postulate is concerned with world-wide experiences. Walker has also deduced some of the results obtained by Robertson by using the postulate of spherical symmetry. Robertson has particularly stressed the necessity of superposing a law of gravitation on the kinematical system. On the other hand, Milne has proceeded to explain all gravitational situations as essentially kinematical situations. He has argued that it is not right to derive the material content of a non-static universe, as it is done in relativity, by using gravitational equations which account for both the local causes and the distant causes.

One upshot of all these researches is that if Milne is right, a theory of gravitation must be, in the last analysis, divested of conceptional terms and that if there is anything like a law of gravitation it must be tautological with some fundamental uniformity postulate of an observer's measurements in his own neighbourhood; and, if Poincaré is right, a uniformity postulate of this nature should not restrict the geometry of space-time.

Note (added in proof).—The attention of the reader may be drawn to the recent paper by Milne and Whitrand in *Z. für Astrop.*, **15**, 5, 342 where other important references will also be found.

Irregular Meiosis and Abnormal Pollen-Tube Growth Induced by Acenaphthene.

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CHEMICAL agents like chloral-hydrate, chloroform, ether, alcohol, nicotine sulphate, lactic acid, etc., have been used for inducing irregularities in the mitotic and meiotic processes,[1,2,3,4] which might lead to formation of heteroploid and polyploid cells. More effective agents for this purpose are colchicine[5,6,7] and acenaphthene.[7,8,9] These two chemical agents reduce or completely paralize the activity of the factors that condition the arrangements of the chromosomes into a regular metaphase plate (equatorially) and the formation of a regular spindle. In fact, these two phenomena are causally linked. In the previous publications I recorded some data upon the irregularities of the mitosis induced by these two agents. In the present paper I am giving some new data upon the irregularities in the meiosis and abnormalities in the pollen-tube growth induced by acenaphthene.

For studying the effect of acenaphthene upon the procedure of the meiotic processes, shoots with floral buds from *Nicotiana* species were covered with test-tubes (glass) as shown in Fig. 1. The walls of the tubes were moist and covered from inside with acenaphthene crystals, which sublimate small particles that act upon the buds. In some experiments crystals were also put on the buds directly in addition to those on the tube walls. The test-tubes were closed by cotton from downside in order to keep a

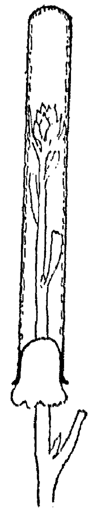

FIG. 1.

A tobacco shoot with floral buds covered with a test-tube (glass) and closed from downside with cotton. The inner sides of the tubes are covered with crystals of acenaphthene.

greater concentration of the sublimating particles around the floral buds.

By this method I treated shoots for 2, 3, 4, 5, 6 and 7 days. The parts of the stems that were under the action of acenaphthene particles in the test-tubes get visibly swollen in 6–7 days. The diameters of *Nicotiana longiflora* treated stems, for example, became about twice as thick as the lower untreated parts below the tubes, while in the controls the corresponding parts of the stems were thinner than the lower ones that corresponded to the parts below the tubes. The flowers that developed inside the tubes with acenaphthene were shorter and broader. Floral buds treated 2, 3, 4, 6 and 7 days with acenaphthene had abnormal meiosis. I have studied the meiosis in the following nine tobacco species: *N. rustica* ($n = 24$), *N. tabacum* ($n = 24$), *N. glauca* ($n = 12$), *N. paniculata* ($n = 12$), *N. Langsdorffii* ($n = 9$), *N. Sanderæ* ($n = 9$), *N. Cavanilessii* ($n = 12$), *N. longiflora* ($n = 16$) and *N. megalosiphon* ($n = 20$).

During the first metaphase I found usually the same number of bivalents that they appeared in the normal untreated branches, namely: in *N. longiflora*—10 bivalents, in *N. Langsdorffii* and *N. Sanderæ*—9 bivalents, etc. (Fig. 2), but in the treated material

FIG. 2.

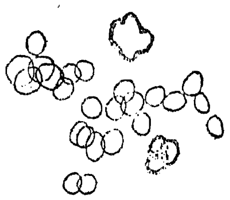

FIG. 3.

FIG. 2. Abnormal appearance of the bivalent chromosomes during the first metaphase in a PMC of *N. Langsdorffii* ($n = 9$) (regular metaphase plate, normal spindle and polar orientation of the bivalents fail) after treatment of the shoot with floral buds with acenaphthene for two days (comp. Fig. 1).

FIG. 3. Phase that corresponds to second anaphase from a *N. Langsdorffii* PMC after treatment with acenaphthene.

bivalent chromosomes were not arranged in normal metaphase plates at the equator as they were in the untreated material. Bivalent chromosomes had not a polar orientation; spindle was not formed and the bivalent chromosomes appeared disorganised during the I metaphase reminding of their appearance during the diakinesis (Fig. 2).

Absence of spindles during both divisions and failure of polar orientation of the chromosomes is the cause for the great irregularities observed in the subsequent phases. The chromosomes from the I metaphase begin to spread irregularly in the cytoplasm. They undergo interkinesis in several groups (rarely in one group) and during the "second meiosis" they get distributed in many more groups in the cytoplasm.

