ment of Entomology, University of Massachusetts, Amherst, Mass., U.S.A., during the conduct of the above studies, are very much appreciated.

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## STAGE OF DEOXYRIBONUCLEIC ACID SYNTHESIS DURING MITOSIS AND MEIOSIS

IT is now well established that of all the chemical constituents of the nucleus so far analysed, the deoxyribonucleic acid (DNA) content is quantitatively the most predictable and consistent. The constancy of its content in nuclei of various plant and animal tissues has its parallel in the constancy of the chromosome number of these cells, and the genetic significance of DNA is hence evident.[1] Data from microspectrophotometric and autoradiographic studies in normal and irradiated plant and animal cells indicate that DNA synthesis and chromosome doubling are synchronous events thereby strengthening the view that an intimate relation exists between chromosome duplication and synthesis of DNA. While the importance of DNA as genetic material is no longer in doubt, there is still some controversy regarding the exact stage and time when DNA duplication takes place during cell division in somatic and gametic cells. Thus, Pasteels and Lison[2] found that DNA synthesis occurs during anaphase and early telophase of mitosis while Alfert and Swift[3] found it to occur during interphase. Similarly, while Swift[4] observed that in microsporocytes of *Tradescantia* DNA synthesis takes place during leptotene, Sparrow *et al.*[5] reported from studies in *Trillium* that DNA content increases till late pachytene or diplotene. On the other hand, in studies in *Lilium* involving the detection of $P^{32}$ incorporation into the DNA fraction of chromosomes by the autoradiographic method, Taylor and McMaster[6] found that DNA synthesis occurs during preleptotene, i.e., that part of pre-meiotic interphase which immediately precedes leptotene.

Improvements in cytophotometric techniques such as the use of the two wavelength method introduced by Patau[7] and Ornstein[8] have rendered accurate estimations of DNA content of individual nuclei possible. Using a microspectrophotometer constructed on the two wavelength principle,[9] we studied the DNA content of individual cells during various stages of mitosis and meiosis in *Secale cereale* ($2n = 14$). The results of this study are summarised in Tables I and II (DNA content is expressed in arbitrary units).

From Table I, it will be seen that the DNA value at the resting stage during mitosis was $4{\cdot}75 \pm 0{\cdot}055$. This amount can be referred to as the 2c content corresponding to the $2n$ number of chromosomes. The DNA content increased during interphase and values ranging from 2c to 4c were observed, thus suggesting that DNA synthesis was in progress during this stage. At metaphase, anaphase and telophase, the DNA content remained at the 4c level. The data hence lend further support to the findings recorded earlier by Seshachar,[10] Patau and Swift,[11] Pelc and Howard[12] and many others that during mitosis DNA synthesis is initiated and completed during interphase.

TABLE I

*DNA content at various stages of cell division in the root tips of* Secale cereale

| Stage | No. of measurements | Range | Mean DNA content ± S.E. |
|---|---|---|---|
| Resting .. | 17 | 4·09–5·13 | 4·75±0·055 |
| Interphase .. | 24 | 4·68–9·98 | 8·22±0·369 |
| Prophase .. | 19 | 8·78–10·23 | 9·65±0·086 |
| Metaphase .. | 16 | 8·65–10·35 | 9·56±0·108 |
| Anaphase .. | 10 | 8·99–10·20 | 9·56±0·123 |
| Telophase .. | 10 | 9·16–10·12 | 9·67±0·107 |

The meiotic observations can be grouped into 4 classes (Table II). First, the lowest value

TABLE II

*Relative DNA content during microsporogenesis in* Secale cereale

| Stage | No. of measurements | Range | Mean DNA content ± S.E. |
|---|---|---|---|
| Pre-meiotic .. | 10 | 3·95–4·93 | 4·72±0·053 |
| Leptotene .. | 19 | 7·65–10·13 | 9·23±0·168 |
| Zygotene .. | 10 | 9·23–9·97 | 9·47±0·083 |
| Pachytene .. | 10 | 9·36–9·99 | 9·60±0·080 |
| Diplotene .. | 10 | 9·13–10·07 | 9·47±0·090 |
| Diakinesis .. | 10 | 9·34–10·13 | 9·57±0·099 |
| Microspore .. | 15 | 2·28–3·13 | 2·50±0·060 |

corresponding to 1c content occurred in the microspores. Secondly, the nuclei of cells at pre-meiotic interphase had a DNA content equivalent to the 2c content. Thirdly, the greatest variability in DNA content ranging from 3c to 4c content was observed during leptotene. Fourthly, the DNA value remained constant at the 4c level during zygotene, pachytene, diplotene and diakinesis. From the data, it seems likely that DNA synthesis takes place during leptotene. However, we did not observe typical 2c amounts of DNA in the cells at leptotene studied by us. We had chosen clear leptotene cells for the study and since these had a minimum of 3c DNA content, it is likely that DNA synthesis had started at a stage slightly earlier to leptotene. The finding of Taylor and McMaster[6] that DNA synthesis is initiated during pre-leptotene hence appears to be correct. However, the process of DNA duplication is not completed during pre-leptotene as concluded by these authors but continues during leptotene and ends only before the onset of zygotene. Thus, our data support in part the findings of both Swift[4] and Taylor and McMaster.[6] Mitra[13] has recently presented data showing that in cells of *Lilium longiflorum* irradiated at the pre-meiotic stages prior to pre-leptotene only chromosome type of aberrations were obtained. They persisted in cells treated up to early leptotene but disappeared before the beginning of zygotene. Chromatid breaks, on the other hand, appeared abruptly about mid-pre-leptotene and persisted until diakinesis. From this and our data it seems reasonable to conclude that during meiosis, DNA synthesis (and consequently chromosome duplication) is initiated during pre-leptotene and completed during leptotene.

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## IRON-COPPER ANTAGONISM AND GROWTH OF *PIRICULARIA ORYZAE*

THE essentiality of heavy metals, iron, zinc, manganese and to a certain extent copper, for the growth of *Piricularia oryzæ* Cav. has been reported.[1] During the course of further investigations,[2] a close scrutiny of the deficiency yields of the fungus revealed antagonism, additive effects and interaction among these ions (Table I). The most noticeable toxic effect was that of Cu and to a lesser extent that of Zn on growth and was apparent only in the absence of other essential elements, but if Fe and Mn were also present the toxic effect of Cu and Zn tended to be counteracted. These effects were, however, noticed in heavy metal deficient media where growth was too little to permit definite conclusions. This ionic toxicity of Cu and the interaction of other heavy metals in counteracting the same were, therefore, studied with induced toxicity in an otherwise complete medium by supplying 110 µg. of Cu (per flask of 20 ml. medium) and the Cu toxicity counteracted with the same amounts of Fe, Zn and Mn singly and in all possible combinations when the elements other than those under consideration were always present in optimal doses. It must be emphasized here that these three elements were not toxic to gowth at 110 µg./flask.[2] The various treatments and the results obtained are recorded in Table II.

TABLE I

| | Treatments | Mat weight in mg. |
|---|---|---|
| 1 | −all (Purified medium) .. | 11 |
| 2 | +Cu .. | 1 |
| 3 | +Zn .. | 7 |
| 4 | +Zn Cu .. | 0 |
| 5 | +Fe Cu .. | 6 |
| 6 | +all (Fe Zn Cu Mn) .. | 153 |

Table II shows that '+Cu' (110 µg.) was toxic even in the presence of other elements in optimal amounts though slight growth took