plate-iron cylindre jacket. By its aid the temperature can be easily kept constant to within 0°.01.

The temperature is determined by a platinum resistance thermometer, which is inserted in a WHEATSTONE bridge formed by a HARTMANN and BRAUN resistance box. The galvanometer is a HARTMANN and BRAUN mirror galvanometer. The image of the incandescent rod of a NERNST-lamp is thrown by a mirror and a lens on a large scale fastened on the wall. The sensitiveness of the instrument is such that a deviation of 0°.01 corresponds with a deviation of about 6 cm. on the scale. So it can be seen all through the room whether the temperature remains constant, resp. how much it changes. The indication of the thermoscope inside L is thrown on this screen in the same way (only the NERNST-burner has here two incandescent rods to distinguish it). Accordingly the observer, who is engaged with the pressure balance or some other part of the apparatus, can ascertain from far whether the stationary state has set in.

The resistance thermometer is gauged with the same leads and in the same bridge arrangement as that with which the measurements take place. For this purpose it is placed by the side of the chief-temperature-normal of the laboratory in a tube filled with oil in the thermostat which surrounds the vessel A; the temperature is here kept constant in the ordinary way.

Amsterdam. *Physical Lab. of the University.*

Botany. — *"Experiments on Hybridisation with Canna indica."* By J. A. HONING. (Communicated by Prof. F. A. F. C. WENT.)

(Communicated in the meeting of January 31, 1914).

Among the plants which my Javanese gardener planted in the beginning of 1910 in order to make the empty space round the house look somewhat like a garden, there were two varieties of *Canna*, which occurred as escapes on the high bank of the Deli river. One of them had leaves entirely green, green bracts, a green stem, small red flowers, with yellowish labellum and fruits, which in an unripe condition are green. This variety completely corresponds to the plants, grown from seeds, which I received as *Canna indica* from the Botanic gardens of Buitenzorg. The other had somewhat darker leaves with a red edge and the flowers were also of a somewhat darker red. Further the stem was dark red as were the conical papillae on the unripe fruits.

If BAUER's "Einfuhrung in die experimentelle Vererbungslehre" had at that time already appeared, I should probably have chosen two other forms, differing in more characters, in order to be able to investigate whether there exists a connection between reduction-division and Mendelian segregation, as BAUER considers possible. Since there are only 3 chromosomes in the reproductive-cells of *Canna indica*, only three characters can independently segregate according to Mendel, if the hybrid-segregation is based on the division of the chromosomes of the parents

The chance that two varieties, which only differ outwardly by the possession and absence of a red colour in almost all their aerial organs, might differ in more than three characters, is at first sight small. Yet this must be the case here, because from the proportions in which the self-pollinated "red" plants segregate as well as from those of the second generation of hybrids it is seen that even for the red edge of the leaves alone the cooperation of three factors is necessary, whilst the colour of the fruits requires at least one additional factor. For this reason the hybridisations have from a theoretical standpoint become of greater importance than I at first suspected.

The *Canna indica* without the red colouring matter has remained constant to the fourth generation. I have had in all 165 specimens, descendants of 14 mother-plants. All are descended from a single "green" *G* 11.

The "red" Canna on sowing was seen to be a hybrid. Only from two specimens, *R* 4 and *R* 13 did I obtain seeds by self-pollination, from most of the others only a little seed after free-pollination. This fact makes it probable that these plants were homozygotically "red", because later I very often got few seeds or none from the pure "red" individuals and a sufficient number from the hybrids. Seeds were obtained after self-pollination from 20 descendants of *R* 4 and from 25 of *R* 13 and although in many cases the proportions, by reason of the small number of specimens, were not wholly certain, yet it was established that segregation occurs in three different ways:

a. In the proportion 3 1 (e.g. 27 red and 10 green; 44 red and 15 green; 69 red and 19 green; 24 red and 8 green).

b. In the proportion 9 : 7 (e.g. 146 red and 123 green [theoretically 151.3 red and 117.7 green]; 53 red and 38 green. [theoretically 51.2 red and 39.8 green]; 31 red and 24 green, [theor. 30.9 and 24.1]; 41 red and 29 green [theor. 39.4 and 30.6]).

c. As 27 : 37 (7 red and 10 green [theor. 7.2 and 9.8]; 11 red and 15 green [theor. 11.0 and 15.0].

These proportions suggest segregation according to three Mendelian factors and this is also completely confirmed by the proportion of the second generation of hybrids. By means of the character of the red leaf-edge the "red" *Canna* can therefore be represented as *AABBCC* and the pure green *G* 11 as *aabbcc*.