At the end of the phase that corresponds to the second anaphase the chromosomes were spread abnormally in the cytoplasm in groups of several chromosomes or even of single chromosomes (Figs. 3, 4). Each chromosome group or even each chromosome gets surrounded with nuclear membrane, thus at the end of the meiosis numerous nuclei (instead of four) are formed. The

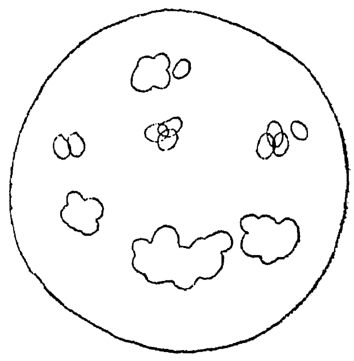

FIG. 4.

A pollen-mother cell from *Nicotiana megalosiphon* after treatment with acenaphthene. Note the irregular spreading of the chromosomes in the cytoplasm.

cytoplasm contracts around each nucleus or group of closely situated nuclei so that a variable number of microspores are formed. Each microspore has one nucleus or more than one (Fig. 5). The number of the microspores formed depends: (1) on the amount

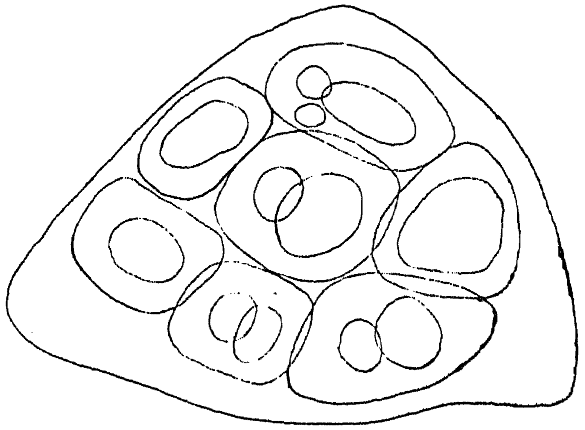

FIG. 5.

A pollen-mother cell from *N. megalosiphon* with seven (instead of four) abnormal microspores, each one having one, or more than one nucleus, formed under the influence of acenaphthene.

of the acenaphthene crystals in the tubes and (2) on the chromosome number of the species treated. When I have put a relatively small amount of crystals in the tubes, from which a smaller amount of acenaphthene particles have been sublimated, the irregularities in the meiosis were not great and the number of microspores was not very large. In pollen-mother cells (PMC) taken from floral buds that were treated with relatively small amount of acenaphthene crystals, a tendency of equatorial arrangements of the chromosomes was observed. In those taken from buds that developed into tubes with a large amount of acenaphthene crystals no such tendency was found. On the contrary, each pollen-mother cell, from buds treated with large amount of crystals, had very irregular meiosis, and during the "tetrad" stage normal tetrads were not found. The treated species *N. rustica*, *N. tabacum* and *N. megalosiphon* having larger chromosome number than the other species, formed many more microspores than the other *Nicotiana* species with smaller chromosome number.

The meiotic irregularities induced by acenaphthene lead to formation of a large number of abortive pollen (50–100%). In *N. rustica* and *N. megalosiphon* flowers, that developed from buds treated during the meiosis with large amount of acenaphthene, I found usually 100% abortive pollen. Single large viable pollen grains were rarely found. Considering this fact I applied acenaphthene for producing egg cells with abnormal chromosome numbers.

Pollinating such flowers with normal pollen, I am attempting to produce various chromosomal aberrants.

Working further upon the methods for producing chromosomal aberrants after acenaphthene treatments, I studied the reaction of the pollen-tube growth to the acenaphthene particles. Ripe stigmas from castrated *N. tabacum* flowers were pollinated with normal pollen of the same species and at the same time a few acenaphthene crystals were added to each stigma. The lower parts of these flowers were then immediately immersed in small short (ca. 2 cm.) tubes with water and transferred to a glass cylinder (6 cm. diameter and 11 cm. height), the walls of which were moist and covered with acenaphthene crystals. The glass cylinder was covered then with moist Petri-dish which also was covered from inside with acenaphthene crystals. After 18 hours, the flowers were taken out of this cylinder and the pollen germination was studied in aceto-carmine preparations. In doing this I found that the majority of the pollen germinated abnormally under the influence of acenaphthene. The swelling of the ends of the pollen-tubes was the most striking abnormality found, sometimes branching of the tubes were observed. Several abnormal pollen-tubes were drawn and are given in Fig. 6. In the same figure a normal (N) pollen-tube is drawn for comparison. The abnormalities induced by acenaphthene in the pollen-tubes might prevent further the growth which will lead to a failure of fertilisation.

