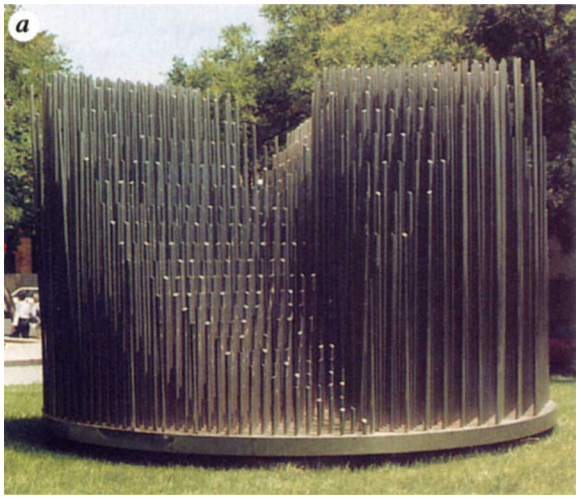
Sound attenuation by sculpture

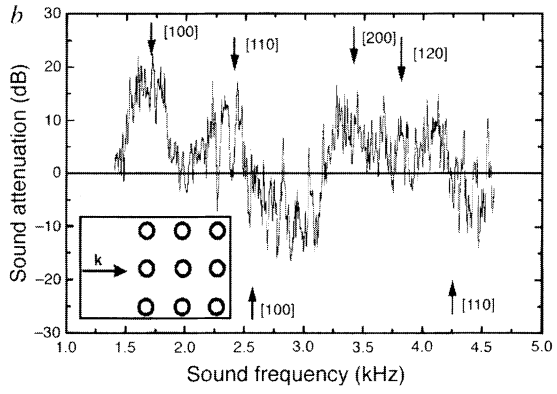
SIR — It is generally accepted that sculptures or *objets d'art* are useless from the scientific point of view. We would like to show here an example of a certain type of sculpture that is of scientific relevance, and which can be related to the recent discovery of the so-called photonic band-gap materials and their generalization to other classical waves[1,2].

Theory predicts that a periodic distribution of wave scatterers, distributed in three-dimensional space, would induce severe attenuation of wave propagation in some spectral regions. The crucial parameters that allow the appearance of gaps are the ratio between the wave velocity in the scatterer and in the host, and also the volume fraction occupied by the scatterers[3]. For elastic or acoustic waves, the density ratio is also important. Experiments are mostly restricted to electromagnetic waves in the microwave region and gaps will appear in a region of wavelengths that corresponds to the periodicity of the scatterers and their geometric size. We are unaware of any experiments on band-gap materials for acoustic waves where band gaps would appear in structures with a periodicity of between a few centimetres and one metre.

These types of structures are well known in modern art and are classified as a form of 'minimalism'. We report here on sound attenuation experiments performed on one of these sculptures (*a* in the figure). The sculpture, by Eusebio Sempere, is exhibited at the Juan March Foundation in Madrid. It consists of a periodic distribution of hollow stainless-steel cylinders, with a diameter of 2.9 cm, simple cubic symmetry and a unit cell of 10 cm. The cylinders are fixed on a circular, 4-m-diameter platform that can rotate around a vertical axis. We have measured sound attenuation in outdoor conditions for sound-wave vectors perpendicular to the cylinders' vertical axis.

The transmission characteristics in decibels vary as a function of the sound frequency (*b* in the figure) with the **k** vector along (100). Similar attenuation spectra have been obtained for other vectors perpendicular to (001), $\mathbf{k}_\perp$. All the spectra have a large noise induced by the sound reflections from nearby buildings. Several maxima (sound attenuation) and minima (sound reinforcement) are present and their frequencies do not depend on $\mathbf{k}_\perp$. The agreement between these features and theoretical maximum and minimum attenuation due to interference of the different crystal planes of the sculpture is fairly good, even though the sculpture does not have an ideal external shape for experimental purposes.





a, Kinematic sculpture by Eusebio Sempere. *b*, Sound attenuation results as a function of the sound frequency. The wave vector is along the (100) direction as shown in the inset. Arrows indicate the calculated maxima and minima due to interference from the different crystal planes of the sculpture.

