process of organization an institute to be called the "Ronald Ross Clinique for Tropical Diseases and Hygiene," in which it is proposed that laboratory research and clinical investigation shall be combined as closely as possible in accordance with his teaching. There are already in this country two schools of tropical medicine which have done good work, but their activities are in the main educational. It is proposed that the institute shall supplement and not compete with them; that its primary object shall be research, that a clinical establishment shall be maintained in intimate conjunction with the laboratories, and that the master mind of Ross, assisted by other experts, shall have the fullest scope for the initiation and continuation of researches into the still unsolved problems of tropical medicine. There is a Pasteur Institute in Paris; a Kitasato Institute in Japan; a Gorgas Institute in Panama. It is strongly felt that Great Britain should honor one of her greatest investigators by establishing a Ross Institute in London. To initiate this, $250,000 is required. The public is invited to send subscriptions to the honorary treasurer, Lord Willoughby de Broke, 29 Queen Anne Street, London.—*The Journal of the American Medical Association.*

THE DIRECTORSHIP OF THE RECLAMATION SERVICE

SECRETARY WORK might have given a shorter explanation of the recent removal of Arthur Powell Davis, Director of the Reclamation Service, which would have been more convincing. If he had merely said that Mr. Davis was turned out to make room for a practical politician, that would have been enough.

In his long letter addressed to the American Society of Civil Engineers, Secretary Work labors the point that the time when engineering skill and experience were of first importance in the Reclamation Service is past and that the need now is for "a practical business man familiar with conditions peculiar to irrigation in the West" as Director. The facts are that Arthur Powell Davis was for twenty-one years an engineer in the Reclamation Service, that since 1914 he had been director, and during his term of service all the large storage dams of the West were constructed and others begun, and that Gov. D. W. Davis, of Idaho, who succeeds him, has been known only as a grocer and banker who entered state politics.

The charges that big power interests have conspired to bring about the removal of the distinguished engineer because they are opposed to the Government's policy in reclamation and Arthur Powell Davis's part in it under successive administrations Secretary Work passes over in silence. His answer to the engineers is lame and evasive. To confess the truth would be to admit the unworthiness of his own motives in removing from office Arthur Powell Davis to make room for an Idaho politician.—*The New York World.*

SPECIAL ARTICLES

THE VIBRATIONAL ISOTOPE EFFECT IN THE BAND SPECTRUM OF BORON NITRIDE

THE quantum theory of band spectra[1] indicates that there should be quite appreciable differences between the spectra of isotopic molecules. This is essentially because the spectroscopic frequencies, or, rather, such portions of them as are due to changes in molecular vibrational energy, should be proportional to actual molecular vibration frequencies. The expected isotope effect has already been found[2] in one of the *infra-red absorption* bands of hydrogen chloride; here the absorbed energy is nearly all vibrational.[3] A displacement of 0.055 A.U. has also been found in a comparison of certain lines in the *visible emission* bands of two samples of lead of different atomic weight. Here the emitted radiant energy is partly vibrational, partly electronic in origin.[4]

A much more favorable case than the two foregoing is to be found in boron nitride. Here the vibration frequency should be 2.76 per cent. greater for the lighter isotope $B_{10}N$ than for the heavier, $B_{11}N$, as compared with 0.08 per cent. for HCl and perhaps 0.04 per cent. for lead. The ratio of abundance, 1:5 from the atomic weight 10.83 (Baxter & Scott), is of course somewhat unfavorable. Jevons[5] has measured the heads of two systems of bands which he has satisfactorily shown to be due to boron nitride. In addition to the main "α" and "β" systems, he found certain less developed "subsidiary systems," β_1 and β_2, related to the β system, as well as some extra bands not fitting any system.

Theory predicts that for the band due to the passage of a vibrationless, but electronically excited molecule, to an electronically less excited, and still vibrationless, state, there should be *no isotope effect*

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[1] See, for example, Sommerfeld, "Atombau und Spektrallinien," 3rd Ed., Chap. VI.

[2] Loomis, *Astrophys. Journal,* 52, 248 (1920); Kratzer, *Zeit. für Physik.,* 3, 460 (1920).

[3] There is also a change in molecular rotational energy involved, with a corresponding isotope effect. This is, however, usually a minor factor, and will not be considered in the following discussion.

[4] Grebe and Konen, *Phys. Zeit.,* 22, 546 (1921). The emitting molecule is probably that of some lead compound.—The effect should not be confused with those observed in the *line* spectra of lead isotopes.

