The rubber is of the same weight as that used in Faber's large, office band, $3\frac{3}{8}'' \times \frac{3}{4}''$. These sizes fit

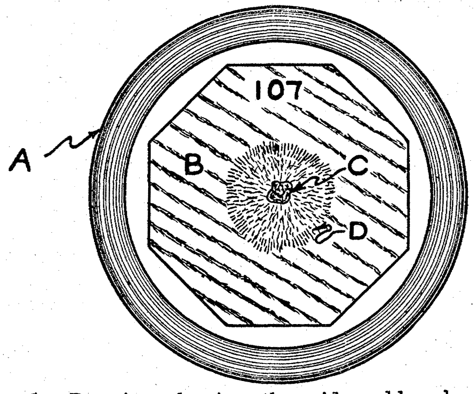

FIG. 1. Drawing showing the wide rubber band A, surrounding the edge of the Petri dish, in which is enclosed the flat, octagonal piece of moist wood, B. The fungous inoculum is shown at C, and the mycelium which spreads from it is indicated at D. The number, 107, indicates the number of the test piece.

snugly, with no loose edges, and leave the top of the dish unobstructed for observation and measurements.

The band method greatly reduces water loss, though it does not completely prevent it. The average loss per week when using bands was shown to be from 0.2 to 0.4 of a gram per dish containing wood test pieces at 100 per cent. moisture content, whereas without any protection this loss is from 2.0 to 3.8 grams. The difference is so marked that further explanation is unnecessary.

This method is applicable to toxicity tests of wood preservatives, studies in the decay resistance of woods, the determination of moisture and temperature requirements of fungi, cultural tests of various kinds and to a variety of uses where controlled moisture conditions are desired for test materials or living organisms contained in Petri dishes.

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SPECIAL ARTICLES

THE DISPLACEMENT OF TOXIN FROM NEUTRALIZED TOXIN-ANTITOXIN MIXTURES BY "TOXOID" OR ANATOXIN

MADSEN and S. Schmidt[1] have recently shown that neutralized toxin-antitoxin mixtures become toxic on addition of anatoxin. Schmidt[2] also showed that "toxoid" exerted the same effect and concluded that toxoid and anatoxin have a greater affinity for antitoxin than the original toxin itself, and can therefore displace it.

The tendency of recent immunological work (Obermayer and Pick, Landsteiner, Avery and Goebel) has been to show that even minute alterations in the structure of an antigen diminish an existing specificity rather than augment it, so that it would seem preferable to seek some other explanation.

This can readily be found in the conception of Arrhenius and Madsen[3] that the toxin-antitoxin reaction is a reversible chemical equilibrium of the type $T + A \rightleftarrows TA$, to use the simplest possible form, in which $T =$ toxin and $A =$ antitoxin. Letting this equation represent a "neutralized" mixture, we may express the equilibrium state by $\frac{[T][A]}{[TA]} = K$, or $[T][A] = K[TA]$, in which K is the equilibrium constant and the bracketed letters refer to concentrations. Since the toxin in the mixture is "neutralized," [T], and consequently K, are relatively small at equilibrium.

If the concentration of any of the reactants is changed the relative quantities of the other constituents also change so that K remains constant. Thus, if an additional amount of T is added it reacts with part of the A, decreasing [A] and increasing [TA], thus keeping K constant. If some other substance capable of reacting with A is added, [A] will also be decreased, but to keep K constant some of the TA will dissociate, increasing [T] and decreasing [TA].

Such a condition would arise when anatoxin or toxoid is added to a neutralized toxin-antitoxin mixture. If toxoid (Td) reacts with antitoxin in the same way that toxin does, $Td + A \rightleftarrows TdA$, a similar mass-law expression may be formulated, namely: $\frac{[Td][A]}{[TdA]} = K'$.

If toxoid is now added to a mixture containing neutralized toxin, the component substances will interact until their concentrations fulfil the conditions of the mass law equations $\frac{[Td][A]}{[TdA]} = K'$ and $\frac{[T][A]}{[TA]} = K$. As [A] is common to both expressions a relationship between [T] and [Td] can be derived, namely, $\frac{K[TA]}{[T]} = \frac{K'[TdA]}{[Td]}$. If the assumptions are made that one equivalent of TA is present before addition of one equivalent of Td, that the concentrations of

[1] T. Madsen and S. Schmidt, *Compt. rend. soc. biol.*, 102: 1091, 1929.

[2] S. Schmidt, *ibid.*, 1095.

[3] Arrhenius, "Immunochemistry," Chapters VI and VII, New York, 1907.

free T and A in a "neutralized" mixture are negligible and that x equivalents of TdA are formed at the expense of TA, the expression at equilibrium would be

$$\frac{K[1-x]}{[x]} = \frac{K' \ [x]}{[1-x]}.$$

This would, of course, be strictly true only if K is so small that essentially all of A is in the form of TA. If $K = K'$, that is, if T and Td have the same affinity for A, $x = 0.5$. In other words, one half of the toxoid added has combined with the antitoxin and half of the toxin has been liberated.

