedlings to provide secondary factors (like tryptophan for auxins) which enable vernalized seedlings subsequently to grow and develop more rapidly than those which have not been vernalized as suggested by Jones and Weinberger (1970). Higher protein content inspite of increased protease activity suggests synthesis of many new proteins because of the cold treatment. These new proteins could be helping in stabilizing the metabolic processes influenced otherwise by cold treatment of the seedlings. Appearance of new proteins during the period of vernalization was also reported by Terasaka (1972).

Another temperature effect upon protein composition was observed in cell wall proteins. During vernalization barley sprouts accumulate free proline, while nonvernalized plants incorporate proline predominantly into the cytoplasm proteins and to a lesser extent into cell wall proteins (Shioda and Mori,
The accumulation of unbound proline in vernalized plants may provide the cells with an important substrate for regulating cell expansion (= extension synthesis) during the following growth period at higher temperatures (Fellenberg, G., 1978).

Cold treatment, however, did not appear to influence the qualitative status of amino acids in the seedlings. The control and vernalized seedlings appear to have the same type of amino acids although their respective amounts may be different in the two. Among the many metabolic pathways affected by cold treatment is the change concerning RNA and protein metabolism. Cold-induced changes in protein content were observed primarily in chromosomal proteins (Bate et al., 1968; Teraoka, 1967, 1968, 1973). In wheat, these changes involve the entire histone content as well as the lysine/arginine ratio of the histones. However, these changes occur only in situ, not in isolated embryos (Teraoka, 1973). Figure 10 shows the diagramatic interpretation of the results obtained by gel electrophoresis of protein (Steward et al., 1965). These results, so obtained also are in accordance with the results obtained earlier for soluble proteins. The amount was seen to decrease but later vernalized seedlings showed higher soluble protein levels. Electrophoretic separation of proteins showed extra protein bands in two weeks old vernalized seedlings. But in the fifth week control seedlings showed extra protein bands as compared to vernalized seedlings. It is likely that the absence of certain proteins result in early devernalization of carrot.
This means that the very absence of certain proteins makes the seedlings susceptible to damage from high environmental temperatures followed by vernalization since, when transferred to the sudden pots, the seedlings experienced high temperatures and thus, a stress condition was created. The absence of a protective substance did make the seedlings succumb to such a sudden change and thus, causing devernalization.

The accumulation of reducing sugars (Fig. 11) observed due to vernalization treatment is in agreement with earlier workers (Chinoy et al., 1969; Kuzhilin, 1963; Stenaric and Weinberger, 1971; and Trione, 1960). The sugars accumulated at low temperature will form metabolites of vernalization (Chailakhyan, 1966). Increase in the invertase activity during vernalization is in accordance with the reports of Iden and Ferren (1971), Chinoy et al. (1969) and Roberttt (1975). Cold treatment resulted in a significant hydrolysis of sucrose to reducing sugars which may be a source of energy as the vernalized seedlings would require (Rutherford, 1977, 1981). The results obtained are in agreement with those observed by Pherser (1983).

Phenols, the loss studied of all substances, influence growth by lowering growth stimulating activities of IAA, GA and cytokinins. They do this by causing a depression in the biosynthesis of L-tryptophan which is a precursor for IAA (Kefeli and Kutacek, 1977). High levels of phenols was correlated with less growth by Kefeli et al. (1969) and Kefeli and Kutacek (1977). This implies that as a plant grows its phenol content
should decrease. And that was observed to be true in carrot seedlings. Phenols like p-coumaric acid were reported to serve as cofactors for IAA-oxidase which enhances the enzyme activity and hence causes inhibition of growth (Gortner et al., 1978). On the other hand, o-diphenols serve as inhibitors of IAA oxidases and thus enhance growth (Husford et al., 1961; Hitch and Hitch, 1962). However, the qualitative changes of phenols may only give a picture of their regulatory role in the vernalization process. Hesker (1983) reported a decrease in phenol content of both vernalized and control seedlings as the seedling growth progressed with time. Higher levels of phenols in vernalized seedlings might be responsible for the slower growth of the cold-treated seedlings.

The influence of low temperatures upon enzymes is a dual one. In some cases only enzyme activity is affected by vernalization (Kasperska-Palesz and Uliasz, 1974; Bock and Leidhardt, 1966); in other cases enzyme synthesis must be affected, because the number of isoenzymes was changed (Ito and Khan, 1976). In other cases, it is still unknown whether cold treatment altered enzyme activity or enzyme synthesis (Hycskowki, 1970; Ishikawa et al., 1976).

