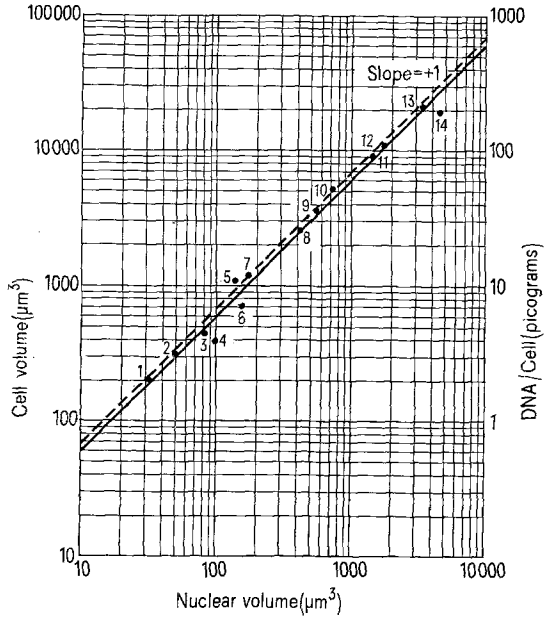
Regression analysis indicates that log cell volume is linearly related to log nuclear volume and the slope of the line (+ 0.990) is not significantly different from +1.0 ($p = 0.78$) (Figure). The data of BAETCKE et al.[20] relating nuclear volume to DNA content fit a parallel regression line (Figure).

Nuclear and cell volumes were determined for 4 additional species, a gymnosperm, a subshrubby angiosperm and two pteridophytes. The same NV/CV correlation was observed, extending the data into a fourth order of magnitude for both parameters. This would suggest that the observed relationship probably holds for plant groups other than the herbaceous angiosperms.

Factors other than DNA content such as age of the meristem, location of the meristem on the plant, degree of hydration, time of year, physiological activity of the tissue, and nutritional state of the plant are known to influence chromosome size and nuclear volume[20,22-27]. The cytonuclear ratio varies among tissues of the same plant[28-30], may change during cell elongation and differentiation[28-30], and is influenced by physiological, genetic and environmental factors[31]. Hence the simple relationship shown above for the two size parameters and DNA content may not always hold for differentiated cells.

A linear relationship also exists in diploid plants between nuclear volume and mitotic cycle time[32], between DNA content per cell and mitotic cycle time[32-34] and between DNA content and the duration of meiosis[35]. BENNET[36] reported a relationship between DNA content and minimum generation time in herbaceous angiosperms. Studies of nuclear parameters and cell size in relation to growth form and ecological adaptations appear to be a promising approach to a better understanding of the evolutionary significance of the wide variation in DNA content per cell among higher plants.



Relationship between nuclear volume and cell volume in apical meristems of 14 herbaceous angiosperms. Numbered points correspond to data in the Table. Dashed line represents correlation between nuclear volume and DNA content per cell as reported by BAETCKE et al.[20].

Résumé. Les volumes cellulaires et nucléaires de 14 espèces herbacées d'angiosperme ont été mesurés dans les méristèmes apicaux. Pour un accroissement de 100 fois, le volume cellulaire est directement proportionnel au volume nucléaire et, sur une échelle doublement logarithmique, donne une régression linéaire de pente équivalente à +1.

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Enhancement of Ethylemethane Sulfonate-Induced Mutation Frequency in *Drosophila* by Dimethyl Sulphoxide

Dimethyl sulphoxide (DMSO) is a dipolar, aprotic substance[1], possessing a high dielectric constant[2] (3.9), which makes this reagent an excellent solvent for most of the inorganic and organic compounds[3]. JACOB et al.[4,5] reported a high penetrability of DMSO through biological membranes. Other investigators also demonstrated that in biological systems DMSO is a very good carrier for drugs[6-8], electrolytes as well as non-electrolytes[9], polar and polarizable molecules[10]. Its role has been suggested to be to enhance the penetrability for dyes[11], bacteriocides[12], nutrients[13] and also to transform activity of polyoma virus[14]. It has been shown to be a useful carrier for chemical mutagens[15,16] and colchincine[17] in plants. ALEXANDER[18] did not observe any induction of mutations in *Drosophila* by DMSO alone.

