suggest that there is a physiological difference in the two types of pollen. This suggestion is supported by the differential color change verified in the two types of pollen of *L. pisonis* and by the observation that the bee *X. frontalis* collects only hood pollen from *L. pisonis*. In addition, ring and hood pollen of *C. guianensis* are morphologically distinct. Consequently, we suggest that pollen differentiation in these species of Lecythidaceae has evolved in response to different functions, that of the hood to attract pollinators by providing them with a reward and that of staminal ring to function in fertilization.

Dimorphic pollen has been reported in a number of plant groups (*8*), especially where heterostyly and its associated diallelic incompatibility occurs (*9*), as in *Linum* (*10*), *Waltheria* (*11*), and Rubiaceae (*12*). In these genera, both pollen forms are normally fertile. Dimorphy has been reported in a number of homostylous angiosperms such as *Silene alba* (*13*), *Utricularia flexuosa* (*14*), *Cuscuta reflexa* (*15*), and *Urena lobata* (*16*). Ong and Rao (*8*), in a study of the dimorphic pollen of six nonheterostylous species, found only one, *Brexia madagascariensis* (Saxifragaceae), that showed significant differences in germination between pollen morphs. The smaller pollen form showed no germination in vitro. In the above examples in which heterostyly does occur (*9–12*), the pollen is not produced from different parts of the androecium, as it is in the two species of Lecythidaceae. Therefore, our findings differ from those previously reported. Furthermore, the physiological difference in vitro in the pollen of the two Lecythidoideae studied is established.

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Genesis of Petroleum Hydrocarbons in Marine Sediments

Abstract. *Distribution patterns of isopentane and normal pentane in marine sediments show a reversal in slope at a subsurface temperature of about 90°C. The data indicate that three types of reactions are involved in pentane formation: (i) biological origin at the sediment surface, (ii) low-temperature (< 90°C) chemical reactions yielding predominately secondary carbon structures, and (iii) high-temperature (> 90°C) cracking reactions at great depth yielding predominately straight carbon chains.*

Living organisms and Recent sediments contain a predominance of *n*-alkanes with odd-numbered carbon chains (*1–3*). For example, $C_{29}H_{60}$ composes 86 percent of the normal alkanes in apple wax, and over 90 percent of the normal alkanes in marine plants contain either $C_{15}H_{32}$, $C_{17}H_{36}$, $C_{19}H_{40}$, or $C_{21}H_{44}$. The biogenic origin of *n*-alkanes with odd-numbered chains causes these compounds to dominate mixtures of branched alkanes in surface sediments (*3*).

We have found that normal pentane is dominant over isopentane and neopentane in near-surface samples of Recent marine sediments. Also, the concentration of normal heptane always exceeds that of the methylhexanes. The evidence to date indicates that these *n*-alkanes, like the higher members, are of biological origin. They are believed to be biosynthesized in the organism or by low-temperature decarboxylation of even-numbered fatty acid chains (*4*). Normal pentane is present in concentrations of up to 5 ng per gram of sediment. The mole ratio of isopentane to normal pentane in these sediments is generally less than 1 (Table 1). Most of the samples listed in Table 1 were obtained at sediment depths of less than 25 m with a gravity or piston corer. Nine other samples from the U.S. Gulf Coast, six from the Gulf of Maine, and one from Walvis Bay contained normal pentane but no isopentane.

In many areas, this ratio changes from a value of less than 1 to greater than 1 in the first 500 m of sediments, indicating that isopentane is being formed in larger quantities than normal pentane by low-temperature (< 50°C) diagenetic chemical reactions (*5, 6*). The formation of isopentane by microbiological reactions is considered unlikely due to the rapid decrease in microbial activity in fine-grained sediments after the first few meters. (Most of these sediments are fine-grained clays or carbonates.)

In the Black Sea, the mole ratio of isopentane to normal pentane in the free gas state is about 1 at a sediment depth of 300 m. We previously determined values for the mole ratio of these pentanes in the first 1050 m of Black Sea sediments

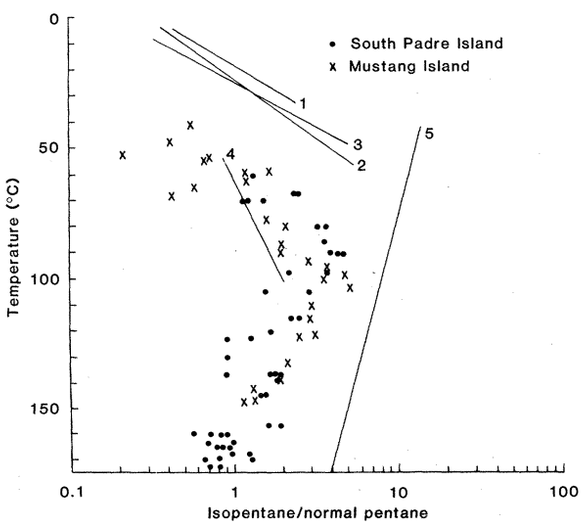

Fig. 1. Change in the mole ratio of isopentane to normal pentane with increasing subsurface sediment temperature. Lines 1, 2, and 3 represent Deep Sea Drilling Project holes 379, 380, and 381 in the Black Sea; line 4, the Paris Basin. Line 5 indicates the calculated equilibrium value.