[5] W. Jevons, *Roy. Soc. Proc.* A, 91, 120 (1915).

except the very small electronic effect corresponding to that in line spectra.[3] This band may be designated (0, 0), since it corresponds to the change $(n'=0)\rightarrow(n=0)$, n' and n respectively denoting the *initial* and *final* number of vibrational quanta possessed by the molecule. The band (0, 0) is usually one of the more intense members of a band system. On the high frequency side of (0, 0) lie bands for which $n' > n$, or strictly, for which $W_{n'} > W_n$, W denoting vibrational energy. Here the electronic energy emission is supplemented by a contribution from the vibrational energy; the reverse is the case for the bands on the low-frequency side, where $W_{n'} < W_n$. Going from (0, 0) toward either shorter or longer wave-lengths in the band system, there should be a progressively increasing displacement between the bands of two isotopes, the frequencies all being *higher* on the *high*-frequency side for the *lighter* isotope, and *lower* on the *low*-frequency side. The reason for this is that the intervals between successive bands are approximately proportional to the molecular vibrational frequencies, so that the bands of the lighter isotope are on a somewhat *more extended scale* than those of the heavier.

In order to apply the theory to the boron nitride bands, it is first necessary to determine the proper values of n and n′ for each band. This can be done without great difficulty with the help of certain criteria applied by Heurlinger to the cyanogen and nitrogen bands. The following equation then gives, in wave-number units (*in vacuo*), by substitution of suitable values of n and n′, the positions of all the 50 heads of the β system

$$\nu = 42885 + 1268.5n' - 10.20n'^2 - 1873n + 11.85n^2.$$

The (0, 0) band lies at $\nu = 42885$ ($\lambda = 2331$ A.U. (in air)); the values of n run from 0 to 10, those of n′ from 0 to 5.[6]

On examining Jevons's data on the position of the β_1 and β_2 systems, it is found that the β_1 bands all lie at lower frequencies than the (0, 0)β band, and the β_2 bands all at higher frequencies. Furthermore, the β_1 band nearest β(0, 0) lies *very near* β(0, 2), on the *low*-frequency side; and the β_2 band nearest β(0,0) lies *very near* β(1, 0), on the *high*-frequency side. Going toward lower and higher frequencies, respectively, the β_1 and β_2 bands become gradually more and more separated from the corresponding β bands. Moreover, each β_1 or β_2 band is *weaker* than the corresponding β band. All this is exactly what would be expected if the β_1 and β_2 bands belong to the lighter isotope $B_{10}N$. This idea is very greatly strengthened by a comparison of the frequency intervals between neighboring β bands (*e.g.*, the bands (1, 3) and (1, 4), or (1, 4) and (1, 5)) with the intervals between corresponding β_1 or β_2 bands. The theory predicts that these intervals should be approximately proportional to the molecular vibration frequencies, and should therefore be greater for $B_{10}N$ than for $B_{11}N$ approximately in the ratio 1.0276. Making the comparison above suggested for every possible pair of β_1 or β_2 bands with the corresponding pair of β bands, an average value of 1.029 is actually obtained for the ratio. In view of the inexactness of the theoretical prediction,[7] the agreement is very good.

The explanation of the apparent gap between the β_1 and β_2 systems is obviously that the bands of the two isotopes lie very near together in this region. There remain a number of bands which should belong in the β_1 system, but which appear to be missing. The positions of these bands can be calculated by means of the following empirical equation which holds for both the β_1 and the β_2 bands:

$$\nu = 42871 + 1306.5n' - 10.50n'^2 - 1925n + 12.188n^2$$

It is then found that the head of every missing $B_{10}N$ band, with three exceptions, should lie just inside the head of a more intense $B_{11}N$ band, so as to be completely masked by the latter.[8] The three remaining bands are accounted for by three bands observed, but not correlated, by Jevons. A $B_{10}N$ band corresponding to *every* observed $B_{11}N$ band of the β system is thus either observed or accounted for.[9]

The maximum displacements between corresponding bands for the two isotopes are of notable magnitude, *viz.*, 4.5 A.U. toward shorter wave-lengths at λ 2145 (band (3, 0)), and 34.1 A.U. toward the red at λ 3256 (band (3, 9)).

The evidence given above as to the presence of a corresponding set of bands for each of the two isotopes of boron nitride leaves little room for doubt, especially in view of the fact that the absence of such bands would seem to involve the overthrow of the present theory of band spectra. There are, however, certain apparent minor discrepancies and gaps in the data, which it is hoped to remove by means of new

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[6] A corresponding equation has also been determined for the α system, but as the present data on the isotope effect are much more fragmentary than for the β system, the α system will not be discussed here.

[7] This is due to the fact that the measurements refer to band heads. This introduces a variable rotational isotope effect whose magnitude it is not possible to calculate exactly with the data at hand, but which should, qualitatively, increase the ratio above 1.0276, in agreement with observation.

[8] In most cases the $B_{11}N$ band does not correspond to the same values of n and n′ as the $B_{10}N$ band which it masks.

