bacteria (antigens) stimulate the formation of antibodies by the animal and these accumulate in its blood. When such immune serum is mixed with a suspension of the exciting bacterium, the bacteria adsorb the corresponding antibodies upon their surfaces (antigen-antibody union) and become capable of adhering specifically to each other. Previous to the mixing of the antibody and the bacteria, the bacteria remained separate, apparently repelled by similar electrical charges. Removal of the mutual repulsion, by neutralization of the individual electrical charges, is apparently a general non-specific step in the agglutination mechanism. There seem to be no "attractive" forces involved, but contacts are brought about through random movements due to currents, to temperature agitation or to motility of the organism itself. When two bacteria coated with the same antibody chance to meet, a union is formed through the antibodies, and agglutination or clumping follows.

An animal may simultaneously produce antibodies against an indefinitely large number of kinds of bacteria. Also, immunization against one bacterium often results in the production of five or more demonstrably different antibodies and probably others which have not been demonstrated. All these antibodies act together simultaneously without interference in affording the animal protection against a simultaneous multiple infection.

Topley, Wilson and Duncan[1] showed that when a heterogeneous mixture of bacteria is agglutinated by a heterogeneous mixture of the specific antisera, each cluster of bacteria is homogeneous. The "forces" which determine the formation of clusters containing each a particular kind of bacterium are specific so that each cluster is a lattice of identical unions through the adsorbed antibodies.

The present hypothesis proposes that the specificity of chromomere synapsis is similarly effected by one or more specific agglutinins for each of the different chromomeres. The surface of each chromomere may be assumed to stimulate in the protoplasm the formation of specific antibodies just as do the surface antigens of each type of bacteria. It is not necessary that the contained genes themselves act as antigens (although they may do so), since the nucleoproteins of the envelope overlying each chromomere would be sufficient. The molecules of antibody which then chance to come in contact with the corresponding chromomere surface are adsorbed. Each chromomere thus becomes specifically capable of adhering to its partner chromomere and couples with it upon contact.

After the leptotene threads are produced in sperm- or egg-mother-cells, any two allelic chromomeres which touched would be cemented together by the antibody junctions specific for themselves. The chromomeres which are on each side of the already agglutinated ones would then be more likely to touch and fuse, so that synapsis would proceed, zipper-like, from the first points of homologous contact throughout the entire lengths of the chromosomes.

Since all the chromomeres of a given kind are coated with the same antibody, synapsis in auto-triploids or tetraploids could include all strands. Such inclusive synapsis for triploids and tetraploids is observed to be the case in the salivary gland pseudo-synapsis, and was formerly believed to be the general case. However, if meiotic synapsis occurs predominantly or exclusively in pairs (Darlington), then this would be similar to the formation of separate clumps in agglutination. In triploids, strands *a* and *b* would usually come into contact at different points than strands *b* and *c*, and pairing would proceed from the separate contact points.

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[1] W. W. C. Topley, J. Wilson and J. T. Duncan, *Brit. Jour. Exp. Path.*, 16: 116, 1935.

ROOT AND SHOOT PRODUCTION INDUCED IN CABBAGE BY BETA (3) INDOLE-ACETIC ACID

AT the suggestion of Professor George K. K. Link a study of the responses of cabbage to applications of Beta (3) indole-acetic acid was undertaken. Paste containing 30 mg of the acid per gram of lanolin was applied to decapitated first internodes of young seedlings. This treatment resulted not only in the production of an apical ring of adventitious roots, as reported for other plants, among them bean and tomato, but also in the production of viable shoots.

The first cellular response of cabbage upon application of the paste was enlargement of the cells underlying the cut, shortly followed by rapid cell divisions in the rays, phloem, parenchyma and endodermis. Root primordia were organized from the proliferated cells of rays and phloem, and their apical histogens were apparent by the end of 144 hours. Mounds of external callus tissue were produced on the cut surface, mostly over the phloem, and within them matured irregular areas of vascular tissue intermingled with highly meristematic regions in a very confused pattern.

Many of the decapitated and treated plants then developed shoots, which were detectable in 288 hours after treatment. They were found to arise either in the external callus or from internal callus (in the sense of Jost and Link) considerably below the cut surface at the level of adventive root production. Origin of shoots from internal callus was less fre-

quent than from the external callus. Most shoots arose from external callus produced by the pith and by the phloem, though in some cases the xylem and endodermis also were involved to a small extent. These regenerated shoots always established organic union with the vascular tissue of the decapitated shoot and became functional.

This observation of shoot regeneration by cabbage following treatment with Beta (3) indole-acetic acid is not an instance of induction of a new characteristic by a chemical agent. Occasionally (very rarely) decapitated control cabbage plants produced shoots without application of the acid. The chemical treatment apparently merely induces the internal conditions requisite for expression of a capacity which normally rarely comes to expression in the cabbage plant.

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EXACT PROBABILITIES IN CARD-MATCHING PROBLEMS

A DECK of mn playing-cards composed of m suits of n cards each, may be arranged in $(mn)!/(n!)^m$ ways. If one of these is compared with some standard order, the number of coincidences is called the score. The frequency of any score r may be denoted by (r ; m,n). Huntington[1] gave the values of (r ; 3,3) and (r ; 4,4). He considered the labor in the determination of (r ; 5,5) to be prohibitive. Sterne[2] found the values of (21 ; 5,5) up to (25 ; 5,5) but knew of no way to determine these for smaller r. Greville[3] has recently found all values of (r ; 5,5); his solutions are correct, but involve much labor.