Since *R* 4 (9 red and 4 green), *R* 4—1 (27 red and 10 green), *R* 4—1—1 (19 red and 7 green) and also the 4th generation *R* 4—1—1—1 (10 red and 3 green) segregate according to 3 : 1, *R* 4 must, at least if it is assumed that the three factors are independent of one another, be heterozygotic for one of these three and homozygotic for the other two, e.g. *AaBBCC*, which in the following generation gives 1 *AABBCC* : 2 *AaBBCC* . 1 *aaBBCC*. But in that case descendants of *R* 4 must segregate according to 3 : 1 in so far as they are not pure "red" or "green". However *R* 4—1—11 segregated as 9 : 7 (146 red and 123 green) and *R* 4—1—14 likewise (53 red and 38 green) These can therefore be represented for example as *AaBbCC* or *AaBBCc*, because they are clearly heterogyzotic for two factors instead of for one. Since now *AaBbCC* cannot be directly derived from *AaBBCC*, we know that the representation *AaBBCC* for *R* 4 is incorrect and that *R* 4 also must have been heterozygotic for at least two factors, but behaved as if this was so for only one factor and that therefore in their Mendelian behaviour these two factors were not independent of each other.

If we apply this same reasoning to *R* 13—1, which in like manner segregates as 3 : 1 (namely 20 red and 9 green), whilst *R* 13—1—13 separates in the proportion 27 37 (7 red and 10 green) then we come to the conclusion that *R* 13—1 must have been heterozygotic for three factors, therefore *Aa Bb Cc*, and nevertheless behaved as a hybrid with only one half-representative factor, in other words, the three factors were not independent but correlated as if there were only the one.

This is established by the second generation of crossing of "pure red" with "pure green". All the specimens of F_1 correspond to the formula *Aa Bb Cc*. Yet segregation took place in *F* 2, as was also the case with the self-pollinated offspring of *R* 4 and *R* 13, not only according to 27 : 37, but also in the proportions 3 : 1 and 9 : 7, as the following table shows.

Probably it is no great error to say when considering all the cases with more "green" than "red" individuals that they segregate in the proportion of 27 red to 37 green, those with slightly more "red" than "green" ones as belonging to those which segregate as 9 : 7 and thirdly, the cases with more than twice as many "red"

TABLE.

Segregation in the second generation of hybrids after crossing of green with pure red-edged specimens.

First generation	Second generation			Agrees with the proportion	Theoretically	
	Number	red	green		red	green
$(G\,11\text{–}5)\times(R\,13\text{–}4)\,R\,1$	31	14	17	27 : 37	13.1	17.9
$R\,3$	51	29	22	9 : 7	28.7	22.3
$R\,4$	25	12	13	27 : 37?	—	—
$(R\,13\text{–}4)\times(G\,11\text{–}6)\,R\,1$	52	28	24	9 : 7	29.25	22.75
$R\,2$	39	21	18	9 : 7	21.9	17.1
$(R\,4\text{–}7)\times(G\,11\text{–}5)\,R\,1$	222	95	127	27 : 37	93.6	128.3
$R\,2$	23	10	13	27 : 37	9.7	13.3
$R\,3$	18	8	10	27 : 37?	—	—
$R\,4$	195	83	112	27 : 37	82.3	112.7
$R\,5$	58	28	30	27 : 37?	24.5	33.5
$R\,6$	62	45	17	3 : 1	46.5	15.5
$R\,7$	77	36	41	27 : 37	32.5	44.5
$(R\,4\text{-}7)\times(R\,4\text{-}4\text{ green})\,R\,1$	18	7	11	27 : 37?	—	—
$R\,3$	17	8	9	27 : 37?	—	—
$R\,5$	13	9	4	3 : 1?	—	—
$R\,6$	16	10	6	9 : 7?	—	—
$R\,7$	38	18	20	27 : 37?	—	—

as "green" as belonging to the category of those segregative as 3 : 1. When the figures of these three groups are added, the agreement of the totals with the figures is, I think, complete:

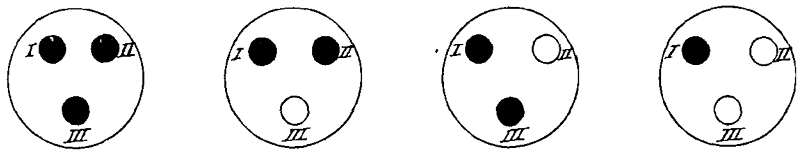
Nature of segregation	Found		Calculated	
	red	green	red	green
According to 3 : 1	54	21	56.25	18.75
„ 9 : 7	88	70	88.9	69.1
„ 27 : 37	319	403	304.6	417.4

Parents which have a hybrid nature for three factors, can therefore distribute these three factors to their off-spring in different ways and in such a manner that the proportional figures show that either all three segregate independently of one another, or that two are correlated and the third remains free or that all three are correlated.

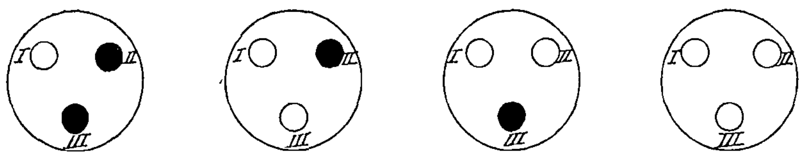
On BAUR's hypothesis this phenomenon is easily explained. The factors *A*, *B*, and *C* may be distributed over the three chromosomes as follows:

1. *A*, *B*, and *C* all in 1 chromosome, e.g. in *I*.
2. *A* and *B* together in one chromosome, e.g. in *I* and *C* in another, e.g, *II*.
3. *A*, *B*, and *C* in three different chromosomes e.g. *A* in *I*, *B* in *II*, and *C* in *III*.

