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DURATION OF MEIOSIS IN RELATION TO TEMPERATURE

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1. INTRODUCTION

Knowledge of the time taken by meiosis is rather fragmentary and is sometimes given without specifying the temperature. The following examples of published data on the duration of meiosis illustrate this : *Lilium longiflorum* and *Gasteria*, 4 days (Marquardt, 1937 ; Straub, 1937) ; *Vicia faba*, 3 to 4 days (Marquardt, 1951) ; *Antirrhinum majus*, from the last premeiotic mitosis to tetrad, 30 to 34 hours (Ernst, 1938) ; *Tradescantia reflexa*, at room temperature, 18 to 23° C., 2 days (Sax and Edmonds, 1953) ; *T. paludosa*, at an unspecified room temperature, 52 hours (Steinitz, 1944) ; *Œnothera* at 10° C., 12 days, but from leptotene to metaphase I, only 6 days (Linnert, 1951). No attempt seems to have been made to determine the times taken by meiosis in the same organism over a wide range of temperatures. On the other hand, in mitosis Barber (1939) studied the rate of chromosome movement at anaphase in staminal hairs of *Tradescantia* at various temperatures, and much fuller data on plant and animal material have been provided by Hughes (1952). Brown (1951) determined the duration of various stages of cell division in root tips of *Pisum* at the temperatures of 15, 20, 25 and 30° C.

In the present paper an account is given of an attempt to determine the rate of complete meiosis (not the various stages) in pollen mother-cells of the Bluebell, *Endymion nonscriptus* (L.) Garcke at different temperatures, and to compare this with the rate of mitosis.

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2. EXPERIMENTAL PROCEDURE

The material came from Madingley Wood, Cambridge, during the winter of 1955-56. In *Endymion nonscriptus* the outermost anther, with respect to the floral axis, is commonly the most advanced in development but is generally closely followed in clockwise sequence (seen from above) by the other two outer anthers and the three inner ones in the same fashion (fig. 1). The differences between the age of the three outer anthers were small and were regarded for the present study as negligible. But there was a much more significant difference between the age of the youngest of the outer anthers and the oldest of the inner anthers. The latter were not used in the experiments.

After removing the upper half of the scales of a bulb to expose the inflorescence, the outermost anther in the lowest flower-bud was removed and its meiotic stage determined in an aceto-carmine smear. If this anther showed an early stage of meiosis, then the inflorescence (with the stem and roots of the bulb still attached to it) was labelled and placed on a pad of wet cotton-wool in a petri-dish and covered with a similar pad in the lid. Bulbs prepared in this way were kept in constant-temperature chambers at −5° C., −3° C., 0° C. and at intervals of 5° to 35° C. Others were kept at room temperature (15-21° C.). The plants were regularly watered through the cotton-wool, using water stored at the appropriate temperatures. At intervals the other two outer anthers in the bud were removed, examined as above, and the meiotic stage reached recorded.

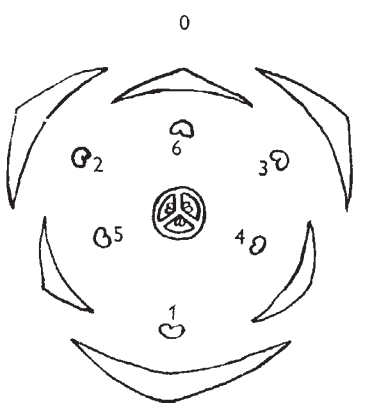

FIG. 1.—Floral diagram showing the usual (clockwise) order of progression of meiosis within the anthers of a flower-bud in the Bluebell. (Oldest and outermost anther is numbered 1; youngest and innermost anther, 6.)

3. EXPERIMENTAL RESULTS

No results were obtained at −5, −3 and +35° C., since at these temperatures the plants died before full meiosis was completed. The results for the remaining temperatures are set out in table 1. It is evident that the time taken from leptotene to metaphase I is about half the time taken for the whole of meiosis.

The duration of meiosis (Leptotene to Tetrad) at the various temperatures is as follows :

Temperature ° C.	0°	5°	10°	15°	20°	25°	30°
Time in Days (24 hrs.)	36·00	15·00	7·00	3·50	2·00	1·25	0·83

At room temperature (15-21° C.) meiosis took 2·75 days.

