of any movement, absence of mitosis (Slifer[7]) and very low rates of respiratory metabolism (Bodine[8]). The third period begins with the resumption of mitotic activity followed by blastokinesis. After the embryo has revolved, it grows rapidly and engulfs the remaining yolk. The third phase marks the completion of differentiation and embryonic organogenesis.

This preliminary report on the glutathione reaction is based upon observations of 13 embryos in early development, 70 embryos in diapause, and 30 in various stages of later development. The nitroprusside test for —SH groups was used and the color lasted from 18 to 90 seconds. All embryos (even those in diapause) gave a definite positive color reaction. The stain was apparently more intense and lasting where the tissues were thicker. Yolk did not stain and embryonic membranes colored only momentarily.

It is significant that embryos in all stages of diapause showed an intense color reaction indicating the presence of the protein bound —SH groups. It is possible that the —SH group relates more to potential cell activity, rather than indicating active cell division as postulated.

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Physico-chemical Aspects of Sex in Plants.*

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The excellent review by Joyet-Lavergne[1] of the earlier work on this problem obviates the need of recapitulation here. It may be stated, however, that the formative responses of the sexes in dioecious plants under various conditions have been much more thoroughly recorded than their concomitant physiology. This investigation was undertaken in an attempt to secure comprehensive data concerning normal staminate and pistillate metabolism in

[7] Slifer, E. H., *Physiol. Zool.*, 1930, **3**, 503; *J. Morph. and Physiol.*, 1931, **51**, 613.

[8] Bodine, J. H., *Physiol. Zool.*, 1932, **5**, 538.

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[1] Joyet-Lavergne, Ph., *La Physico-Chimie De La Sexualite.* Borntraeger, Berlin, 1931.

typical dioecious plants. For comparison of long and short day photoperiodic responses, data are presented for spinach and hemp as representative of these two types.

Plants were grown in the greenhouse in the early spring and summer in triplicate series which were thinned to between 50 and 100 plants each, depending upon the age at which they were to be analyzed. The vegetative-reproductive cycle was controlled by supplementing daylight with electric light as needed at the rate of two 100-watt lamps per square yard at the height of one foot above plants. It was necessary to lengthen the early spring daylight 6 to 7 hours per day to prevent young hemp from flowering prematurely. Otherwise all plants developed normally. Six to 10 plants of each series were analyzed in early flowering stages prior to shedding of pollen, and a similar number during incipient fruiting. Entire plants were gathered and divided into duplicate samples of whole tops and roots for analysis, the average of analyses of all series being reported. Each table thus represents data from a study of over 100 plants. Roots were washed free of soil, rinsed in distilled water and then dried for 30 minutes at room temperature. Spinach had begun to shift from the flat rosette of its vegetative phase to the shooting phase of the central axis preparatory to flowering when the first analyses were made. Male hemp plants had begun to show the formation of a leafless tip and the females the terminal rosette prior to flowering at the time the first materials were collected for analysis.

Conductivity and pH were determined electrometrically at 25°C. Indophenol-oxidase activity was measured colorimetrically at 25°C. as the amount of indophenol formed by 1 cc. of expressed sap per hour in 25 cc. portion of a freshly prepared solution made up as follows 0.144 gm. a-naphthol, 0.209 gm. dimethyl-paraphenylenediamine HCl, 0.1175 gm. anhydrous sodium carbonate, 10 cc. of 95% ethyl alcohol and 140 cc. of water. The sap test was compared with a 50% alcoholic color standard containing 0.353 gm. indophenol per liter and then corrected by deducting the reading of a 25 cc. blank without sap.