The present investigations were undertaken to study the combined treatment of DMSO and ethylemethane sulphonate (EMS) on mutation rate in *Drosophila melanogaster*. Male flies of Oregon K strains were given intra-abdominal injection of 1% DMSO, 0.15% EMS in 0.7 *N* saline solution and 0.15% EMS solution made in 1% solution of DMSO. Flies injected with 0.7 *N* saline solution

served as control. After 24 h following the injection, each male was crossed with 3 virgin Muller-5 females. Only the eggs laid within the first 3 days after mating were used for determining the rate of sex-linked recessive lethals. All experiments were carried out at constant temperature of 25 ± 1 °C.

The frequency of sex-linked recessive lethals is shown in the Table. These data show that even though DMSO alone is not capable of inducing mutations, it increased the mutation induction up to 46.3% over the rate induced by EMS alone.

It is interesting that DMSO provides protection against radiation in plants[19] and animals[20]. It is also an efficient cryoprotective substance[21]. The possible causes for these properties have been indicated as hypoxia[22], osmotic shock[23] and removal of water sheath[24] from biopolymers. However, specifically planned experiments have not confirmed a direct relationship between radioprotection by DMSO and oxygen tension[25-27] or hypothermia[28]. Moreover, if the radioprotective and cryoprotective effects were due to action on molecules of genetic significance, DMSO would decrease and not increase the effectiveness of a chemical mutagen. Therefore the enhancement of EMS-mutagenecity would require some other explanations.

It is significant, in this respect, that EMS is not easily mixable in water and even after thorough shaking it makes a suspension of fine particles. It seems reasonable to expect that solubility of EMS is increased in a solution of DMSO. Secondly, even after intra-abdominal inoculation of the mutagenic solution, the chemical has to pass through the biological barriers of testis-wall and cell-walls of mature spermatozoa. These barriers may be made more permeable by the direct action of DMSO on the cellular membranes. Another property of DMSO is to inhibit the activity of several enzymes like trypsin[29, 30], cholinesterase[31] urease and chymotrypsin[32], phosphomonoesterase, β-galactosidase, peroxidase, catalase, dehydrogenase[33], and increases the activity of destructive enzymes like deoxyribunoclease[34]. DMSO also activates lysosomes[35] and leads to the release of acid phosphatses[36]. These changes are caused due to conformational changes induced in the protein molecules. The structural changes in enzyme molecules lead to altered interaction between substrate and active site of the enzyme[37] and similar changes in structural proteins increase the permeability of cellular membranes[38]. Similar action is shown to alter the secondary structure of DNA and RNA[39] by denaturation[40]. EMS is known to induce mutations through alkylation. KORNBLUM et al.[41] have demonstrated that alkylation at oxygen atom is increased in the presence of DMSO.

All the above findings make it possible to propose that DMSO can facilitate mutation induction by chemicals in many ways: increased solubility, penetration, denaturation of DNA, inhibiting repairative enzymes, releasing degradative enzymes, improving efficiency of alkylation process. All the above-mentioned effects of DMSO are almost completely reversible. But in the present experiment DMSO and EMS were applied together, and perhaps the increased mutation induction was brought about under the direct influence of DMSO before it could be metabolized to dimethyl sulphide or dimethyl sulphone[41, 42].

Frequency of induced sex-linked recessive lethal mutations

Treatment	No. of chromosomes analysed	No. of mutations	Mutations (%)
Control (0.7 *N* saline)	1161	6	0.52
DMSO (1%)	433	3	0.69
EMS (0.15%)	652	106	16.25
DMSO + EMS	656	156	23.78

Zusammenfassung. Die mutagene Wirkung von Aethylenmethansulfonat in *Drosophila*-Männchen wird durch DMSO um 46% erhöht. DMSO allein kann keine Mutation über die Spontanrate hinaus induzieren.

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