Peroxidases are widely distributed in plant tissues and are of immense physiological interest because of their association with numerous catalytic functions (Melik and Singh, 1960). Despite the fact that large number of workers have attempted to characterise plant peroxidase activity, its precise function
still remains obscure. Among the most important functions proposed, is the ability to oxidise indole-3-acetic acid (Siegel and Calston, 1975; Stonier et al., 1979). Other function in which role of this enzyme has been implicated include ethylene biosynthesis (Napson and Hardale, 1972), hydroxylation of proline (Ridge and Osborn, 1970), lignification (Fielding and Hall, 1975), wound healing (Kawashima and Uritani, 1963) and disease-resistance (Johnson and Cunningham, 1972).

Increase in peroxidase activity during vernalization period supports Chiloe et al. (1969). In wheat, Young et al. (1981) observed two new peroxidases which were not seen in control seedlings, but one of them had disappeared at the end of vernalization treatment. Peroxidase activity of vernalized seedlings was higher than the control seedlings and was maximum during the sixth week of cold treatment.

The higher catalase activity is in agreement with Pavlov and Aukova (1964). Higher activity of these oxidising enzymes keeps the rate of respiration high (Altman et al., 1966) catalase directly affects the oxidation and reduction of cytochrome C oxidase system in mitochondrial respiration (Yokoyama, 1956).

Low temperatures also controls the activity of some glycolytic enzymes. Because glycolysis is more strongly suppressed by low temperatures than are other sugar metabolizing pathways, considerable amounts of hexose phosphates accumulate during vernalization (Pollock and Rees, 1975; Rees et al., 1977). On
the other hand, high temperatures (23°C) specifically stimulate glycolysis (especially the enzymes phosphofructokinase, aldolase, glycerinaldehydophosphate dehydrogenase) (Kees et al., 1977). Physiological consequences of temperature controlled glycolysis are not entirely understood, except for the fact that, accumulated sugars increase the osmotic value of the cytoplasm and decrease the possibility of cold injuries.

The second environmental factor taken into account in the present study is light. Every plant has its own photoperiodic requirement essential for it, to produce flowers. Experiments with Carrot showed, that its critical daylength would be 11 hours since the plant flowered even when subjected to an average of 11 hours of photoperiod. Hamer (1983) has reported a critical day length of 6 hours required by TD plant, Brassica juncea to flower. Sawhney et al. (1981) have reported 5-6 hours of photoperiodic requirement for Calendula officinalis also a long day plant. However, Carrot plants did not flower when subjected to photoperiods less than 11 hours.

In addition to regulating flowering, light influences the overall vegetative growth of the plant. This can be understood better by observing the various growth indices of plants grown in the three different photoperiods. From the experimental data obtained, RGI and KAS was found to be maximum in normal day plants while LHR was highest in short day plants. In addition photoperiodic control on stem elongation, leaf shape and size, also tuberization etc., has been observed (Kaylor, 1953). Leaf shape
and size was smaller in SB plants as compared to KD and LD plants. Stomaterization was best observed in LD plants, and stem elongation first initiated in LD plants.

An interaction of light and temperature made an interesting study. The vernalized seedlings got quickly devernalized when they were transferred to the three photoperiods. This was perhaps, because, the seedlings were too delicate to withstand the high environmental temperature. Devernalization of seedlings has been reported by Vora (1969) and Bhasker (1983) in oats and mustard, respectively. And the plants received the natural cold period because of the winter season, but cv. Early Nantes plants did not flower in any of the photoperiods inspite of the natural chilling of the shoot apices.

The hormonal concept of growth and development in plants has been in use since long. Evidences obtained till date, pointed out the numerous difficulties experienced in exact location, extraction, purification, isolation, crystallization, identification and synthesis of hormonal substances. The florigen concept by Chailakyan in 1936 is still a working hypothesis and suffers from a number of objections which have been highlighted by Chinoy and Mansuri (1966). The bioassay method used to determine gibberellins or gibberellin-like substances is based on such biological tests, as are given by various growth regulators (Letham, 1967; Steward and Shantz, 1959; Saxena et al., 1969). The situation gets further complicated because of increasing number of gibberellins from plants (Brian, 1966).
Similarly, the other component of the so-called florigen - 'anthestrin' is still claimed by Chailakhyon himself (1968) as a hypothetical one. Still another serious objection, may be raised against the florigen concept, that, the vernalization phenomenon, is not taken into consideration. Thus, it appears, that relying too much on the florigen concept, is not likely, to lead to any solution, as far as, physiology is concerned. In fact, this is further supported by Chailakhyon (1961, 1968) himself, when he recognizes the fact, "that in flowering induction processes, the plant should be regarded as an entity, possessing stable structural and physiological basis, for complete coordination and interaction of its organs". This is further supported, by Street (1966) who advocates that, growth, development and reproductive activities are the outcome of highly complex and organized chemical changes; visible patterns of development, arising out of invisible patterns of metabolic activities.

