contain any organizer chromosome but themselves generate small nucleoli.

The holed globule (Fig. 1 A) also suggests that these may be assemblages of "drained off chromatin" from the chromosomal mass. This figure casts doubt on the belief that micronuclei are formed at exactly the same time when ordinary nucleus is being formed by the chromosomes that have completed anaphase-movement. Micronucleus formation in squashes from magnetic field and X-ray exposed roots was comparatively rare.

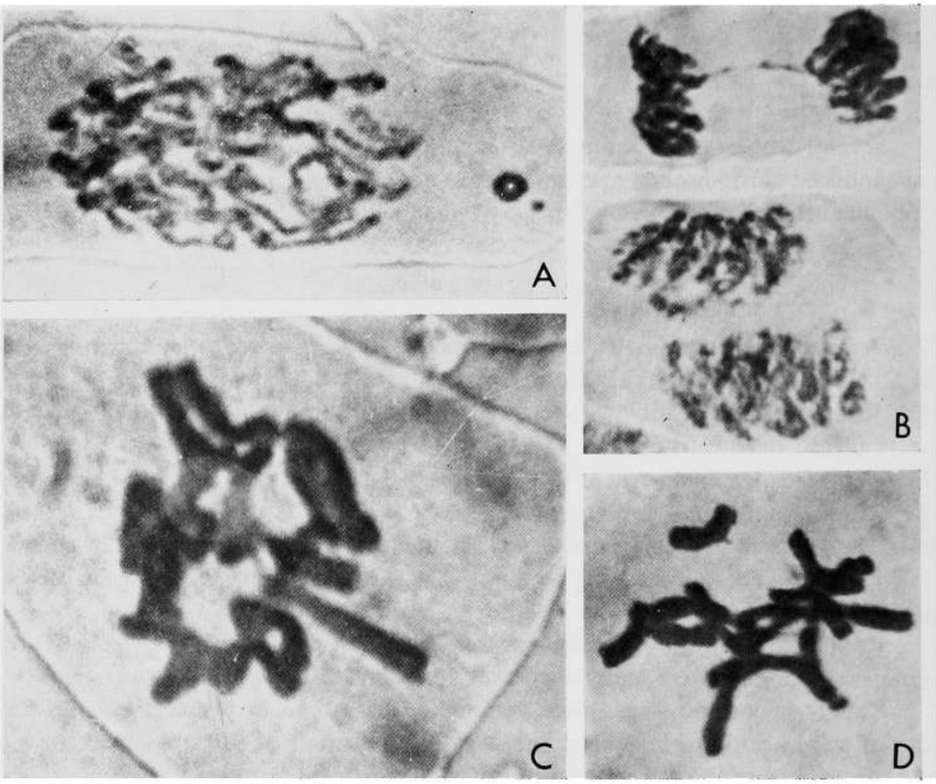

Fig. 1. A, late prophase indicating the mode of formation of micronuclei and micronucleolus. B, mis oriented telophase and chromosome bridge. C, pseudo Renne complex. D, somatic translocation. All figs, X Ray 15 mnts; ×1500.

iii) *Stickiness*: This, so much known change on chromosome surface is considered by Darlington (Grundmann 1966) due to heterochromatinization of a chromosome resulting in denaturation of nucleic acid; the chromosome contour hence becomes adhesive.

This is more pronounced by X-rays and numerous configurations have been observed e.g. chromosome bridge at anaphase, tripolar, sticky anaphase and tendency of polar movement of chromosomes at late prophase (Fig. 1 **B**); pseudo-Renner complex (Fig. 1 C, referable to the attachment of chromosomes in order to form a ring) and somatic translocations (Fig. 1 D). Last two features were never observed in either urea or magnetic field treatment.

iv) *Chromosome breaks*: Figure 2 points out that magnetic field exposed roots exhibit a higher frequency of chromosome breaks.