0036-8075/80/0718-0403$00.50/0

(*7*). Durand and Espitalie (*8*) determined values for this ratio in the Paris Basin to 2100 m. Their data also show an increase in the concentration of isopentane with depth, causing the ratio to be as high as 2. However, Liebovici and Van der Weide (*9*) calculated equilibrium values for this ratio, and their data indicate that the more stable isomer normal pentane should increase with increasing temperature (depth). Figure 1 shows changes in the pentane ratio with depth in three drill holes in the Black Sea (lines 1, 2, and 3) and one in the Paris Basin (line 4). The calculated equilibrium value is also given.

More recently, we analyzed well cuttings from two coastal offshore stratigraphic tests (COST wells 1 and 2) that were drilled to sediment depths of 4800 and 3962 m, respectively. The wells are located east of Mustang and South Padre islands off south Texas. The data show that the ratio of isopentane to normal pentane follows the same trend as in the Black Sea and Paris Basin. It obeys the calculated equilibrium values at temperatures above about 90°C—although the reason for this is probably kinetic rather than thermodynamic. Normal pentane is dominant in the top 25 m. With increasing sediment depth, there is an increase in isopentane due to low-temperature diagenetic reactions. As the temperature exceeds about 90°C (equivalent to 2290 m in COST well 1), there is an increase in normal pentane from the thermal cracking of the organic matter. Research by Thompson (*10*) supports our observations: in three Gulf Coast samples, he found the ratio of isopentane to normal pentane to be 0.7 at 41°C, 1.7 at 66°C, and 0.9 at 193°C.

As previously stated, near-surface normal pentane is believed to be of biological origin. The isopentane, which appears to increase from the surface to a depth equivalent to a temperature of about 90°C, most likely comes from low-temperature carbonium ion or free radical reactions. Such reactions yield branched hydrocarbons as the dominant products (*11*). Isopentane may also originate from the low-temperature alteration of isoprenoid carbon structures containing functional groups that are widespread in nature. Examples are the phytol chain in chlorophyll, terpenoids, steroids, and many plant and animal pigments. The degradation and reduction of even a small portion of these materials would yield the increasing quantities of isopentane observed with depth to 90°C in marine sediments. At higher temperatures, thermal cracking reactions would gradually acquire enough energy to break carbon-carbon bonds in straight chains to give primary free radicals. This would cause an increase in the percentage of normal pentane in the products. Analyses of several hundred natural gases and about 100 crude oils in the United States and Canada show that the ratio of isopentane to normal pentane is usually around 1 (*12*). Three deep Russian oils have an average ratio of 0.4 (*13*).

Table 1. Mole ratio of isopentane to normal pentane in gases of near-surface marine sediments. Numbers in parentheses give number of samples taken.

Area	Mean	Range
Walvis Bay, Southwest Africa (8)	0.58	0.37–0.94
U.S. Gulf Coast (4)	0.18	0.02–0.57
Black Sea (4)	0.13	0.10–0.18
Arabian Sea (2)	0.69	0.55–0.83
Gulf of Maine (1)	0.54	
Shelf off Nantucket Island (1)	0.50	

In summary, at least three types of reactions are involved in the formation of pentanes and, by inference, of other alkane homologs. The normal pentane initially formed originates biologically or chemically at very low temperatures (< 20°C); therefore its concentration is dependent on biological precursors. The relative increase in isopentane with depth up to about 90°C appears to be a universal phenomenon independent of precursors. It results from low temperature (< 90°C) reactions yielding predominately secondary carbon structures. The relative increase in normal pentane at temperatures above 90°C represents free radical cracking reactions that are also basically independent of source material.

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Antibody-Dependent Cell-Mediated Cytotoxicity: Detection by Automated Flow Cytometry with Ultramicro Techniques

Abstract. *Antibody-dependent cell-mediated cytotoxicity can be measured with as few as 1000 leukocytes with an automated flow cytometry technique.*

Antibody-dependent cell-mediated cytotoxicity (ADCC) is a phenomenon of cell-mediated immunity in which antibody-coated target cells are killed by leukocytes bearing Fc receptors in vitro (*1*). Studies in mice have shown ADCC to be an important component in tumor immunity and immunity to parasitic infections (*2*). Clinical studies of the role of ADCC in human disease, however, have been hampered by the need for large quantities of purified mononuclear cells from peripheral blood, an amount that the patient often cannot afford to lose. The reason for large numbers of cells is directly related to limitations of current assay systems. In a common assay for ADCC, antibody-coated ^{51}Cr-labeled target cells are incubated with a 50- to 100-fold excess of mononuclear effector cells; killing is quantified by measuring release of ^{51}Cr (*3*). Since a minimum of 20,000 target cells is usually needed for statistical precision in gamma counting, each single culture requires 1×10^6 to 2×10^6 purified effector cells. To reduce the number of effector cells needed for ADCC assays one can reduce the ratio of effector cells to target cells (E:T) or reduce the number of target cells, or both. In an attempt to achieve these goals we recently developed an assay for ADCC by automated flow cytometry (FCM) in which target cells are distinguished from effector cells on the basis of cellular DNA content; killing is quantified by monitoring the relative loss of target cells. With this method, significant killing could be detected

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