having bivalent properties. In the solubility of the ferricyanide[3] and in several basic precipitation processes[4], yttrium is intermediate between neodymium and samarium. No abnormalities associated with bivalency are observed in these cases. In the atomic state, yttrium appears to be interpolated six places earlier, that is, larger, in the lanthanide series than when in the ionic form. Its electron density is lower, and the three additional electrons cause a greater proportional increase in size than in the lanthanide series.

The position which should be occupied by element No. 61 in the rare-earth series appears to be capable of being filled in various circumstances by actinium, thorium, bismuth or yttrium.

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[1] Takvorian, *Ann. chim.*, (xi), **20**, 113 (1945).
[2] Klemm and Bommer, *Z. anorg. Chem.*, **231**, 138 (1937).
[3] Prandtl and Mohr, *Z. anorg. Chem.*, **236**, 243; **237**, 160 (1938).
[4] See Moeller and Kremers, *Chem. Rev.*, **37**, 130 (1945).

Supersonic Cries of Bats

DR. GRIFFIN has recently published[1] some further observations on the cries of bats, which are of great interest. He demonstrates clearly that the pulse of sound is often extremely short, having a duration which usually does not exceed 2·3 milliseconds. He also finds that the frequency of the supersonic tone alters during the pulse, having a frequency, for example, of 80 kc. at the beginning, dropping to less than 50 kc. at the end. This drop of somewhat less than an octave seems to be typical. The records which Dr. Griffin has obtained are very convincing on both these points.

What are not so convincing are his arguments with regard to the mode of production of the supersonic tone. In my paper I advanced the hypothesis that this is emitted through the snout, rather than through the mouth. I also suggested that the buzz and click originated in different structures from those responsible for the production of the supersonic tone. With both these suggestions Dr. Griffin disagrees. He thinks emission takes place through the mouth, and that the three sounds just mentioned are all produced by the same structure.

With regard to the first point: he says that plugging the anterior nares of a bat does not prevent the production of the supersonic tone; secondly, when bats are feeding, the supersonic tone is interrupted; further, if the mouth is sealed with collodion, bats do not fly until they have scraped an opening into the mouth cavity; lastly, covering the nostrils causes an increase in the audible component of a bat's cry.

My comments on the above are as follows: Spallanzani found that plugging the nostrils of a bat caused acute respiratory embarrassment. Why was it that Dr. Griffin did not find the same thing? With regard to the second point, it seems to me much more likely that the interruption during feeding is not produced by the closure of the mouth cavity, but by the act of swallowing. No mammal can both swallow and speak at the same time, because the food-stream has to pass across the ducts which convey the air-stream from the nose to the larynx. Thirdly, since bats do not fly for fun, but to collect food, it would be quite useless for a bat to fly while its lips are sealed in such a manner that food cannot gain access to the mouth cavity. Lastly, it seems to me to be likely that the increase in the audible component of the bat's cry, on sealing the nose, is due to the increased efforts which are necessary in order to force a sufficiently intense supersonic tone for localizing purposes through the mouth cavity.

With regard to the click and buzz which accompany the supersonic tone, Dr. Griffin advances the following arguments: (1) there is no evidence in his records of the presence of a low frequency component; (2) whispered sounds which had approximately the same loudness as the bat's audible click gave cathode ray deflexions which were easily visible; (3) the envelope of the pulse is rather abruptly cut off towards its end.

These facts prove, in Dr. Griffin's opinion, that the audible click results from the abrupt starting or stopping of the pulse. In this case also, I have a feeling that Dr. Griffin is misinterpreting the facts. (1) With regard to the first point, the presence or absence of evidence depends entirely on the properties of the amplifier used by Dr. Griffin. It might be that such low-frequency components, even if present, do not adequately disclose themselves, because of amplifier defects. (2) The fact that whispered sounds produce a visible record does not throw any light on this point because, as is well known, such sounds consist essentially of quite high-pitched components. (3) With regard to the envelope of the pulse, it is true that there are some differences between their beginnings and endings. In Fig. 1 they are about equally abrupt; in Fig. 2 the beginning is much more abrupt than the end; in Fig. 3 the end is much more abrupt than the beginning; in Fig. 4 it is a little difficult to draw any exact conclusion, so that, to my mind, the evidence is far from clear on this point.