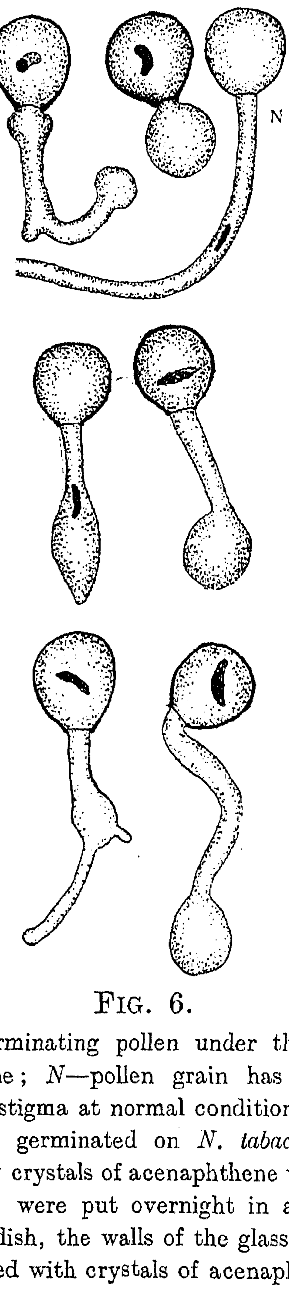

FIG. 6.

N. tabacum germinating pollen under the influence of acenaphthene; *N*—pollen grain has germinated on *N. tabacum* stigma at normal conditions while all the others have germinated on *N. tabacum* stigma on which a few crystals of acenaphthene were added and the flowers were put overnight in a glass covered with Petri-dish, the walls of the glass and Petri-dish being covered with crystals of acenaphthene.

On the basis of the observations given above in connection with those reported in the previous publications upon the reaction of plant cells to acenaphthene particles one can make the following inferences:—

1. Acenaphthene induces swelling of the plant organs but at the same time a slow development in length. This obviously results from the enlargement of the cell volumes due (*a*) to chromosome duplications, (*b*) to a simple cell expansion, and (*c*) to suppression of the cell division.

2. Acenaphthene particles act upon the dividing cells during the mitosis and meiosis in a specific way which is expressed in an absence of equatorial arrangements of the chromosomes and an absence of regular spindles.

3. The chromosomes divide but do not separate; thus duplication of chromosomes takes place. Sometimes (especially during the meiosis) the chromosomes get abnormally spread into the cytoplasm. This phenomenon leads to polynucleation and further to formation of polyads during the meiosis. Consequently acenaphthene might induce polyploidy and heteroploidy. Pollen developed from polyads are usually unviable.

4. Acenaphthene does not induce chromosome rearrangements of the type X-rays do induce, or if it does, they are so insignificant that I have not been able yet to detect them.

5. The appearance of the expected numbers of bivalent chromosomes during the meiosis suggests that acenaphthene does not prevent chromosome pairing. Special experiments are required, however, for studying the question: 'does acenaphthene reduce synapsis?'.

6. Acenaphthene interferes with the normal growth of the pollen-tubes, inducing swellings at the growing ends.

1. Némec, B., *Das Problem der Befruchtungsvorgänge, usw*, Berlin, 1910.

2. Kendall, J., "Histological and cytological studies of stems of plants injected with certain chemicals," *Inaug. Dissert.*, Sofia, 1930.

3. Kostoff, D., *Degeneration of the pure lines*, Sofia, 1930.

4. Kostoff, D., *Bull. Soc. Bot. de Bulgarie*, 1931, **4**, 87.

5. Blakeslee, A. F., and Avery, A. G., *Journ. Heredity*, 1937, **28**, 393.

6. Nebel, B. R., and Ruttle, M. L., *Genetics*, 1938, **23**, 161.

7. Kostoff, D., *Compt. Rend. Acad. Sci.*, Moscow, 1938, No. 3; *Curr. Sci.*, 1938, **6**, 549; *Nature* (in print), 1938.

8. Shmuk, A., *ibid.*, 1938, No. 3.

9. Navashin, M., *ibid.*, 1938, No. 3.

Medical and Veterinary Importance of Fleas and Ticks and the Possibilities of their Control.*

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FLEAS and ticks are external parasites of great economic importance on account of their blood-sucking habit. They transmit numerous diseases to man and domesticated animals, and are also harmful to them in other ways. They have thus a direct bearing on medicine and veterinary science, and an indirect bearing on agriculture through affecting the efficiency of work in man and his live-stock by lowering their vitality.

(A) Fleas.

Fleas affect man and domestic animals in two ways: firstly, as vectors of diseases and secondly, as blood-suckers and annoyers of man and domestic animals.

The chief interest of fleas centres round their connection with the bubonic plague due to *Bacillus pestis*, which is primarily a disease of rodents from which it is transmitted to man by fleas. This disease has played havoc with man from times immemorial and is caused largely, if not exclusively, through the agency of fleas. In India alone upwards of 7,000,000 deaths, due to this disease, have occurred between the years 1896 and 1911. The disease is transmitted by the bite of an infected flea in which the regurgitation of blood due to the obstruction of the proventriculus introduces the plague bacilli in the body of the host. The proventriculus is blocked by the rapidly multiplying plague bacilli which

* Remarks in a discussion of the Sections of Zoology, Medical Research, Veterinary Research, Entomology and Agriculture in the Silver Jubilee Session of the Indian Science Congress Association, Calcutta, 1938.