Few breaks are very fine dots of varying sizes (Fig. 3 B) appearing like chromatin droplets; others, were pieces of chromosomes revealing 4 uncoiled chromonemata. Breaks due to X-rays do not show any such detailed structure, may be that the mode of action of magnetic field differs with X-rays. Exposure to magnetic field has additionally, given a "puffy" appearance to chromosomes (Fig. 3 A)

Other aberrations like fragmentation of the nucleus, C-metaphases, lagging chromosomes and chromosome bridges were also observed.

v) *Mitotic index*: The mitotic index is depressed due to the action of external agents (Table 2). However, the recovery of stages and their ratio due to sucrose is most remarkable (Tables 1 and 2) in order to interpret it, data on analysis of variance from Table 2 has been analysed with the graphic representation of three dimensional figures (Fig. 4) erected by a new formula

$$MI = (V+Mr)^2+R$$

where V = Variance
Mr = Metaphase/Anaphase ratio
and R = recovery due to restitution.

Thus for urea, magnetic field and X-rays the MI values are calculated.

The MI value 71.66, among controls is taken as "expected" value and each time compared with the calculated MI values of urea, X-rays and magnetic field. X^2 and probability thus obtained (Urea, $X^2=18.42$, .001; X-ray, $X^2=3.96$, .50; magnetic field, $X^2=0.85$, .10) indicate that urea affects the mitotic index more significantly than other two studied treatments.

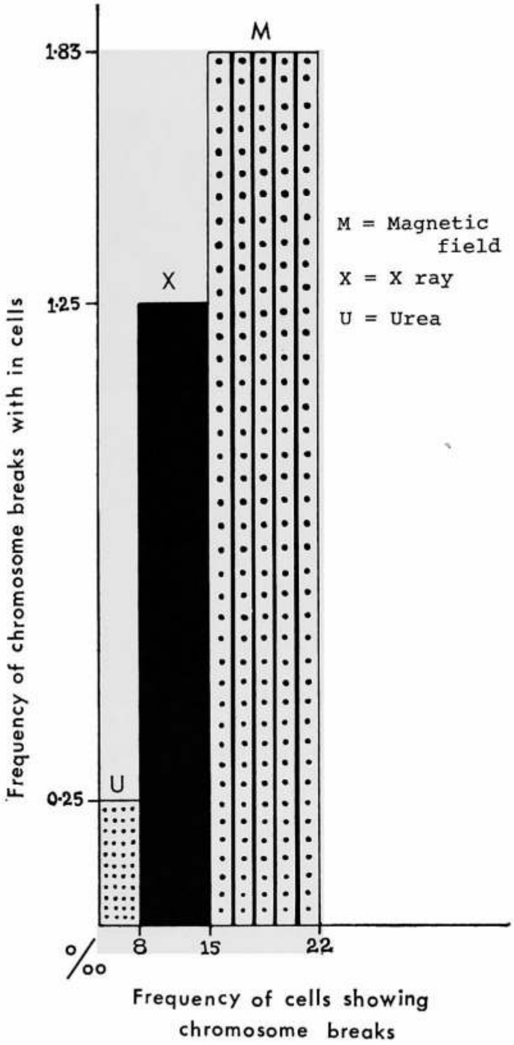

Fig. 2. Graph indicating the relationship between frequencies of cells exhibiting breaks and average number of breaks in a cell. On both criteria magnetic field surpases urea and X-rays treatment.

Discussion

In a population of cells that is dividing repeatedly at random, the ratio of mitotic time (prophase to telophase) is inferred from the mitotic index but it is already known, that mitotic index is affected by external agents. Mitotic index is the percentage of cells found in mitosis at any given instant. The fundamental relationship (DuPraw 1969) is given by the equation

$$\frac{MT}{MT+IT}\times\log_e 2=\log_e \quad (1+MI)$$

where MT is the mitotic time, (MT+IT) is the generation time and MI is the mitotic index.