If $K = 0.5\ K'$ (Td has 0.5 the affinity of T for A),

$$x = 0.41;$$
$$\text{if } K = 0.1\ K', \quad x = 0.24;$$
$$\text{if } K = 0.01\ K', \quad x = 0.09.$$

Thus, in the case considered, even if T has one hundred times the affinity of Td for A, an appreciable amount of toxin would be liberated from the neutralized mixture by the addition of Td. Actually, the greater the value of K, the smaller the amount of toxin liberated, since free A would be greater and less dissociation of TA would occur. However, if one accepts the experimental results of Madsen and Schmidt, as well as the explanation herein given, K must be relatively small, since liberation of toxin is actually observed.

Interesting in this connection is the analogy to the toxin-toxoid reaction pointed out some years ago by Northrop;[4] namely, that a pepsin-albumin mixture diluted with inactivated pepsin contains more active pepsin than one diluted with buffer alone, the effect being in harmony with the hypothesis that inactivated pepsin, as well as active pepsin, combines with the peptone formed by digestion of the protein.

A simple physicochemical consideration of the conditions of equilibrium therefore suffices to account for the increase in toxicity of neutralized toxin-antitoxin mixtures to which toxoid or anatoxin has been added, and the experimentally untouched affinity relations of these as yet vaguely defined substances need not be taken into account.[5]

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[4] J. H. Northrop, *J. Gen. Physiol.*, 2: 482, 1919–20.

[5] The authors of this paper are working under the Harkness Research Fund of Presbyterian Hospital.

A NEW LAW OF SATELLITE DISTANCES

BESIDES the celebrated Bode's (or Titius) law there have been a number of attempts to establish a law governing the distances of satellites from their central body, including two discussions of the subject in SCIENCE in 1929. My approach to this subject was made about four years ago in somewhat the same manner as that of Dr. A. E. Caswell[1] who holds "the mean distances of the planets from the sun are proportional to the squares of simple integral numbers." I added, however, to the square of the integer the integer itself, thus assuming that the terms differ from the squares of integers by a progressively changing amount. For example, adding to each of the integers 1, 2, 3, 4, 5 . . . its square, we obtain the values 2, 6, 12, 20, 30. . . . This is simplified by dividing throughout by 2, giving us the series 1, 3, 6, 10, 15. . . . Those familiar with Bernoulli's *Tabula Combinatoria*[2] will recognize the series as the ternaries of his table.

The following table shows the results for all the satellite systems, including the planets as satellites of the sun, of the solar system where there are at least

TABLE ILLUSTRATING LAWS OF SATELLITE DISTANCES

System	Satellite	Relative Distance	New Law	Bode's Law	Caswell's Law
Sun	Mercury	3.87	3	4	3.82
"	Venus	7.23	6	7	6.80
"	Earth	10.0	10	10	10.6
"	Mars	15.2	15	16	15.3
"	Ceres	27.7	28	28	27.2
"	Jupiter	52.0	55	52	51.4
"	Saturn	95.3	91	100	95.6
"	Uranus	191.0	190	196	187.0
"	Neptune	300.0	300	....	310.0
"	"Planet X"	{ 400.0	406	388	408.0
		{ 430.0	435	388	435.0
Mars	Phobos	1.00	1	....	1.70(?)
"	Deimos	3.22	3	4	3.82
Jupiter	V	2.71	3	4	3.82
"	I (Io)	6.27	6	7	6.80
"	II (Europa)	10.0	10	10	10.6
"	III (Ganymede)	15.8	15	16	15.3
"	IV (Callisto)	27.9	28	28	27.2
"	VI	169.4	171	....	170.0
"	VII	173.0	171	196	170.0
"	VIII	348.5	351	....	357.0
"	IX	371.0	378	388	382.0
Saturn	Mimas	10.0	10	10	10.6
"	Enceladus	12.8	....	....	....
"	Tethys	15.8	15	16	15.3
"	Dione	20.3	21	....	20.8
"	Rhea	28.0	28	28	27.2
"	Titan	66.0	66	52	61.2
"	Themis	78.1	78	....	83.1
"	Hyperion	79.0	78	100	83.1
"	Iapetus	190.0	190	196	187.0
"	Phoebe	698.0	703	772	712.0
Uranus	Ariel	10.0	10	10	10.6
"	Umbriel	14.1	15	16	15.3
"	Titania	22.8	21	....	20.8
"	Oberon	30.4	28	28	27.2

[1] A. E. Caswell, "A Relation between the Mean Distances of the Planets from the Sun," SCIENCE, n.s., 69: 384, 1929.

[2] D. E. Smith, "Source Book in Mathematics," p. 273, 1929.