The analytical data for spinach (Table I) flowering under long day conditions, show the more rapid development of staminate plants in the earlier stages even though these are lower than females in dry weight. Total ash is also higher both in tops and roots throughout. Once sexual dimorphism has developed, there is practically no overlap of the sexes in ash or moisture content in

TABLE I.
Analyses of Prickly Seeded Spinach

	Age 8 weeks[a] Tops		Age 12 weeks[b] Tops		Age 12 weeks[b] Roots		Age 15 weeks[c] Tops	
	♂	♀	♂	♀	♂	♀	♂	♀
Fresh weight, gm.	2.30	2.60	20.60	15.00	7.40	6.90	33.41	31.08
Dry Weight, %	7.62	7.93	7.80	9.40	6.20	7.20	8.23	10.24
			% of dry weight					
Total Ash	22.10	17.68	24.00	18.80	8.65	9.05	24.80	19.68
Iron	0.09	0.05	0.09	0.06	0.05	0.08	0.07	0.06
Calcium	2.92	2.87	3.00	2.00	0.60	1.33	2.20	1.63
Magnesium	0.64	0.12	0.88	0.40	0.22	0.80	0.99	0.78
Potassium	2.34	3.92	4.00	3.10	1.20	0.98	4.40	2.58
Phosphorus	0.78	0.21	0.60	0.39	0.40	0.27	0.58	0.42
Nitrogen	4.12	4.94	4.70	4.85	3.07	3.27	4.53	4.91
Sugars	3.59	3.20	3.84	3.30	3.00	2.20	2.62	3.34
Starch	11.10	8.45	10.70	9.90	21.10	14.42	11.52	10.32
			Expressed sap					
pH	6.03	6.14	6.10	6.00	5.60	5.84	6.16	5.83
Osmotic Pressure[d]	11.58	11.58	15.12	12.50	6.95	5.80	14.87	13.63
Conductivity[e]	.0257	.0236	.0303	.0270	.0288	.0200	.0334	.0342
			Gm. per liter of expressed sap					
Dry Weight	38.04	38.60	42.10	40.80	27.07	20.48	48.20	42.00
Total Ash	11.50	10.26	16.20	11.40	8.04	6.42	14.20	12.00
Sugars	5.37	4.10	6.46	3.55	4.80	3.65	2.36	3.05
Nitrogen	1.18	0.64	1.44	0.60	0.78	0.51	1.07	0.51
Indophenol[f]	36.39	42.78	66.20	42.90	44.87	26.09	61.33	43.46

[a] Formation of flower primordia commenced at time of analysis.
[b] Plants in full flower but little pollen shed.
[c] Most pollen shed and some young fruits started.
[d] Osmotic pressure in atmospheres.
[e] Specific conductivity in reciprocal ohms.
[f] Milligrams of indophenol formed per liter of sap per hour.

plants of comparable age. Practically all of the mineral nutrients are higher in staminate plants, although the differences between the sexes diminish as the males continue to shed pollen. This is especially true of iron and magnesium, of which the lowest values recorded in males were well above the highest found in females of similar age. Total nitrogen not including nitrates remains consistently slightly higher in females but with a tendency of extremely low females and high males to overlap as anthers mature. Due to the small variations in reducing and non-reducing sugars, only total sugars are reported. These along with starch are also significantly higher in males, except that pollen formation eventually reduces the sugar content of males below that of females in the early fruiting stages.

On the whole, the rate of mineral absorption by males exceeds that of females and translocation from roots to tops also occurs more rapidly. In young plants insoluble calcium, magnesium and iron, for example, tend to accumulate in roots of females, evidenced by the fact that even though the total ash content of female roots is higher than in males, soluble salts in expressed sap are lower. Probably the most significant difference between the sexes in spinach is the larger amount of soluble material in the male sap, shown by its higher osmotic pressure as well as by its greater ash, sugar and nitrogen content. Staminate tissue fluids also maintain a higher specific conductivity and greater oxidase activity than females. Despite variations of individual plants, even the lowest rates of indophenol formation by oxidase were above those of the most active females.

These facts all reflect the more rapid metabolism of the staminate plants, necessitated in part by the need for rapid elaboration of relatively large amounts of pollen often comprising 10 to 15% of the entire dry weight of the tops. The celerity of staminate development correlates well with the rapidity of nutrient absorption, especially of iron which is important in oxidase activity and of phosphorus which presages early maturation of males.