The Bragg attenuation peak at 1,670 Hz (which corresponds to [100] destructive interference) shows a ratio between the full width at half maximum and the peak energy position of 0.18. This value is similar to that obtained in photonic band experiments for a two-dimensional system[4]. The sculpture corresponds to a Cermet topology with a volume fraction occupied by the scatterers of 0.066 and a velocity ratio of 17.9. These values are close to those for which the calculations predict the appearance of a band gap for the propagation of sound waves in a two-dimensional periodic structure[3]. Therefore, the sound attenuation peak at 1,670 Hz could be ascribed to the formation of the first gap in this sculpture.

R. Martínez-Sala, J. Sancho
J. V. Sánchez, V. Gómez
J. Llinares
Departamento de Física Aplicada,
Universidad Politécnica,
46022 Valencia, Spain
F. Meseguer
Instituto de Ciencia de Materiales (CSIC),
Campus de Cantoblanco,
28049 Madrid, Spain

1. Yablonovitch, E. *Phys. Rev. Lett.* **58,** 2059–2062 (1987).
2. John, S. *Phys. Rev. Lett.* **58,** 2486–2489 (1987).
3. Economou, E. N. & Sigalas, M. M. *Phys. Rev.* B**48,** 13434–13438 (1993).
4. Smith, D. R. *et al. J. opt. Soc. Am.* B**10,** 314–321 (1993).

Why leaves are sometimes red

SIR — Anthocyanins are present in leaves of autumn foliage and rapidly developing shoots in tropical trees, but their function has never been satisfactorily explained. In addition, leaf undersurfaces of many tropical rainforest understory herbs are also red because of the presence of anthocyanins. We have examined leaves of two such taxa and report that anthocyanins intercept quanta otherwise absorbed by chlorophyll *b*, thereby protecting leaves from photoinhibition. We thus confirm what may be a general explanation for anthocyanin function in leaves.

The strong association of undersurface coloration with forest understory and the uniformity of anthocyanins suggest that they are selectively advantageous to plants in extreme shade. The hypotheses of increasing leaf temperature or protecting against damage by ultraviolet-B radiation have been discounted[1,2], and no mechanism has yet been discovered by which they could backscatter radiation and increase light-capture efficiency in the red wavelengths[1]. We have thus examined the hypothesis of photoprotection by anthocyanins in these plants.

Anthocyanins *in vivo* should capture wavelengths otherwise absorbed by chlorophyll *b*, which has a longer wavelength absorbance in the Soret band. Chlorophyll *b* is especially associated with the light-harvesting complex of photosystem II, the principal site of photoinhibition and photodamage in the chloroplast[3]. In understory shade, photosystem II-enriched plants are more susceptible to photoinhibition and damage in brief flecks of sunlight[4]. Anthocyanins should absorb at wavelengths otherwise absorbed by chlorophyll *b*, diminish photoinhibition and increase maximum photosynthesis. Anthocyanins may also allow higher chlorophyll concentrations, possibly correlated with changes in photosystem components and function.

PIGMENT CONCENTRATIONS AND PHYSIOLOGICAL RESPONSES IN GREEN- AND RED-UNDERSURFACED LEAVES OF *BEGONIA PAVONINA* AND *TRIOLENA HIRSUTA*