If the tympanic membrane and ossicles of a bat act together as a rectifier for the incoming sound, then on the analogy of electricity, one would expect a pulsating direct-current component to be present when the supersonic tone is falling on the ear. This should be appreciated as a musical tone, the frequency of which would depend on the number of pulses per second of the supersonic tone. It is not suggested that this musical tone would be a pure one: on the contrary, Dr. Griffin's records demonstrate clearly that some over-tones would be present. But a musical tone accompanied by over-tones is not at all what a human listener perceives, for Galambos and Griffin describe it as a buzz when it is recurring time after time and as a click when it takes place singly. Dijkgraaf describes the sound as a rattling one. These descriptions do not seem to me to tally at all with what I would have expected from audio-frequency components produced by the incidence of the supersonic tone on the ear. Is it not much more likely that the buzz, click or rattle is produced quite separately from the supersonic tone, that is, by a structure different from the vocal cords? In my article in *Nature*, I suggested the false cords as the originators of these noises; it is possible that the laryngeal orifice is used instead. One or other of these structures being shut, the air pressure in the lungs is raised by muscular contraction, the orifice in question is then suddenly opened, causing a burst of high-pressure air to pass between the vocal cords; at first the pressure is high and the vibrations rapid, but as the pressure drops the frequency drops at the same time.

There are two further points in favour of the view that the supersonic tone is emitted through the nose. It was pointed out to me that the nasal cavities of a bat are almost in a straight line with its vocal cords, thus supersonic tones would have an uninterrupted course out through the anterior nares. Secondly, that the snout, modified into a flat plate as it is in some bats, would be a much more efficient emitting surface for a supersonic tone than would the mouth, which contains the soft structure of variable shape, namely, the tongue.

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[1] *Nature*, **158**, 46 (1946).

Chaos, International and Inter-molecular

STATISTICS of wars have been collected from the whole world for the 120 years beginning with A.D. 1820. Attention was directed to the number of nations, or other large belligerent groups, on each side of any war. Accordingly, wars were classified as 1 group versus 1 group, or as 2 versus 1, or as 2 versus 2, and in general as r versus s. The number of wars of each of these types was counted. The result was a fairly regular statistical distribution, having a peculiar shape. Among a total of 91 wars there were 42 of the type '1 versus 1', 24 of the type '2 versus 1', and not more than five wars of any one more complicated type. The simplest type of encounter was the most frequent.

In a gas at N.T.P. encounters of two molecules are much more frequent than encounters of three, as is well known from chemical experiments. This resemblance between a gas and the political world suggested a theory for each of them. The frequency of an encounter, of specified type, can be regarded, after the manner of Bernoulli, as the product of the following three factors. (i) The number of mutually exclusive encounters of that type. (ii) The probability that the opponents encounter one another. In this factor the probabilities for the separate pairs of opponents combine by multiplication. That is the chief reason why, in the chaos, complicated encounters are rarer than simple encounters. (iii) The probability that all the other nations, or molecules, keep out of the encounter. Strange to say, this third factor escaped the attention of the authors of the classical theory of gases. Consequently at high densities a proportion of the encounters which Guldberg, Waage and their modern successors have regarded as binary, are now shown to be ternary. How this affects the chemistry depends on whether, for molecules, 'two can be company but three none'.

Although three factors of the aforesaid sort are likely to appear in the theory of any chaos, yet their particular forms depend on circumstances; so that many varieties of chaos are conceivable. In the political world there were restrictions depending on geography and on sea-power. When they had been formulated, another effect became conspicuous, namely, the infectiousness of local fighting.

The justifications of the foregoing brief statements have been accepted for publication, those concerning gases in the *Proceedings of the Royal Society*, and those concerning the political world in the *Journal of the Royal Statistical Society*.

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Robert Hooke's Letter of December 9, 1679, to Isaac Newton

THE correspondence between Hooke and Newton in November and December 1679 dealing with experiments on falling bodies led to bitterness and to the final break between them. But "it must be looked upon as one of the greatest and most fortunate events, since it was the direct cause of the composition of the Principia".

When W. W. Rouse Ball published this Hooke–Newton correspondence in 1893, two of the letters were missing. Jean Pelseneer published one which had been found and which is now in the British Museum ("Une lettre inedite de Newton", *Isis*, **12**; 1929). Hooke's letter of December 9, 1679, the rough contents of which were known from the minutes of the meeting of the Royal Society on December 11, the last missing link in this correspondence, has just been rediscovered by me and is in my possession. It is the letter of which Pemberton says that it "put him [Newton] on inquiring what was the real figure in which a body, let fall from a high place, descends, taking the motion of the earth round its axis into consideration", and which caused Brewster ("Life of Newton", 1855, I, p. 291) to add "this gave occasion to his resuming his former thoughts".

The letter covers two folio pages with diagrams; it was at the end of the last century in the collection of Alfred Morrison (1821–97), the well-known collector. It is not described in the thirteen-volume catalogue of the "Morrison Collection of Autographs" (1883–96), nor was its importance recognized by later owners after it was sold on April 19, 1918, at Sotheby's. The publication of the full text is better left to other hands.

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