[9] Note the close approach for the calculated position of the (0, 0) band to that for $B_{11}N$. Discussion of the significance of the remaining difference (presumably electronic isotope effect) will be postponed.

experimental work which is now under way.[10] A detailed discussion will therefore be postponed.

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HYDROGEN ION CONCENTRATION AND THE DEVELOPMENT OF SCLEROTINIA APOTHECIA

Recent experiments, performed under the general direction of Dr. J. B. S. Norton, have demonstrated a marked relation between the growth of the apothecial stage of the sclerotinia causing brown-rot of stone fruits and the hydrogen ion concentration of the substrate. The special significance of this relation is due to the following facts: As is now well known, the perfect or apothecial stage of the fungus arises in spring from old mummied fruits on the ground. Mature Sclerotinia apothecia are usually first noted as they discharge ascospores at the time peach trees are blooming, but previous to this time these apothecia have been developing slowly on the ground for a number of weeks. Hence there is a period of weeks, prior to the time when any infection can be caused by the ascospores, during which the apothecia are exposed to possible injury. With this idea in mind a number of experiments, of which a few will be summarized here, have been performed on the effect of different environmental conditions on the developing apothecia.

A preliminary experiment was made in the spring of 1922, using peach mummies with the sporophores developed just sufficiently to protrude from the sclerotia as light brown, rod-like stipes. The mummies were suspended in glass tumblers containing unbuffered HCl and NaOH solutions, to which final pH determinations gave a range of only pH 4.5 to 7. Apothecia developed rapidly to maturity in all. Meanwhile similar peach mummies had been placed partly buried in sand in some pots, and powdered sulphur dusted on in quantities equivalent to 100, 500 and 1,000 lbs. per acre. The apothecia were coated with sulphur, but after temporary inhibition for six days the treated apothecia grew even more rapidly than the checks. In the three treated pots the soil solution reached a pH of 3.5 (colorimetric).

The experiments above had revealed remarkable acid tolerance in developing apothecia, and this phase was followed up in the spring of 1923. Well-buffered solutions were used in a series from pH 1.4 to 11.9, at intervals of about one pH unit. When young apothecia were grown in these, the optimum seemed to be near pH 2.5 with good growth from 1.4 to 5.8. At pH 6.8 growth occurred, but the apothecia did not mature; at 7.7 and higher no growth was observed. Using more nearly mature apothecia, growth was seen in one case near pH 9.5; otherwise, the results were as in the other series.

It seemed probable from this that slight alkalinity in the soil should be sufficient to inhibit the growth of Sclerotinia apothecia. Some peach mummies with developing apothecia were placed in pots of sandy soil, and hydrated lime applied in quantity and with the results indicated in Table I. Note especially the initial inhibition and final development of apothecia in pot 1 in connection with the falling pH in this pot.

TABLE I

Effect of hydrated lime on growth of apothecia

Pot No.	$Ca(OH)_2$ in lb. per acre	pH after	
		1 day	14 days
1	125	6.81	6.55
2	625	6.65	6.65
3	5000	7.30	10.70
4	0 (check)	5.99	6.40

Pot No.	Development of apothecia after				
	1	6	10	14	20 days
1	—	—	trace	++	+++
2	—	—	—	—	—
3	—	—	—	—	—
4	++	+++	+++++	++	-

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[10] Preliminary measurements on the visible part of the boron nitride spectrum now indicate equally good agreement with theory for the α as for the β system, and a quantitative analogy between the two systems in respect to the relative positions of the $B_{10}N$ and $B_{11}N$ bands. The fact that each $B_{11}N$ α band has two pairs of heads, whose structure lines overlie and often resemble the corresponding $B_{10}N$ band heads, tends to obscure the latter, except far from the (0, 0) band, and accounts for Jevons's failure to note $B_{10}N$ heads. A number of the $B_{10}N$ heads are, nevertheless, plainly visible, with the present set-up, even in visual examination of the spectrum. The isotope heads are unmistakable in the two red bands, (0, 4) and (1, 5). For the latter, the stronger pair of $B_{10}N$ heads (middle of pair at λ 6462) lies 94 A.U. farther to the red than the corresponding $B_{11}N$ pair (middle of pair at λ 6368). Some new α bands in the extreme red show an even greater isotope effect. In the ultraviolet, Jevons's data include three unidentified heads which agree closely with calculated positions for $B_{10}N$ head pairs of the α system. One is evidently the weaker head pair of the (4.0) band (the expected stronger pair for this band should, according to calculation, coincide with the weaker $B_{11}N$ pair). The other two heads ($\lambda\lambda$ 3353.3 and 3369.3) evidently are those of the (5.0) band of $B_{10}N$; these lie 18 A.U. farther into the ultraviolet than the corresponding $B_{11}N$ pairs ($\lambda\lambda$ 3373.5 and 3386.8).