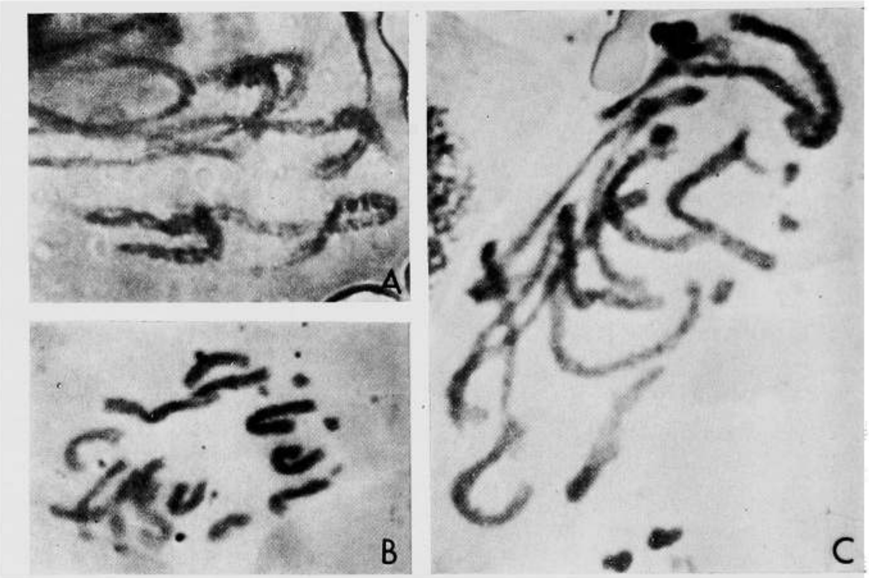

Fig. 3. A, part of a cell showing puffy structure of chromosomes. B, chromosome breaks due to magnetic field; note too small chromatin droplets. C, typically coiled chromonemata providing a gap in a coil seen after magnetic field exposure. All figures ×2000.

We have adopted a direct approach of counting, mitotic stages at a particular time under all conditions being studied (including controls) and estimated their ratios. Assuming that Metaphase/Anaphase ratio (Table 1) should depict the active time; the limit of recovery (restitution) should be directly proportional to the "shock" received due to any treatment and variance should form "base" for the cell population under study. Fig. 4 is thus in a position to immediately express the effect of treatment under identical conditions and recovery in sucrose.

Another important feature concerns the light microscopic proof to the coiled chromonemata in chromosomes of classical cytologists. Typically coiled 4-chromonemata providing a gap (Fig. 3 C) in a coil were seen in all preparations. Urea-sucrose preparations even revealed "gyres" in chromosomes.

Table 1. M/A ratio under different experimental conditions designated as mitotic ratio

Treatment	M/A	Mitotic ratio	Remark
Urea treatment control	44/16	2.750	Control
1% urea	15/17	0.882	
Urea-water	19/11	1.727	
Urea-sucrose control	37/23	1.608	
Urea-sucrose	41/13	3.153	Urea-sucrose
X-ray control for 10, 15 mnts. and also for magnetic field	37/21	1.761	
X-ray 10 mnts	41/23	1.782	
X-ray 15 mnts	56/24	2.333	
X-ray-sucrose control	24/23	1.043	
X-ray 15 sucrose	25/07	3.571	X-ray sucrose
Magnetic field.	39/24	1.200	
Magnetic field sucrose	31/08	3.875	Magnetic field sucrose

Table 2. Distribution of frequency, standard deviation variance and standard error in mitotic stages under different experimental conditions of pea roots

No. of cells	Mitotic figures	Frequency	S.D.	Variance	Standard error
1720	111	0.064	2.385	5.69	0.74
1381	89	0.064	1.979	3.92	0.62
1095	47	0.042	3.226	10.41	1.20
1194	134	0.112	2.991	8.95	0.94
1272	124	0.097	2.601	6.77	0.82
2146	221	0.103	2.780	7.72	0.85
1964	138	0.070	2.941	8.65	0.93
2152	183	0.082	3.934	15.48	1.24
1060	104	0.098	2.289	5.24	0.72
1075	120	0.111	2.624	6.89	0.88
1278	145	0.113	3.250	10.56	1.02
1224	139	0.105	2.908	8.46	0.91

Fig. 5. Sucrose treatment after magnetic field exposure, note the restituted morphology of all chromosomes and presence of two extra chromosomes and a break. ×2200.