In view of the importance of spinach as a source of iron in the diet and the fact that the human assimilation of nutrients is favored by their solubility in the vegetable foods ingested, the established commercial practice of thinning the spinach crop is unfortunate because it involves essentially the elimination of males which are the more desirable in both respects.

Hemp (Table II), normally flowering under short day condi-

TABLE II.
Analyses of Common Hemp, *Cannabis sativa*.

	Age 5 weeks[a]		Age 7 weeks				Age 10 weeks	
	Tops	Roots	Tops		Roots		Tops	
	Veg.	Veg.	♂	♀	♂	♀	♂	♀
Height of tops, cm.	65.00		90.00	80.00			90.00	91.20
Fresh Weight, gm.	9.77	0.81	36.85	48.68	2.38	4.45	80.00	67.62
Dry Weight, %	20.30	15.41	20.84	18.80	21.10	17.87	23.34	24.09
			% of dry weight					
Total Ash	14.08	11.06	17.25	17.70	8.08	9.52	15.00	18.38
Iron	0.015	0.079	0.029	0.009	0.030	0.042	0.039	0.031
Calcium	4.66	1.11	5.24	5.04	0.90	0.92	5.04	5.30
Magnesium	0.30	0.15	0.42	0.21	0.27	0.34	0.26	0.53
Potassium	1.75	2.24	1.31	1.45	1.07	1.17	0.66	1.08
Phosphorus	0.47	0.53	0.54	0.50	0.30	0.36	0.47	0.60
Nitrogen	3.98	2.18	3.49	3.65	1.99	1.64	3.61	3.69
Sugars	4.40	3.31	4.49	3.39	5.32	4.92	7.40	6.10
Starch	10.07	17.04	13.52	17.89	17.62	19.50	12.63	16.45
			Expressed sap					
pH	6.81	6.11	6.38	7.23	6.20	5.95	7.49	7.02
Osmotic pressure	15.32	10.49	14.59	12.90	12.18	10.25	16.30	15.80
Conductivity	.0253	.0218	.0268	.0295	.0231	.0293	.0209	.0216
			Gm. per liter of expressed sap					
Dry Weight	61.00	39.40	81.80	70.75	42.80	51.40	99.54	87.09
Total Ash	11.45	7.77	12.53	12.45	9.84	9.46	12.38	8.22
Sugars	19.50	4.80	10.38	7.93	9.40	7.39	20.87	17.96
Nitrogen	3.10	0.66	5.85	5.75	2.90	2.84	7.05	5.24
Indophenol	73.67	29.45	88.25	73.67	40.40	27.57	52.00	51.86

[a] Vigorously vegetative plants showing no sex dimorphism. See corresponding footnotes to Table I.

tions of late summer, shows fewer contrasts between the sexes than observed in spinach, due probably to the fact that the life span of the 2 sexes is more nearly equal in hemp. In view of the differences in length of vegetative activity in spinach and hemp, the common characteristics of their corresponding sexes probably constitute the chief physico-chemical differences of staminate and pistillate metabolism.

Staminate hemp is consistently higher in percentage of dry weight until considerable quantities of pollen have been shed. Though differences in percentage of total ash in tops are inappreciable during flowering stages the iron and magnesium content of males is nevertheless greater, with practically no evidence of overlap between sexes. Total nitrogen and sugars of tops and roots are also higher in males as are total solids dissolved in sap including ash, sugars and nitrogen. These conditions are clearly reflected in the osmotic pressure and specific conductivity of body fluids when analyses are averaged but not always this definitely in individual cases. Phenoloxidase activity remains higher in staminate plants until they near the close of their activity after flowering. These metabolic conditions all correlate excellently with the known precocity of staminate hemp plants.

In summary, it may be noted that staminate plants of photoperiodic, long day spinach and short day hemp correspond in having higher percentage of iron, magnesium and sugar, more soluble sap constituents, and greater oxidase activity of tissue fluids.