It is claimed by a number of workers that gibberellin induces flowering in cold requiring plants under long day conditions. One of the most potent gibberellins in stimulating elongation growth seems to be gibberellic acid (GA₃) according to Hertz and Lutz (1975). The significance of gibberellin action for elongation growth is further confirmed by experiments with growth retardants, interacting with gibberellins (Knipl, 1977; Sniir and Kessler, 1975).

Further, like IAA, GA₃ promotes an acidification process in
Evans stem segments (pH 6.5 → pH 5.15), which becomes measurable immediately after the beginning of GA$_3$-induced elongation (Berbarel et al., 1976). Also, GA$_3$ increases the plasticity (not the elasticity) of the cell walls. The appearance of higher plasticity coincides well with the onset of GA$_3$-induced elongation and with stimulations of cell wall synthesis (Adams et al., 1975; Stuart and Jones, 1977).

Another early GA$_3$ effect is a change of distribution of inorganic ions within the cells. Without a lag phase, the Cl$^-$ content of cytoplasm and plastids increases, while the K$^+$ level rises immediately only within the cytoplasm; in the plastids, however, it increases 2 hours later (Leusmann and Janossy, 1977). In this way, GA$_3$ causes a rapid increase in the osmotic pressure of the cytoplasm.

A further GA$_3$ effect is to change cell wall composition by influencing polysaccharide metabolism (Kawamura et al., 1976). Thus, cell walls with low pectic acid and pectic uronic acid content are formed, while substances inhibiting GA$_3$-induced cell elongation (Ca$^{2+}$, kinetin, ethylene) mediate cell wall formation with much pectic acid and pectic uronic acid (Moell, 1975).

The change in cell wall composition is obviously related to alterations in RNA and protein synthesis, because GA$_3$-induced cell elongation can be inhibited by antibiotics that suppress RNA and protein synthesis. On the other hand, successive growth is accompanied by an incorporation of labeled amino acids into proteins (Samhney et al., 1977) and of labeled RNA precursors
Into B.A as well as by a stimulation of the formation of polysomes (Basilewsky and Klaczkowski, 1976).

Gibberellin acid also has several diverse points of primary action during cell elongation: (Pelle Berg, 1978),

1. \( \text{GA}_3 \) influences nuclear DNA (directly or after binding to cytoplasmic proteins), so that DNA and protein synthesis is stimulated.

2. \( \text{GA}_3 \) acts upon cell membranes and changes the ion distribution and increases osmotic pressure of the cytoplasm, as explained above.

3. \( \text{GA}_3 \) induces cell wall loosening by \( \text{H}^+ \) excretion of the cytoplasm. This effect is either due to an unknown \( \text{GA}_3 \) action or (more probable) it is mediated by \( \text{GA}_3 \) dependent increase in the IAA content of the cell. The increase in IAA content can be either due to activation of tryptophan catabolism versus IAA formation (Kuraishi and Fair, 1964) or to inhibition of IAA oxidase activity (Pilet, 1957).

Gibberellins are known to influence growth and development with special reference to flowering. Many biennials could be converted into annuals by \( \text{GA}_3 \) treatment. In the present study, too, \( \text{GA}_3 \) proves to be most effective in \( 10^{-3} \text{M} \) concentrations for flowering. Late sowing of carrot seeds with a foliar spray of \( 10^{-3} \text{M} \) \( \text{GA}_3 \) under long days could initiate flowering within 80 days in cv. Early Nantes and normal early sowing of carrot seeds with a foliar spray of \( 10^{-3} \text{M} \) \( \text{GA}_3 \) under long days and normal days
could initiate flowering within 90 days in cv. Early Mantes. Thus, GA$_3$ and light period together influence flowering. In fact, Wittwer and Bukovac (1953) and Wittwer et al. (1959) showed that the photoperiod was an important factor controlling the plant's response to GA$_3$. Perhaps, that's the reason why SD plants did not flower in spite of the same GA$_3$ treatment. It is presumed that some factor(s) produced under proper photoperiods is necessary for the GA$_3$ action, or complementary in nature.