	B. pavonina		*T. hirsuta*	
Response	Green	Red	Green	Red
Anthocyanin ($n = 5$)				
Absorption peak (nm)		530 ± 4		520 ± 9
μg cm^{-2}	0.0	14.0 ± 0.9	0.0	24.4 ± 4.1
% Dry mass	0.0	1.0	0.0	0.8
Chlorophyll ($n = 10$)				
$a + b$ (μg cm^{-2})	7.22 ± 0.22	10.05 ± 0.29***	17.37 ± 0.65	28.54 ± 1.22***
b (μg cm^{-2})	1.82 ± 0.06	2.92 ± 0.10***	5.71 ± 0.19	9.94 ± 0.40***
a/b	2.96 ± 0.04	2.44 ± 0.04***	2.02 ± 0.02	1.86 ± 0.02***
% Dry mass		0.7		1.0
Maximum photosynthesis (μmol m^{-2} s^{-1}) ($n = 4$)	1.87 ± 0.35	2.27 ± 0.34*	2.81 ± 0.25	3.80 ± 0.34*
F_v/F_m ($n = 10$)	0.672 ± 0.006	0.733 ± 0.007***	0.698 ± 0.011	0.780 ± 0.005***
Quantum efficiency				
Red-enriched ($n = 4$)	0.047 ± 0.014	0.038 ± 0.014 NS	0.026 ± 0.004	0.025 ± 0.002 NS
Far-red-enriched ($n = 4$)	—	—	0.030 ± 0.004	0.031 ± 0.002 NS

Means ± standard errors. *, **, *** Denote levels of significance of <0.05, 0.01 and 0.001, respectively; NS, not significantly different (Student's *t*-test); n = sample size. Plants were grown in a 12-h photoperiod at 25°C and at 35 μmol m^{-2} s^{-1} photosynthetic photon flux density (400–700 nm, PFD); *B. pavonina* in a red : far-red ratio of 0.12, and *T. hirsuta* in a ratio of 0.85. We isolated and identified anthocyanins[2], and estimated chlorophyll and anthocyanin concentrations[10,11]. We measured transient fluorescence with a CF-1000 measurement system (P. K. Morgan Instruments, Andover, MA), with excitation at 500 mmol m^{-2} s^{-1} PFD and dark acclimation of 30 min. We measured photosynthesis with a Li-6200 photosynthesis system (Li-Cor Instruments, Lincoln, NE) illuminated by a tungsten–halogen lamp with heat-reflecting mirror and neutral-density filters, deriving apparent quantum efficiencies from the slopes of light-response curves with the same lamp, also filtered for far-red enrichment.

We examined red and green individuals from populations of two taxa native to rainforest understory shade: *Begonia pavonina* Ridl. (Begoniaceae), from Bukit Lanjang Forest Reserve, Malaysia, and *Triolena hirsuta* Triana (Melastomaceae), from La Selva Research Station in Costa Rica. Undersurface reflectance[5] above 570 nm was not greater in red than in green leaves of either species, which is inconsistent with the backscatter hypothesis[1]. The anthocyanic mesophyll cells (with appreciable concentrations of peonidin-5-glucoside) overlapped in absorption wavelengths with chlorophyll *b* (see table)[6]. Anthocyanins in this layer should produce a spectral gradient that particularly protects the more shade-adapted chloroplasts deep within the leaf[7]. Variable to maximal fluorescence (F_v/F_m; inversely correlated with photoinhibition[4]) was significantly lower in green than in red leaves of both taxa. Anthocyanic leaves in *B. pavonina* sustained greater maximum photosynthesis, consistent with earlier measurements for *T. hirsuta*[8]. Higher chlorophyll concentrations explained the slightly greater red leaf absorbance at 700 nm (ref. 1). However, lower a/b ratios were not associated with an increase in the light-harvesting complex of photosystem II. Chloroplasts of red and green leaves of *T. hirsuta* had less photosystem-I and more photosystem-II oligomer than a spinach control, but were not different from each other from analysis by Deriphat polyacrylamide gel electrophoresis[9]. These leaves also had similar apparent quantum efficiencies (see table).

The photoprotective function of anthocyanins may pre-date their roles as visible pigments, as they occur in plant groups antecedent to the angiosperms. Thus, additional research may further our understanding of the evolutionary origin of anthocyanins.