TABLE 1

	6×6							
Score	Frequency							
0 ...	4	165	949	769	769	961	828	425
1 ...	28	996	446	742	915	700	420	640
2 ...	98	700	744	213	619	952	591	700
3 ...	218	864	808	829	456	293	367	200
4 ...	355	341	281	078	962	422	086	175
5 ...	450	116	994	274	568	927	912	160
6 ...	462	909	014	435	100	202	332	336
7 ...	397	123	967	735	823	016	052	640
8 ...	289	793	784	100	001	073	868	710
9 ...	182	524	670	735	530	786	230	560
10 ...	100	344	596	349	272	804	505	000
11 ...	48	575	943	371	163	005	793	504
12 ...	20	851	099	196	639	140	076	850
13 ...	7	980	545	109	018	220	394	400
14 ...	2	735	656	277	729	448	992	400
15 ...		842	844	533	954	374	188	000
16 ...		234	038	576	801	926	712	520
17 ...		58	693	462	370	532	698	400
18 ...		13	313	942	477	144	955	600
19 ...		2	734	372	820	642	421	600
20 ...			508	679	897	516	240	400
21 ...			85	715	584	272	352	800
22 ...			13	076	448	757	088	400
23 ...			1	804	316	455	605	600
24 ...				224	849	404	787	850
25 ...				25	255	852	293	600
26 ...				2	550	498	318	360
27 ...					230	827	143	200
28 ...					18	656	661	150
29 ...					1	339	048	800
30 ...						85	377	840
31 ...						4	709	664
32 ...							243	135
33 ...							8	640
34 ...								540
35 ...								0
36 ...								1
	2 670	177	736	637	149	247	308	800

Sterne, SCIENCE, 86: 500–501.

The problem is by no means as difficult as these papers imply. Macmahon[4] gave a direct method of attack by which Greville's results may be checked with about 12 hours of machine calculation. I have recently determined the values of (r ; m,n) for all m and n less than 7 (m and n not being necessarily equal). The frequencies for the case in which both m and n are 6 are given in Table 1.

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[1] Huntington, SCIENCE, 86: 499–500.
[2] Sterne, SCIENCE, 86: 500–501.
[3] Greville, *Journal of Parapsychology*, March, 1938.
[4] Macmahon, *Combinatory Analysis*, Vol. 1, p. 99–112, Cambridge, 1915.

BOOKS RECEIVED

DARLING, F. FRASER. *Bird Flocks and the Breeding Cycle.* Pp. viii + 124. Cambridge University Press. Macmillan. $1.75.

HILL, M. A. and J. BURTON LINKER. *Introduction to College Mathematics.* Pp. xii + 373 + 93. 188 figures. Holt. $2.40.

HORVATH, A. A. *The Soybean Industry.* Pp. vi + 221. Chemical Publishing Company of New York.

KELLEY, TRUMAN L. *The Kelley Statistical Tables.* Pp. 136. Macmillan. $4.50.

KILBY, CLINTON M. *Introduction to College Physics.* Second edition. Pp. ix + 398. 389 figures. Van Nostrand. $3.25.

KILLIP, ELLSWORTH P. *The American Species of Pssifloraceae.* Pp. 335–613. Field Museum. $2.50.

MASSEY, H. S. W. *Negative Ions; Cambridge Physical Tracts, No. 1.* Pp. xii + 105. 19 figures. Cambridge University Press. Macmillan. $1.75.

Scientific Reports of the Great Barrier Reef Expedition, 1928–29; Vol. V, No. 5, by OSKAR CARLGREN, *Cerianthria and Zoantharia.* Pp. 177–207. 34 figures. 1 plate; Vol. VI, No. 1, by ROBERT GURNEY, *The Larvae of the Decapod Crustacea Palaemonidae and Alpheidae.* Pp. 40. 265 figures. British Museum, London. 5/ each.

Scientific Reports of the John Murray Expedition, 1933–34; Vol. II, No. 2, by E. F. THOMPSON and H. CARY GILSON, *Chemical and Physical Investigations.* Pp. 15–81. 16 figures. 5/. Vol. V, No. 1, by H. G. STUBBINGS, *Phyllirhoidae.* Pp. 14. 5 figures. 2/. Vol. V, No. 5, by M. RAMADAN, *The Astacura and Palinura.* Pp. 123–145. 12 figures. 2/6. Vol. V, No. 6, by W. T. CALMAN, *Pycnogonida.* Pp. 147–166. 10 figures. 2/6. British Museum, London.

SEAVER, GEORGE. *Edward Wilson; Nature Lover.* Pp. xi + 221. Illustrated. Dutton. $3.00.

SMITH, ALPHEUS W. *The Elements of Physics.* Fourth edition. Pp. xix + 790. 789 figures. McGraw-Hill. $3.75.

TARR, W. A. *Introductory Economic Geology.* Second edition. Pp. xi + 645. 257 figures. McGraw-Hill. $5.00.

TIMM, JOHN A. *An Introduction to Chemistry.* Third edition. Pp. xvii + 568. 162 figures. McGraw-Hill. $3.50.