TABLE 1

Determinations of time taken by meiosis at different temperatures

Plant no.	Original stage	Time in days	Final stage	Plant no.	Original stage	Time in days	Final stage
0° C.				5° C.			
1	Lept.	7	Pach.	1	Lept.	10	Diak.
2	Lept.	10	Pach.	2	Lept.	10	Met. I
3	Met. I	21	Tetrad	3	Lept.	11	Diak.
4	Lept.	20	Met. I	4	Lept.	12	Anaph. I
5	Lept.	24	Anaph. I	5	Lept.	6	Pach.
6	Lept.	20	Met. I	6	Dipl.	9	Tetrad
7	Lept.	22	Met.+ Anaph. I	7	Lept.	16	Tetrad
8	Lept.	36	Tetrad	8	Lept.	14	Tetrad
9	Lept.	36	Tetrad				
10° C.				15° C.			
1	Lept.	5	Anaph. I	1	Lept.	1·5	Met. I
2	Lept.	4	Met. I	2	Lept.	2	Tet. I
3	Lept.	6	Met. II	3	Met. I	2	Met. II
4	Diak.	5	Anaph. II	4	Lept.	1·5	Diak.
5	Lept.	3·5	Met. I	5	Met. I	2	Anaph. II
6	Lept.	7·0	Tetrad	6	Lept.	3·5	Tetrad
7	Lept.	7·0	Tetrad	7	Lept.	3·5	Tetrad
20° C.				25° C.			
1	Lept.	2	Met. II	1	Lept.	24	Tet. I
2	Lept.	3	Tetrad	2	Lept.	26	Anaph. II
3	Lept.	1	Met. I	3	Anaph. I	10	Tetrad
4	Diak.	1·5	Anaph. II	4	Lept.	20	Anaph. I
5	Diak.	1·5	Tet. I	5	Lept.	15	Met. I
6	Lept.	2·00	Tetrad	6	Lept.	30	Tetrad
7	Lept.	2·00	Tetrad	7	Lept.	30	Tetrad
30° C.				Room 15-21° C.			
1	Lept.	36	(Destroyed)	1	Lept.	2	Anaph. I
2	Lept.	24	(Destroyed)	2	Dipl.	2	Tet. I
3	Lept.	20	Tetrad	3	Pach.	1	Met. I
4	Lept.	6	Dipl.	4	Diak.	2	Anaph. II
5	Lept.	12	Anaph. I	5	Dipl.	2	Anaph. II
6	Lept.	20	Tetrad	6	Dipl.	1·75	Met. II
7	Lept.	20	Tetrad	7	Met.	1·75	Anaph. II
				8	Lept.	2·75	Tetrad
				9	Lept.	2·75	Tetrad

4. DISCUSSION

The data obtained on the duration of meiosis in *Endymion nonscriptus* at various temperatures agree broadly with the published results given above. Similar studies with other material would be interesting for comparison.

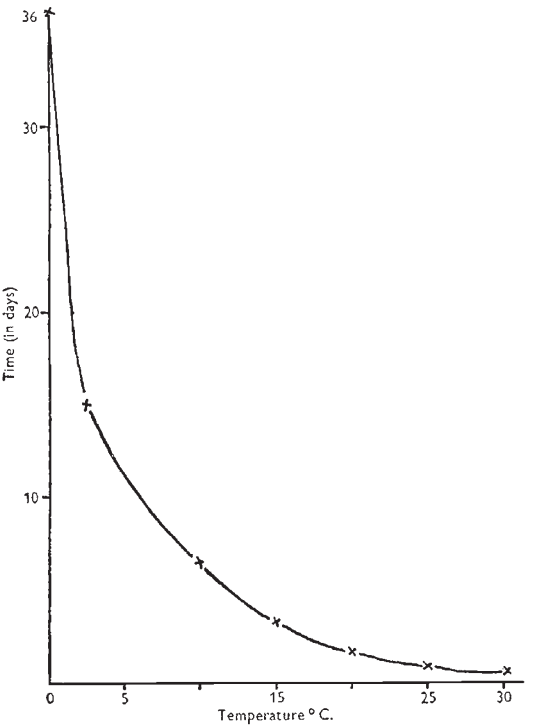

FIG. 2.—Graph showing the effect of temperature in accelerating the time taken by meiosis in the Bluebell.

A great acceleration in the rate of meiosis with increasing temperature is evident (fig. 2). Q_{10} values measured at 5° intervals (see Barber (1939) for method of calculation) are given below :

Temperatures ° C.	Q_5	log	X2	Q_{10}
0-5°	2·4000	0·3802	0·7604	5·759
5-10°	2·1428	0·3308	0·6616	4·588
10-15°	2·0000	0·3010	0·6020	3·999
15-20°	1·7500	0·2430	0·4860	3·062
20-25°	1·6000	0·2041	0·4082	2·560
25-30°	1·5060	0·1761	0·3522	2·250

These results are comparable to those for respiration in plant tissues, where Q_{10} values of 2·0 to 2·5 are usual within the range of 10° C. to 30° C., and with higher values at temperatures below 10° C. (Meyer and Anderson, 1952). Brown (1951) found that the mean duration of mitosis in *Pisum* at various temperatures was as follows : 15° C., 2·95 hours ;

20°, 1·83 hours ; 25°, 1·38 hours ; and 30° C., 1·09 hours. Thus, meiosis in *Endymion* anthers takes about 20 times as long as mitosis in *Pisum* at the same temperature. The Q_{10} values for the rate of mitosis from Brown's data, calculated in the same way as above, are : 15-20°, 2·598 ; 20-25°, 1·758 ; and 25-30°, 1·606. It is thus clear that, while in both meiosis and mitosis Q_{10} values fall with increasing temperature, the values are relatively lower in mitosis.

5. SUMMARY

1. The duration of meiosis in the pollen mother-cells of the Bluebell, *Endymion nonscriptus* (L.) Garcke, has been estimated for various temperatures ranging from 0° C. to 30° C.

2. Meiosis showed a rapid shortening of duration with increasing temperature, but the Q_{10} values fall as the temperature rises.

3. Meiosis in the Bluebell lasted about 20 times as long as mitosis in *Pisum* at the same temperature (data of Brown (1951)).

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