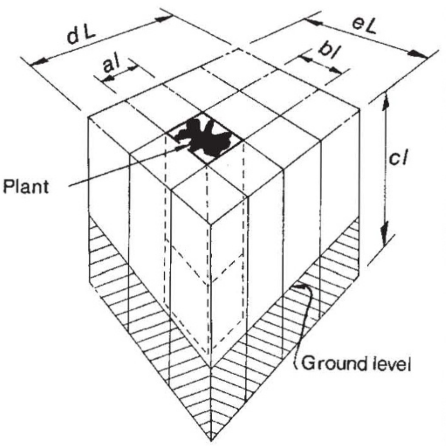
Laying down the –3/2 power law

SIR — Referring to the ecological -3/2 power law, A.F. Hayton[1] mentions White's belief[2] that the ecological "–3/2 law" has not yet been properly explained. The background to the law is indeed traceable to the Japanese origins[3-5] referred to by Hayton. There its attempted explanation is seen to revolve around the consideration of energetics, the energy flux transferring through the surface of a plant to contribute to the energy encapsulated within its volume. Dimensionally these relate to each other according to the square and cube respectively of a typical dimension. In the form of the "–3/2 law" this reduces to the now-famous gradient. However, reservations regarding rigour persist primarily it would appear because mixing the area of the individual plant surface with that of the territory colonized by the whole population threatens to cloud the issue.

Let us instead explore a purely geometric analysis. The figure represents a plant growing within a population of N individuals occupying a territory of area A. Prior to competition the exclusion zones of each, those volumes of air and soil space adequate to meet the entire needs of the plants, would not interfere with one another and the plants could increase their mass without loss of numbers. At the point of interference and thereafter competition would ensue with the result that increasing biomass would be achieved at the price of decreasing distribution density as follows:



The mean mass (m) of the individual, in this case the typical specimen shown in the figure, is $\varrho\, x\, (al)\, (bl)\, (cl)$ in which ϱ is the density of the plant x is the proportion of the space occupied by the plant within its exclusion zone, l is a typical dimension of the plant and, a, b and c are constants for a particular genera relating the plant to its exclusion zone; a would normally be equal to be in this schematic representation.

Thus we have:

$$m = \varrho\, xabc\, l^3 = kl^3 = k\left(\frac{1}{l_2}\right)^{-3/2} = k\left(\frac{N}{Nl^2}\right)^{-3/2}$$

where $k = \varrho\, xabc$, a combination of constants for a particular genera.

Also, if L is a typical dimension of the total territory occupied by the whole population, the area (A) of that territory is $(dL)\,(eL)$ where d and e are constants determining the shape of the area in this schematic representation. However, in a competing community of N individuals $N\,(al)\,(bl) = (dL)\,(eL)$. Therefore, $Nl^2 = (de/ab)L^2$. Hence:

$$m = k\left(\frac{abN}{deL^2}\right)^{-3/2} = k\,(ab)^{-3/2}\left(\frac{N}{deL^2}\right)^{-3/2}$$

$$= K\left(\frac{N}{A}\right)^{-3/2}$$ where K is a derived constant for a particular genera.

Therefore, $\log m = -3/2 \log\left(\frac{N}{A}\right) + \log K$

This is the "–3/2 law". Its derivation thus far requires no significant reference to energetics, although any attempt to quantify K would, as it contains ϱ, x, a, b and c, all of which are to some degree genera-dependent with x in particular almost certainly relating to energetics. However, the basic law is a geometrical phenomenon and perhaps now deserves to be regarded as a true law instead of the mere rule correctly noted by Hayton in relation to previous usage.

A final point, the "–3/2 law" relates the distribution density to the *mean* mass and not the *combined* biomass, as implied by Hayton, although in the context of the above item, in which nations of people are considered as separate units of biomass and treated individually, this does not devalue its contribution.