However, earliness in flowering by applied GA$_3$ in the present study confirms the earlier findings of Chakravarti (1958) who used this hormone as a substitute for vernalization. Friedländer (1967) and Bernard-Hibsaut (1975) also found induction of flowering by GA under noninductive conditions.

Working with Bryophyllum, Leevaert (1969) found that application of GA$_3$ to a leaf of a debudded plant resulted in the production of floral stimulus in leaf. He concluded that the role of GA$_3$ in Bryophyllum is directly on the production of floral stimulus rather than on the growth of the stem, replacing for the longday requirements. In spinach, an absolute longday plant, stem elongation and flowering were observed under shortday by application of GA$_3$ and GA$_7$ (Gleland and Leevaert, 1971). Since 100% flowering did not occur by applied GA$_3$ and GA$_7$, they concluded that gibberellins act primarily on stem elongation, whereas the flowering process is largely, if not entirely, independent of GA control. But, Jacob (1978) has
pointed out that this is not a strong evidence for the lack of floral effectiveness of endogenous gibberellins.

In clover, another long day plant, applied GA$_3$ had induced flowering but high levels of endogenous ABA interferes with the activity of GA in its effort on flowering (Cohen and Dovrat, 1976). They, like in the present study, observed that GA induced flowering is proportional to its concentration.

Application of GA$_3$ to plants under short day condition induced flowering while application of CCC prevented them from flowering (Baldev and Lang, 1965). GA$_3$ induced flowering was seen only in case of cv. Pusa Kesar while cv. Early Rantes plants remained in a vegetative state in short days. There are reports of translocation of applied $^{14}$C-GA$_3$ from leaf to shoot apex (Cottrell, 1969; Matzer and Zeevaart, 1965) where it is reported to enhance the metabolic and mitotic activity of the inactive central zone (Chailakhyan, 1968; Jacquard, 1968; Sachs et al., 1958). A decrease of GA levels in leaves and their concomitant increase in the shoot apex is reported by Hasker (1983). This could be attributed to the translocation of GA from leaf to shoot apex where it may enhance various processes that result into floral bud initiation. In fact, translocation and metabolism of GA in leaves and shoots may be more important than the endogenous concentration for floral induction as suggested by Zeevaart (1970).

Chailakhyan (1977) suggested that GA seems to have an essential role in formation and growth of stem and thereby in the
first phase of flowering. The action of GA at shoot apex is perhaps to enhance mitotic activity which causes stem elongation first and the flowering next.

The rate of absorption of synthetic hormones is greatly influenced by a number of factors. It is observed that when older, more mature organs such as leaves, or stems are treated, the plants do not respond as readily to these substances when the chemicals are applied to young vigorously growing parts. This was also observed in the present study. \( \text{GA}_3 \) could cause flowering only if it was administered during the early growth days of the plants. When \( \text{GA}_3 \) was given to three month old plants, it could only cause slight elongation of the internodes but could not cause any flowering. Moreover, adjuvants such as Tween 80, carbowax which act as solvents and also as spreading agents can be used so that they hold the growth substances in a finely divided state and in close contact with the surface of the plant (Ennis and Boyd, 1946; Hitchcock and Zimmer, 1948; and Mitchell and Faamer, 1944). In the present study, tween 80, was used successfully.

\( \text{GA} \) has tremendous effect on the metabolism of any plant. This has been well reported by Hayashi (1961). There is an increase in dry weight of plants because of \( \text{GA} \) treatment according to Hayashi. And this was also found to be true in the present study. This, according to him, could be because of an increased photosynthetic activity or in the efficiency of utilizing photosynthetic products. In fact, the photosynthetic
activity of whole tomato plants was increased by about 18% by the GA treatment. In rice plants Hayashi (1961) reported an appreciable increase in height especially of the leaf sheaths. CO₂ fixation was increased by about 10% by the GA treatment. Tolbert and Saber (1957), however, found no increase in radioactive CO₂ fixation per unit fresh weight of leaves by GA treatment. Hayashi reported a decrease in the dry weight of root in rice plants, while the total leaf area increased with GA treatment.

Initially, the sugar content (in rice plants) in roots was very low. Later the content of reducing sugars is higher in treated plants than in control. In the root, the content of both reducing and total sugars was decreased as a result of GA treatment (Hayashi, 1961). The results obtained in the present study are thus, in agreement with the above reports. The sugar content in carrot root also decreases especially during the GA treatment.

