

139 This Week in *Science*

Editorial

141 Volatile Contaminants of Drinking Water

Letters

144 Scientific Integrity: J. O. MASON AND L. W. BIVENS; B. D. DAVIS ■ Clinical and Actuarial Judgment: B. KLEINMUNTZ; D. FAUST, P. E. MEEHL, R. M. DAWES

News & Comment

148 Rockefeller Braces for Baltimore
151 How the Soviets Got the H-Bomb
152 Super Collider Advocates Tangle with Cost Cutters
154 NIH Conflict-of-Interest Guidelines Shot Down ■ Some of the Voices from the Chorus of Protest

Research News

156 *Briefings*: Fleas Turn a Deaf Ear ■ CDC Head Named ■ Moss Landing Labs Destroyed by Quake ■ Stanford News Director Resigns ■ Incredible Lightness of Gyroscopes ■ Bridging the Student-Work Gap ■ Brain Decade ■ Russian Moon Non-Landing ■ Asians Up, Africans Down
158 Pushing the Envelope of Life ■ The Third Kingdom of Life
160 Fossils and British Pride
161 What You Find When Looking for a Soccer Ball
162 Hurricane-Drought Link Bodes Ill for U.S. Coast

Articles

166 Climate and Smoke: An Appraisal of Nuclear Winter: R. P. TURCO, O. B. TOON, T. P. ACKERMAN, J. B. POLLACK, C. SAGAN
177 Superconductivity and the Quantization of Energy: D. G. McDONALD

Research Articles

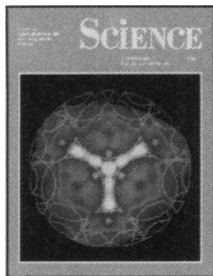
182 Imaging Surface Atomic Structure by Means of Auger Electrons: D. G. FRANK, N. BATINA, T. GOLDEN, F. LU, A. T. HUBBARD

Reports

189 Changes in Mean Concentration, Phase Shifts, and Dissipation in a Forced Oscillatory Reaction: J. G. LAZAR AND J. ROSS
192 Mountains and Arid Climates of Middle Latitudes: S. MANABE AND A. J. BROCCOLI

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COVER Experimental angular distribution of 65-electron volts Auger electrons emitted from an atomically clean platinum[111] single-crystal surface. Lighter colors represent larger signal. Contours (green) depict the theoretical distribution from a pair of adjacent atomic layers. These results reveal that Auger electron angular distributions consist of the “silhouettes” of near-surface atoms “backlit” by Auger emission originating from atoms located deeper in the sample. See page 182. [Data acquisition and graphics by D. G. Frank, N. Batina, and A. T. Hubbard; photography by R. Shaw, University of Cincinnati, Cincinnati, OH]

- 195 Allometric Scaling in the Earliest Fossil Bird, *Archaeopteryx lithographica*: M. A. HOUCK, J. A. GAUTHIER, R. E. STRAUSS
- 198 Global Climate Change and Intensification of Coastal Ocean Upwelling: A. BAKUN
- 201 Ozone Control and Methanol Fuel Use: A. G. RUSSELL, D. ST. PIERRE, J. B. MILFORD
- 205 Repression of *c-fos* Transcription and an Altered Genetic Program in Senescent Human Fibroblasts: T. SESHADRI AND J. CAMPISI
- 209 The Dominant W^{42} spotting Phenotype Results from a Missense Mutation in the *c-kit* Receptor Kinase: J. C. TAN, K. NOCKA, P. RAY, P. TRAKTMAN, P. BESMER
- 212 Localization of an Acetylcholine Receptor Intron to the Nuclear Membrane: S. A. BERMAN, S. BURSZTAJN, B. BOWEN, W. GILBERT
- 214 Perceptual Deficits and the Activity of the Color-Opponent and Broad-Band Pathways at Isoluminance: N. K. LOGOTHETIS, P. H. SCHILLER, E. R. CHARLES, A. C. HURLBERT
- 217 Target Control of Collateral Extension and Directional Axon Growth in the Mammalian Brain: C. D. HEFFNER, A. G. S. LUMSDEN, D. D. M. O'LEARY

Technical Comments

- 221 Phencyclidine, Dizocilpine, and Cerebrocortical Neurons: H. L. ALLEN AND L. L. IVERSEN; J. W. OLNEY, J. LABRUYERE, M. T. PRICE ■ Chloride Channels in Cystic Fibrosis Patients: J. J. WINE AND C. K. SOLC; W. B. GUGGINO; M. J. WELSH, J. D. MCCANN, M. LI, J. P. CLANCY, M. P. ANDERSON

