and extract electrons from a water molecule. Therefore, while the oxidation of water is proceeding in the light, the incorporation of carbon dioxide into the tricarboxylic acid cycle is inhibited by the unavailability of the disulfide.

Whether or not chlorophyll exists intermediately as an ephemeral ionic species in this scheme depends only on the time lag between the initial loss of an electron by the chlorophyll molecule and the subsequent recapture of an electron from a water molecule. If the time lag is relatively great, then the chlorophyll will have been oxidized to a relatively long-lived positively charged ion. If the time lag is extremely small, as it would be if the new electron is acquired to replace the one removed from its normal energy level simultaneous with, or even before, the loss of the activated electron, then oxidative ionization of chlorophyll will not have taken place. In this connection, Rabinowitch (*5*), taking into account the absorption and fluorescence spectra and the photo-oxidation of chlorophyll in the presence of electron-accepting ions and molecules, states "Indications (are) that the activated chlorophyll molecules which fail to emit fluorescence are converted into a long-lived active form which may represent . . . an oxidized or reduced molecular species."

According to the present theory, then, the mechanism of photosynthesis may be summed up by the following equations:

$$\mathrm{Chl} + h\nu \longrightarrow \mathrm{Chl}^* \qquad (3)$$

$$2\mathrm{Chl}^* + \mathrm{RSSR} \longrightarrow 2\mathrm{Chl}^+ + 2\mathrm{RS}^- \qquad (4)$$

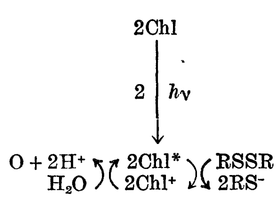
$$2\mathrm{Chl}^+ + \mathrm{H_2O} \longrightarrow 2\mathrm{Chl} + 2\mathrm{H}^+ + \mathrm{O} \qquad (5)$$

in which Chl* and Chl^+ represent chlorophyll with, respectively, an activated electron and a missing electron.[1] It will be noted that four quanta are required for the production of one oxygen molecule according to this scheme.

Equations 4 and 5 may be combined to indicate the possible simultaneity of these two reactions:

$$2\mathrm{Chl}^* + \mathrm{RSSR} + \mathrm{H_2O} \longrightarrow 2\mathrm{Chl} + 2\mathrm{RS}^- + 2\mathrm{H}^+ + \mathrm{O} \qquad (6)$$

This may, perhaps, be best represented in typical biochemical notation for coupled reactions:



(7)

The entire process may thus be visualized as a flow of electrons actuated by light; or, essentially, as a photoelectric current flowing from water through the chlorophyll to the disulfide. The light-activated chlorophyll molecule, according to this view, appears to play the role of an oxidation-reduction enzyme (a dehydrogenase) and functions almost as what might be described as a conducting bridge between two half-cells in which reactions 1 and 2 are, respectively, taking place.

[1] The coefficient 2 before Chl* is not to be construed as indicating that photosynthesis necessarily is kinetically second order with respect to activated chlorophyll, since the two-electron transfer may actually occur in two more or less distinct steps, rather than simultaneously.

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Tolerance of Certain Higher Plants to Chronic Exposure to Gamma Radiation from Cobalt-60[1]

Arnold H. Sparrow and Eric Christensen

Biology Department, Brookhaven National Laboratory, Upton, New York

Although the tolerance of a considerable number of species of higher plants to acute doses of ionizing radiation is known, only a few reports are available concerning tolerance of growing plants to chronic exposure to ionizing radiation. For this reason, a summary of preliminary information is presented here relating to the influence of chronic gamma radiation from cobalt-60 on a wide range of different species.

The Co^{60} sources used varied in strength from about 8 to 1800 curies, and the investigations were conducted under both greenhouse and field plot conditions. The procedure used for growing and irradiating the different species was that previously described by Sparrow and Singleton (*1*).

Under the conditions of our experiment, cytological, genetic, and physiological effects are known to occur (*1, 2*). However, the criterion used here to evaluate the effect of the radiation is the gross morphological appearance of the plant. In general, a mild effect means a slight decrease in height or vigor of the plant, and a severe effect means a definite, often dramatic. deviation from the normal or control plant in size, vigor, and in many cases general morphology (*3, 4*). Thus, in most cases, a "severe effect" means acute stunting or dwarfing from which the plant might or might not recover.