Referring to carbohydrates produced, the dry weight in the top increases, while in the root it decreases by GA treatment (Hayashi, 1961). Brian et al. (1954) had recognized the growth inhibition of roots when GA was added to the culture solution. He considers this to be due to the direct action on roots of GA in a high concentration. Hayashi (1961) also reported that GA increases the rate of respiration per plant but the increase is small.
Vlitos and Neudt (1957) demonstrated using etiolated pea cuttings, that some factor(s), regarded as existing in the shoot apex, is involved in GA action. While Brian and Hemming (1955) and Galston and Harburg (1959) postulated that a third factor is required for GA to be effective.

Shoot apex has been the focus of all attention in almost all the research experiments done so far on flowering. The morphological changes preceding flower initiation like precocious axillary bud growth, change in branching pattern, internode elongation change in leaf form on bract formation, change in phyllotaxis to more complex systems, and enlargement of the apical dome, are common, but not inevitable, concomitants of flowering in most plants, whether or not they need a stimulus to flower. In the present study, we observe internode elongation, change in leaf form and enlargement of the apical dome as some of the morphological changes preceding flower initiation.

According to Lyndon and Francis (1984), rapid internode extension is often a characteristic of the prefloral phase but some plants like daisies (Bellis perennis) and dandelions (Taraxacum officinale) remain as rosettes on flowering. In most plants the size of the apical dome increases just before flower initiation, usually in diameter (Evans, 1960).

Further, the cytohistological zonate pattern is usually lost on flowering (Cougaredé, 1967). The distinction between the central and peripheral zones of the apical meristem tends to disappear as RNA and ribosome density increases throughout the axis (Cougaredé and Ironechart, 1965; Lin and
Gifford, 1976). In carrot, however, the central zone and the peripheral zones did appear as distinct entities. This seems important especially in carrot because the peripheral zones initiate the production of buds while the central zone remains as such for some time.

Changes in the size and numbers of starch grains in the apical meristems are also characteristic of the transition to flowering (Bernier, 1971) and presumably indicate changes in carbohydrate metabolism perhaps associated with increased growth and cell division. Other cytological changes are an increase in nucleolar volume, which may be linked to the synthesis of RNA and an increase in dictyosome number, which is probably linked to changes in carbohydrate metabolism and the increased synthesis of cell-wall material associated with increased rates of cell division and growth (Ravelange, 1980). The results obtained are hence in accordance to the observations of Bernier (1971) as the insoluble polysaccharides localised during the transition showed an increase in the peripheral zone as compared to the central zone and more in bud primordia than in the peripheral zone. This, as written earlier, explains increased growth and cell division in the bud primordia as compared to the peripheral zone and least in the central zone.

The total nucleic acid content of the cells in bud primordia and peripheral zone was comparable and more than that observed in the cells in the central zone. However, RNA content was maximum in the bud and then in peripheral zone and least
in central zone. It can, therefore, be assumed that with increased BivA content, there is an increase in the overall growth and protein content of the cells. A universal observation is that the concentration of BivA increases in prefloral apices and is most marked in the outer layers of the apex corresponding to the meristematic mantle which develops in the reproductive apex (Hougarède, 1967) and in target tissues where floral primordia will develop. It is less marked in the pith and the pith rib meristems (Miller, 1976). This was also observed in carrot.

The bulk of this new BivA is undoubtedly rRNA, as shown by the increase in density of ribosomes in the peripheral regions of the apex on evocation (Hougarède, 1967) and by the amplification of rRNA cistrons (Jacqard et al., 1981). Protein concentration also shows a sustained increase in parallel with BivA (Jacqard et al., 1972; Miller, 1976). In the present study too, protein concentration was higher in the peripheral zone like the BivA content as compared to that in the central zone.

On flowering the rate of initiation of primordia increases markedly, as exemplified by Chrysanthemum (Schwabe, 1959), Tritium (Kiry, 1974) and Silene (Lyndon, 1979a). This is despite a reduction in relative growth rate at this time which has also been shown for Chrysanthemum (Jeffcoat and Cockshull, 1972), Tritium (Williams, 1966) and Silene (Lyndon, 1979a).

Probably then, one of the changes that occurs at flower initiation is, in whatever controls, the size of the primordia
at initiation, relative to the apical dome, substances which consistently affect the positioning of primordia at a node and the fusion of primordia, are auxins and auxin antagonists (Soma, 1968; Schwebe, 1971; Heukenheimer, 1981). Gibberellic acid may speed up the rate of primordium initiation and alter phyllotaxis (Bernier et al., 1981) and it may do so by altering primordial or apical size since it resulted in a reduction in the plastochron ratio in Xanthium which mimicked the reduction occurring on floral induction.