Botany. — *"The Influence of Light on the Cell-increase in the Roots of Allium Cepa"*. By H. W. BERINSOHN. (Communicated by Prof F. A. F. C. WENT).

(Communicated in the meeting of October 25, 1919).

MRS. DROOGLEEVER FORTUYN—VAN LEYDEN [1]) has found that the cells of young cats increase periodically in such a way, that during the night, the number of karyokineses reaches its maximum, and in the later morning hours and the early afternoon a minimum number is reached. KARSTEN [2]) stated likewise that a periodical karyokinesis takes place in the young buds of Zeamais, which reaches its maximum also during the night. However in the roots of Vicia Faba he did not find any periodicity and so he concludes: "Das Wurzelwachstum entbehrt der Periodizitat." During these experiments the plants remained in the dark. Now he tried to influence the periodicity by exposing the young plants to the light of an electric lamp, in which he succeeded. On the other hand he did not trace the influence of light and dark on the cell-increase in the roots. As the root growth is evidently not a periodical one, the influence of light and dark will be most obvious here.

I chose Allium Cepa to experiment upon, because the Alliumcells are easily fixed and stained; because one finds a great number of karyokineses in the roottops and because there are a great many roots, so that it is possible to examine parts of one and the same individual under different circumstances.

At 8 a. m., 11 a. m. and 3 p. m. I took a few roottips away from a germinating onion, which was exposed to full daylight. After that I put the same onion in the dark and left it alone until the next day, then I took a few tips off at 6 a. m., at 12 a. m. and at 6.30 p. m., while the onion remained in the dark. During these two days the temperature differed $^1/_2{}^\circ$ C. (registered with a maximum and a minimum thermometer).

I always took care to take roottips shorter than 25 mm. and of about the same length. The roottips were fixed in sublimate

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[1]) Mrs. DROOGLEEVER FORTUYN—VAN LEYDEN. Proceedings Konink. Akad. Amst. Vol. 19. 1916, p. 38.

[2]) KARSTEN. Zeitschr. f. Botanik 1915, p. 1.

sodium chloride, after passing the different alcohols, they were enclosed in paraffin and then they were cut into series of 10μ and the sections were stained according to HEIDENHAIN's ironhaematoxylin method. I counted the number of nuclei of some of these sections over a length of 1 mm. from the roottop and I fixed the number of mitoses. I took care to count only in the central sections. Table I and II give my results.

TABLE I (in daylight).

Time	Total number of nuclei.	Total number of mitoses.	Spirema and loose chrom.	Monaster.	Diaster.	Two nuclei.
8 a.m.	4000	—	—	—	—	—
11 a.m.	4345	139	53	53	17	16
3 p.m.	2290	47	26	14	5	2

TABLE II (in the dark).

Time.	Total number of nuclei.	Total number of mitoses.	Spirema and loose chrom.	Monaster.	Diaster.	Two nuclei.
6 a.m.	4702	210	125	66	19	0
12 a.m.	4204	180	147	21	20	4
6.30 p.m.	4043	124	65	29	10	20

In order to compare these figures, I expressed them in percentages in the following tables. KARSTEN takes the average of his countings. In my opinion it is more exact to express these facts in percentages, just as Mrs. DROOGLEVER FORTUYN-VAN LEYDEN does, for it is most improbable that KARSTEN always examined the same number of cells.

TABLE III (in daylight).

Time.	Total number of nuclei.	Total number of mitoses.	Spirema and loose chrom.	Monaster.	Diaster.	Two nuclei.
8 a.m.	4000	0.00 %	0.00 %	0.00 %	0.00 %	0.00 %
11 a.m.	4345	3.19 „	1.01 „	1.01 „	0.38 „	0.37 „
3 p m	2290	2.05 „	1.13 „	0.61 „	0.21 „	0.08 „

TABLE IV (in the dark).

Time.	Total number of nuclei.	Total number of mitoses.	Spirema and loose chrom.	Monaster.	Diaster.	Two nuclei.
6 a.m.	4702	4.46 %	3.19 %	1.4 %	0.4 %	0.00 %
12 a.m.	4204	4.28 „	3.49 „	0.49 „	0.48 „	0.09 „
6.30 p.m.	4043	3.06 „	1.60 „	0.71 „	0.24 „	0.49 „

As is evident, the number of karyokineses reaches its maximum between 8 a. m. and 11 a. m. (solar time), which agrees with the well-known fact that good cell-divisions in Hyacinth and Allium are found between 10 a. m. and 11 a. m. From 11 a. m. the number of cell-divisions decreases to 2.05 % at 3 p. m.