As shown in Table 1, there are considerable differences in the tolerance of different species to chronic irradiation. Certain plants (*Tradescantia paludosa* and *Lilium longiflorum*) show a mild effect at a dose rate of about 20 r/day, while others (broccoli and gladiolus) show no definite effects at dosages lower than 1400 and 4100 r/day, respectively. These data indicate a 200-fold difference in sensitivity between the least tolerant and most tolerant species so far investigated. A similar range is also shown by comparing the dose rate required to produce a severe effect

[1] Research carried on at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

TABLE 1

TOLERANCE OF VARIOUS PLANTS TO CHRONIC GAMMA IRRADIATION

Plant	Minimum exposure (weeks)	Effect at indicated dose rate* (r units per day)	
		Mild	Severe†
Lilium longiflorum	15	20(?)	30
Tradescantia paludosa	15	20	40
Tradescantia ohiensis	15	35	65
Vicia faba	15	60	90
Impatiens sp.	18	60	90
Coleus blumei	13	100	240
Melilotus officinalis	14	100	240
Nicotiana rustica	15	100	300
Phytolacca americana	15	100	350
Datura stramonium	7	110	360
Gossypium hirsutum	15	110	250
Dahlia (hybrid)	10	110	275
Althea rosea	12	120	250
Luzula purpurea	10	125	300
Chrysanthemum (hybrid)	18	140	250
Canna generalis	18	180	350
Lactuca sativa	7	180	600
Chenopodium album	15	250	450
Antirrhinum majus	18	250	400
Lycopersicon esculentum	15	250	400
Xanthium sp.	15	250	500
Solanum tuberosum	10	300	600
Petunia hybrida	10	300	700
Celosia cristata	18	300	750
Lupinus albus	12	400	—
Kalanchoë daigremontiana	12	400	800
Allium cepa	18	400	800
Linum usitatissimum‡	10	600	1100
Digitaria (crabgrass)	12	1000	1800
Brassica oleracea (broccoli)	10	1400	2500
Gladiolus (hybrid)	8	4100	6000

* Dose rate is in roentgens/24-hr day; however, the actual dosage/day averaged about 90% of the dose rate shown.
† This dose rate is not necessarily the lowest rate which will produce a severe effect.
‡ Data supplied by C. Konzak.

on these same species. An even greater range may reasonably be expected to appear when the investigation is extended to include a larger number of species.

There is little doubt that a large number of factors operate to determine the radiosensitivity of a given plant species. Changes in auxin (*5*) and ascorbic acid levels (*2*) in irradiated plants indicate that these substances may be involved in determining radiosensitivity. Our data also suggest that plants with large chromosomes (*Tradescantia, Lilium, Vicia*) have a higher sensitivity to chronic gamma irradiation than do most plants with small chromosomes.

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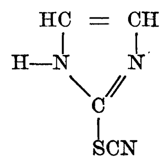
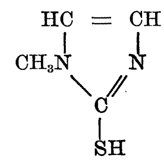
Antithyroid Activity of Thiocyanoimidazoles[1]

Roger E. Koeppe and John L. Wood
Department of Biochemistry, University of Tennessee, Memphis

The 2-thiocyanoimidazoles (I) are a new group of compounds recently prepared in our laboratory (*1*). Since these substances are structurally related to known antithyroid agents, e.g., 1-methyl-2-mercaptoimidazole (II), we have determined their inhibition of iodine uptake by rat thyroids. The method used



(I)



(II)

was essentially that of McGinty *et al.* (*2*). Adult white rats of comparable weight were injected intraperitoneally with 1-ml suspensions of the test compounds in 10% gum acacia. Approximately 1 hr later a tracer amount of I^{131} was injected and, after a 4-hr interval, the thyroids were removed and assayed for total radioactivity. The results of 2 experiments are summarized in Table 1 and show the 2-thiocyanoimidazoles to be thyroid inhibitors. 2-Thiocyanoimidazole and its 1-methyl derivative, in the doses employed, caused an inhibition of iodine uptake comparable to that of 1-methyl-2-mercaptoimidazole

TABLE 1

IODINE UPTAKE BY THYROIDS OF RATS GIVEN ANTITHYROID COMPOUNDS

Compound	No. rats	Dose mg/rat	% uptake of administered I^{131}		% of controls
			Av.	Range	
Expt. 1					
Propylthiouracil	8	0.5	0.21	0.14– 0.27	6.8
2-Thiocyano-imidazole	7	1	0.33	0.10– 0.60	10.6
2-Thiocyano-imidazole	3	5	0.13	0.07– 0.19	4.2
None (control)	8	—	3.1	2.2 – 4.8	100
Expt. 2					
Propylthiouracil	6	0.5	0.9	0.58– 1.38	9.9
1-Methyl-2-mercaptoimidazole	6	1	0.51	0.30– 0.75	5.6
2-Thiocyanoimidazole	4	1	0.54	0.38– 0.71	5.9
1-Methyl-2-thiocyanoimidazole	6	1	0.52	0.38– 0.76	5.7
4(5)-Methyl-2-thiocyano-imidazole	4	1	2.3	1.0 – 3.6	25.3
None (control)	6	—	9.1	5.9 –12.2	100

[1] These studies were supported by the Atomic Energy Commission under Contract AT-(40-1)-283, Title VII.