Book Reviews

- 223 The Formation of Science in Japan, reviewed by D. E. WESTNEY ■ Conservation for the Twenty-First Century, K. RALLS ■ The Empire of Chance, G. R. SHAFER ■ Modern Planktonic Foraminifera, H. J. SPERO ■ Biomolecular Data, J. OSTELL ■ Books Received

Products & Materials

- 230 Immune-Deficient Mice for Research ■ Automated High-Performance Capillary Electrophoresis ■ Volume Rendering Software ■ Automated Viscometer ■ Gamma Counter for Absorbance Measurements ■ Centrifugal Vacuum Concentrator ■ Gas Chromatography on the Macintosh ■ Literature

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Volatile Contaminants of Drinking Water

Public concern about possible contamination of water supplies is a fact of life. It is a fear of the unknown that may be overdrawn, but a fear that could lead to a waste of hundreds of billions of dollars. Development of effective means of reducing water contamination would ease concerns while minimizing costs of remediation. This country is only in the beginning stages of conducting the necessary research and development, but progress is being made, particularly in delineating the problems and in conducting research.

The volatile contaminants in a large number of water supplies have been analyzed and means of destroying them are being discovered. The most ubiquitous class of pollutants is chlorinated hydrocarbons, notably TCE (trichlorethylene, $\text{CHCl}=\text{CCl}_2$) and its degradation products. TCE is one of the leading contaminants found in ground water and is the chemical most often detected at Superfund sites. Large quantities of it were widely used for decades in degreasing, and wastes were carelessly disposed of.

The physical properties of TCE have contributed to its widespread occurrence. It has a boiling point of 88°C and a density of about 1.46. Its solubility in water is about 1000 parts per million (ppm). Thus when dirty fluids were conveyed to waste dumps, part of the TCE evaporated, but much of it moved downward; some ultimately encountered ground water. Ground water in aquifers travels at rates as low as a meter per year and as high as meters per day. Plumes of contaminated water that extend 10 km from sources have been noted.

In pure water at pH 7 and ambient temperatures, highly chlorinated hydrocarbons are remarkably stable, with half-lives as long as a million years or more. However, under strongly reducing circumstances, some of the chlorine is removed and the resultant products are more subject to hydrolysis and later to aerobic metabolism.

Because of its widespread occurrence, TCE has been and is the object of considerable research activity. Work by Perry L. McCarty and colleagues at Stanford several years ago showed that under methanogenic (reducing) conditions TCE was almost completely destroyed in a few days. At ambient temperatures in the dark TCE reacts only slowly with oxygen and is ordinarily not subject to attacks by microorganisms. However, some organisms that can employ methane, propane, or toluene with oxygen as sole energy and carbon sources can co-metabolize TCE. This discovery has led to research designed to form the basis for patents on microorganisms to be used in TCE bioremediation. However, many knowledgeable microbiologists suggest that mixed cultures already adapted to the local circumstances will be quite effective. Organisms that can co-metabolize TCE have been found in many places. In one instance a large and active community of microorganisms was found in an aquifer 50 to 65 m beneath the soil surface.

In situ bioremediation of TCE-containing water is apparently limited to fluids containing less than about 100 ppm of TCE. Higher concentrations seem to be toxic. Nevertheless, this leaves enormous volumes of water to which biotreatment might be applicable.

Some fraction of the TCE that has been placed at waste sites remains there in rusting drums that should be removed at once. An additional approach is to transfer contents of the waste site to an incinerator and subject it to high temperatures. This is probably the procedure of choice when concentrations of contaminating waste are high. However, it is expensive, and the cost per unit of waste destroyed can be excessive if the wastes are dilute. Another technique is to bring contaminated water to the surface and to treat it, usually by air stripping. This transfers the contaminant into the atmosphere. One possibility that has not received much attention is a combination of moderate heat, moisture, and oxygen applied to the waste site. One report* states that when a solution of TCE (1 ppm) was enclosed in the dark in a vessel containing air at a temperature of 25°C, the half-life of the TCE was less than a year. At temperatures near 100°C the reaction should proceed in about a day.

Each waste site is different, and each aquifer is different. No single cure-all exists. But a continued systematic approach involving earth scientists, chemical engineers, and microbiologists will surely lead to more effective remediation than has hitherto been achieved.

—PHILIP H. ABELSON

*W. L. Dilling, N. B. Tefertiller, G. J. Kallos, *Environ. Sci. Technol.* **9**, 833 (1975).