Kevin S. Gould
School of Biological Sciences, University of Auckland, Auckland, Private Bag 92019, New Zealand
David N. Kuhn
David W. Lee
Steven F. Oberbauer
Department of Biological Sciences, Florida International University, and Fairchild Tropical Garden, Miami, Florida 33199, USA

1. Lee, D. W. in *On the Economy of Plant Form and Function* (ed. Givnish, T. J.) 105–131 (Cambridge Univ. Press, UK, 1986).
2. Lee, D. W., Brammeier, S. & Smith, A. P. *Biotropica* **19,** 40–49 (1987).
3. Anderson, J. M., Chow, W. S. & Oquist, G. in *Photosynthetic Responses to the Environment* (eds Yamamoto, H. Y. & Smith, C. M.) 14–26 (Am. Soc. Pl. Physiologists, Rockville, MD, 1993).
4. Björkman, O. & Demmig, B. *Planta* **170,** 489–904 (1987).
5. Lee, D. W. *Nature* **349,** 260–262 (1991).
6. Lee, D. W., Bone, R. A., Tarsis, S. L. & Storch, D. *Am. J. Bot.* **77,** 370–380 (1990)
7. Terashima, I. & Inoue, Y. *Pl. Cell Physiol., Tokyo* **26,** 781–785 (1985).
8. Fetcher, N., Oberbauer, S. F. & Chazdon, R. L. in *La Selva. Ecology and Natural History of a Neotropical Rain Forest* (eds McDade, L. A., Bawa, K. S., Hespenheide, H. A. & Hartshorne, G. S.) 128–141 (Univ. Chicago Press, 1994).
9. Peter, G. F., Takeuchi, T. & Thornber, J. P. *Methods: A Companion to Methods in Enzymology* Vol. 3, 115–124 (1991).
10. Moran, R. *Pl. Physiol.* **69,** 1376–1381 (1982).
11. Fuleki, T. & Francis, F. J. *J. Fd Sci.* **33,** 72–77 (1968).

Protecting HIV databases

SIR — HIV sequence data are accumulating at an ever-increasing pace. To maintain this information as a useful resource, it is imperative that viral sequence sets are carefully screened for problematic sequences before publication. Sources of error include sample mislabelling, viral culture contamination, or cross-contamination of reagents used for polymerase chain reaction (PCR) and molecular cloning[1]. The most compelling indicators of potential problems include divergent viral sequences from a single individual or an epidemiologically linked pair, near-identity of epidemiologically unlinked viral sequences, or similarity to viral clones that are routinely used in the laboratory.

There are many examples of sequences that have been questioned, based on these indicators[2–5]. For example, the original HIV-1 isolates were anomalously similar, and five publications were ultimately required to settle the issue of sample contamination[6]. Although such relationships may not necessarily be a consequence of experimental error, and instead reflect an interesting biological phenomenon, they nevertheless demand added scrutiny.

A case in point is the study by Briant *et al.*[5], in which 308 HIV type-1 V3 envelope sequences were reported from four mother-to-infant transmission pairs. Each pair was evaluated separately, leading to the conclusion that viral sequences from three of the infants were more heterogeneous than their mothers' viral sequences, and that in these cases multiple viral lineages had been transmitted. These results contrast with the viral homogeneity typically observed early after infection in adults[7,8] and in infants[9–11].

Close examination of the Briant *et al.* viral amino-acid sequence alignment (Fig. 4 in ref. 5) revealed instances of identity or near-identity in sequences from unlinked mother and infant pairs. Our subsequent examination of the viral nucleotide sequences aligned to a single consensus sequence (available on request) revealed several examples of such anomalies. Phylogenetic analysis of the combined sets of viral sequences revealed distinct clusters, yet sequences from each mother–infant pair were found in multiple clusters (see figure). Such evidence strongly suggests that contamination or mix-up of samples had occurred. Infant D was unique in showing little evidence of viral sequence contamination, and substantially lower within-patient viral diversity than the designated mother (see figure and ref. 5).

The quality of sequence data is of paramount importance if meaningful trends are to be found in the many studies undertaken