By substitution all other possible combinations can be found, which, however, give no other proportional figures than the examples given, which can be represented, as on page 148 of this book BAUR represents them, e.g. by black for the chromosomes of the "red" plants and white for the "green" ones. The formulae of the reproductive cells appear then as follows:



1 2 3 4



5 6. 7 8

Figure	case I	case II	case III
1	*ABC*	*ABC*	*ABC*
2	*ABC*	*ABC*	*ABc*
3	*ABC*	*ABc*	*AbC*
4	*ABC*	*ABc*	*Abc*
5	*abc*	*abC*	*aBC*
6	*abc*	*abC*	*aBc*
7	*abc*	*abc*	*abC*
8	*abc*	*abc*	*abc*
Number of combinations	2	4	8

In the first case there arise only germ-cells of the constitution ABC and abc. With self-pollination therefore segregation of 3 "red" to 1 "green" must follow. In the second case there are four kinds of pollen-grains and four kinds of ova, whereby F_2 will segregate in the proportion of 9 "red" to 7 "green". In the third case there are eight different reproductive cells and segregation takes place in the proportion of 27 "red" to 37 "green".

BAUR's hypothetical example of Cannas, which differ in 3 characters, refers to one leaf-, one stem-, and one floral character, which should show independent Mendelian behaviour. We now find that, if we hold to the existing ideas, three leaf characters, which one might perhaps be inclined to assume were in one chromosome, behave, as though they might be distributed over two or three chromosomes, which would be an argument for the dissolution and mixing-up of the chromosomes in the synapsis-stage.

The 17 green examples from (R 4—7) × (G 11—5) $R6$ have all been planted out, most of them however died and only 6 grew large enough to ascertain definitely that their leaf-edge completely corresponded with the pure "green" descendants of G 11. They may therefore indeed be represented as $aabbcc$. With respect to the fruits however they differ. Whilst those from G 11 and their offspring possess at most a hardly noticeable red apex on some of the little cones of the fruit wall, the ovaries of one of the "green" examples of (R 4—7) × (G 11—5) $R6$ were clearly red, as was the case in some of the examples, which had no red at all in the leaf-margin, from (R 4—7) × (G11—5) R_1. A sister-specimen had, however, green ovaries, so that for the factor red in the fruits the segregation indeed occurs, independently therefore of the three leaf-edge factors; which remain associated.

The great variability of the red in the fruits, even in one and the same plant, is the reason for my failure to determine with certainty the number of factors for it. I can only say that at least one of them can behave as if it were independent of the three leaf-edge factors.

So far the segregation of "red" and "green" has been spoken of as if all "green" individuals were alike. In reality however this is not so. With sowings, not older than 1 to 2 months, no distinction can be made other than that between red-edged and green, because nothing more can then be seen. If however "green" specimens are planted out, then a few months later it is found that some only are wholly green, as G 11, but other specimens show a narrow red edge on the upper half of the leaf, most distinctly at the apex of the young rolled-up leaves. This is the only one of the three factors which becomes separately visible. When it is present heterozygotically, segregation takes place in the proportion of 3 with and 1 without, for example, from R 4—2 (green) — 3 I obtained 46 large plants, of which 35 had the narrow red edge and 11 were without it. In the same way out of 35 specimens from R 13—1—1 (green) 27 had it and 8 were without it.

In $F2$ of the crosses this segregation is also seen. Of 125 "green" examples of (R 4—7) × (G 11—5) R 1 I obtained only 51 in bloom, the others died by the continuous rain. With segregation in the proportion of 27 : 37 (see the table) 37—16 = 21 plants must occur, which show the narrow red edge, as against 16 real "green" ones. Calculated according to the proportion the number of those with the narrow red edge is 28.94 and of "green" ones 22.05. The figures found were 30 and 21, certainly a sufficient agreement. It is perhaps not unnecessary to add that the 6 specimens which remained from the 16 "green" ones from (R 4—7 × (G 11—5) R 6, were really "green", without the narrow red edge on the leaves.

New crossings of the same two forms but of different origin have in the meantime been made, as also the crossing of R 13—4—3 with Canna glauca, which differ in at least ten characters and probably in still more. The whole $F1$ generation is however up to the present only one specimen, of which the fertility is still doubtful. The leaf shape is intermediate between that of the parents; the leaves have still something of the wax-like appearance of the mother and the red edge of the father.

Medan (*Sumatra*), January 1914.

Chemistry. — *"Equilibria in ternary systems." XIII.* By Prof. F. A. H. SCHREINEMAKERS.

Now we consider the case, that the substance F is one of the components; it is evident that we can deduce then the saturation-curves under their own vapourpressure and the boilingpointcurves in the same way as is done in the previous communications for a ternary and a binary compound.

We take the component B as solid substance and now we choose a T and P in such a way, that no vapour is formed and the isotherm consists only of the saturationcurve rs of fig. 1. On decrease of pressure anywhere a gasregion and the region LG occur. These regions may arise in different points; in fig. 1 the region LG, the