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1. Hayton, A.F. *Nature* **310**, 178 (1984).
2. White, J. *J. theor. Biol.* **89**, 475-500 (1981)
3. Shinozaki, K. & Kira, T. *J. Inst. Polytech, Osaka City Univ.* **D7**, 35 (1956).
4. Todaki, Y. & Shidei, T. *J. Jap. For. Soc.* **41**, 341 (1959).
5. Yoda, K., Kira, T., Ogawa, H. & Hozumi, K. *J. Biol. Osaka City Univ.* **14**, 107 (1963).

Repetitive sequences in structural genes

SIR — In a recent News and Views item[1], Edward Max discusses the implications of CpG clusters in structural genes. He postulates that these CpG clusters will be under-methylated in germ-line DNA and proposes the experiment of determining whether the CpG-rich regions of histocompatibility Class I genes will be found to be under-methylated in sperm DNA. Our recent study in mouse sperm DNA of the state of methylation of *H-2*, Class I CpG sequences recognized by the isoschizomers *Msp* I and *Hpa* II showed them to be highly methylated. The multiplicity of sequences cross-hybridizing to the Class I probe prevents us from determining the 3′ or 5′ location of the few unmethylated sites. The other sequences studied (β-globin, amylase, and a spermatid cDNA clone) were also highly methylated in germ-line DNA, even from immature testes which contain only pre-meiotic cells.

These results are comparable to those reported by others who have found that structural genes are usually highly methylated in sperm DNA (rabbit β-globin[3], ovalbumin[4], α2-collagen[5]). In contrast, those repetitive sequences which have been studied were found to be hypomethylated in sperm DNA[6-8]. Since the two classes of sequences behave differently at meiosis, the alterations in methylation seen in sperm DNA are unlikely to be secondary to the chromatin structure changes which occur during meiosis.

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1. Max, E. *Nature* **310**, 100 (1984).
2. Rahe, B., Erickson, R.P. & Quinto, M. *Nucleic Acids Res.* **11**, 7947 (1984).
3. Waalvaijk, C. & Flavell, R.A. *Nucleic Acids Res.* **5**, 4631 (1978).
4. Mandel, J.L. & Chambon, P. *Nucleic Acids Res.* **7**, 2081 (1979).
5. McKeon, C., Ohkubo, H., Pastan, I & de Crombrugghe, B. *Cell* **29**, 203 (1982).
6. Chapman, V., Forrester, L., Sanford, J., Hastie, N & Rossant, J. *Nature* **307**, 284 (1984).
7. Sanford, J., Forrester, L., Chapman, V., Chandley, A. & Hastie, N. *Nucleic Acids Res.* **12**, 2823 (1984).
8. Ponzetto-Zimmerman, C. & Wolgemuth, D.J. *Nucleic Acids Res.* **12**, 2807 (1984).

Fourier's law and thermal conduction

SIR — Casati *et al.*[1] recently described a many-body system in which the Fourier law for thermal conductivity was shown to result from the deterministically random dynamics of the system. Their conclusions are interesting, and confirm and extend similar results that were found for another one-dimensional system a year ago[2]. In an editorial comment[3] the importance of the results of ref.1 were correctly described, but again there was no reference to our earlier work. We now wish to discuss the numerical calculations which have been done for the diatomic Toda chain, and to outline some of the outstanding problems in this field.

The diatomic Toda lattice is a linear chain with alternating masses which interact by an exponential force[2,4]. The equations of motion for the displacement q_n and the momentum p_n at site n for the mass ratio $\sigma_{2n} = \sigma$ and $\sigma_{2n+1} = 1$ can be written down as:

$$dp_n/dt = \exp(q_{n-1} - q_n) - \exp(q_n - q_{n+1})$$
$$dq_n/dt = \sigma_n\, Vp_n$$

For equal masses ($\sigma = 1$) this is one of the few discrete lattices which are integrable[5]. For alternating masses the system is not integrable[6] but shows mixing behaviour[2,6].

This diatomic Toda chain was coupled at both ends to two different heat baths containing particles with a maxwellian dis-