I found the greatest number of karyokineses with the onion in the dark at 6 a. m., 4.46 %. At 12 a. m. this had slightly decreased to 4.28%, and at 6.30 p.m. the decrease was still greater. At 6 a.m. and at 12 a. m. the maximum number of karyokineses in the dark exceeded the maximum number of cell-divisions found in the daylight, while the maximum number of karyokineses in the light surpassed the minimum number of cell-divisions in the dark only by a slight degree; so that the conclusion seems justified: The number of karyokineses in the rootcells of Allium Cepa increases in the dark, which is stated by KARSTEN[1]) for Spirogyra and other plants.

When we compare in the tables III and IV the number of spirema, loose chromosome stages with the number of monaster stages, then we see in the first table from 11 till 3 o'clock an increase of the number of spirema and loose chromosome stages and a decrease of the monaster stages. This would point to an increase in the number of cell-divisions and nevertheless the total number of mitoses has diminished. We see the same phenomenon on table IV from 6 a. m. to 12 a. m.

By considering spirema, loose chromosomes and monaster as one stage (prophase) the number of nuclei in prophase, in table III at 11 a. m. is 2.02 % and at 3 p. m. 1.74 %, which points to a decrease. The same can be applied to table IV. At 6 a. m. 4.59 % and at 12 a. m. 3.98 % and at 6.30 p. m. 2.31 % is in prophase, so there is a total decrease. In my opinion this fact is a confirmation of the general conception to consider spirema, loose chromosomes and monaster as one stage.[2])

[1]) KARSTEN. Zeitschr. f. Botanik 1918.

[2]) PEKELHARING. Weefselleer, p. 67.

From similar facts, as are contained in table III and IV, it seems also possible to me, to conclude something about the rapidity from prophase to anaphase and from anaphase to telophase. Let us consider table III for that purpose. At 11 a. m. 2.02 % were in prophase and 0.38 % in anaphase. The number of karyokinesis figures in prophase has decreased with 13.8 % at 3 p. m. and the number of cell-divisions in anaphase has decreased with 44.7 %, so the decrease is intenser, that is to say, the transition from anaphase to telophase is quicker than the transition from prophase to anaphase. The same holds good for the onion in the dark during the whole day, but during the day an inversion takes place in such a way that from 6 a. m. to 12 a. m. the transition from prophase to anaphase is quicker than from anaphase to telophase.

Of course these facts are too scanty to draw such far-going conclusions, but the aim of this calculation was only to show that it is possible to learn the relative rapidity. If one wants to undertake such experiments it is necessary in the first place to fix the time of observation much shorter, i.e. one hour or one hour and a half. It is also possible to derive the duration of one cell-division from such tables. When we consider table I we do not find karyokineses at 8 a. m., and at 11 a. m. we find 16 nuclei in telophase. So the cell-division would take about 3—4 hours with Allium Cepa. JOLLY found with Triton the duration of the kariokynesis $2^1/_2$ hours in the erythrocytes at a temperature of 20° C.

From the table of MRS. DROOGLEEVER FORTUYN—VAN LEYDEN I think I may conclude the duration of a cell-division being 12 hours with a cat, because at 2 p. m. $\pm$ 0.23 % nuclei were in prophase and no telophases were stated. Only at 2 a. m. 0.20 % nuclei were seen in telophase for the first time.

When we summarize the results, we see that the roottips of the onion show more cell-divisions in the dark than in the light. Evidently light has a retaining influence. Besides it is probable that the transition process from prophase to anaphase is a slower one than the transition process from prophase to telophase.

By lack of time I could not control these facts any further. To attain this, it would be necessary to make an investigation into the daily oscillations in the number of karyokineses with the onion, if possible the time of observation ought to be as long as possible (3 to 4 days). At the same time the above-mentioned experiment ought to be repeated. One onion suffices for these two experiments. The bulb is cut into two halves and one half is used for the first series of experiments and the other half voor the second experiment.

The two series of experiments are made with parts of one and the same individual. Neither MRS. DROOGLEEVER FORTUYN—VAN LEYDEN, nor MR. KARSTEN have done this, so the results lose reliability.

Notwithstanding the incompleteness of my investigation, I thought the facts I found, of sufficient importance to be examined further, and for this reason I published this communication. At the same time I make use of the opportunity of thanking MR. M. W. WOERDEMAN as well for the incitement to this research, as for the kind assistance lent to me.

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