AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SCIENCE

ISSN 0036-8075
11 JULY 1986
VOLUME 233
NUMBER 4760

■ **SCIENCE is published weekly on Friday, except the last week in December, and with a plus issue in May by the American Association for the Advancement of Science, 1333 H Street, NW, Washington, DC 20005.** Second-class postage (publication No. 484460) paid at Washington, DC, and at an additional entry. Now combined with **The Scientific Monthly®** Copyright © 1986 by the American Association for the Advancement of Science. Domestic individual membership and subscription (51 issues): $65. Domestic institutional subscription (51 issues): $98. Foreign postage extra: Canada $24, other (surface mail) $27, air-surface via Amsterdam $65. First class, airmail, school-year, and student rates on request. Single copies $2.50 ($3 by mail); back issues $4 ($4.50 by mail); Biotechnology issue, $5.50 ($6 by mail); classroom rates on request; Guide to Biotechnology Products and Instruments $16 ($17 by mail). **Change of address:** allow 6 weeks, giving old and new addresses and seven-digit account number. Authorization to photocopy material for internal or personal use under circumstances not falling within the fair use provisions of the Copyright Act is granted by AAAS to libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of $1 per copy plus $0.10 per page is paid directly to CCC, 21 Congress Street, Salem, Massachusetts 01970. The identification code for *Science* is 0036-8075/83 $1 + .10. **Postmaster:** Send Form 3579 to *Science*, 1333 H Street, NW, Washington, DC 20005. *Science* is indexed in the *Reader's Guide to Periodical Literature* and in several specialized indexes.

■ The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

COVER Quadrants from x-ray diffraction patterns recorded from fibers of the two-stranded polynucleotide poly[d(A-T)] · poly[d(A-T)] at various stages during the D to B conformational transition in the DNA double helix. The diffraction patterns were recorded using the Science and Engineering Research Council's Daresbury Laboratory Synchrotron Radiation Source. See page 195. [W. Fuller, Department of Physics, University of Keele, Staffordshire ST5 5BG, United Kingdom]

SCIENCE

11 JULY 1986
VOLUME 233
NUMBER 4760

American Association for the Advancement of Science
Science serves its readers as a forum for the presentation and discussion of important issues related to the advancement of science, including the presentation of minority or conflicting points of view, rather than by publishing only material on which a consensus has been reached. Accordingly, all articles published in *Science*—including editorials, news and comment, and book reviews—are signed and reflect the individual views of the authors and not official points of view adopted by the AAAS or the institutions with which the authors are affiliated.

Publisher: William D. Carey

Editor: Daniel E. Koshland, Jr.

Deputy Editors: Philip H. Abelson (*Engineering and Applied Sciences*); John I. Brauman (*Physical Sciences*); Gardner Lindzey (*Social Sciences*)

EDITORIAL STAFF
Managing Editor: Patricia A. Morgan
Assistant Managing Editors: Nancy J. Hartnagel, John E. Ringle
Senior Editors: Eleanore Butz, Lawrence I. Grossman, Ruth Kulstad
Associate Editors: Martha Collins, Barbara Jasny, Katrina L. Kelner, Edith Meyers
Letters Editor: Christine Gilbert
Book Reviews: Katherine Livingston, *editor*
This Week in *Science*: Ruth Levy Guyer
Chief Production Editor: Ellen E. Murphy
Editing Department: Lois Schmitt, *head*; Caitilin Gordon, Mary McDaniel, Barbara E. Patterson
Copy Desk: Isabella Bouldin, *chief*; Lyle L. Green, Sharon Ryan, Beverly Shields, Anna Victoreen
Production Manager: Karen Schools
Graphics and Production: John Baker, *assistant manager*; Holly Bishop, Kathleen Cosimano, Eleanor Warner
Covers Editor: Grayce Finger
Manuscript Systems Analyst: William Carter

NEWS STAFF
News Editor: Barbara J. Culliton
News and Comment: Colin Norman, *deputy editor*; Mark H. Crawford, Constance Holden, Eliot Marshall, R. Jeffrey Smith, Marjorie Sun, John Walsh
Research News: Roger Lewin, *deputy editor*; Deborah M. Barnes, Richard A. Kerr, Gina Kolata, Jean L. Marx, Arthur L. Robinson, M. Mitchell Waldrop
European Correspondent: David Dickson

BUSINESS STAFF
Associate Publisher: William M. Miller, III
Business Staff Supervisor: Deborah Rivera-Wienhold
Associate Business Supervisor: Leo Lewis
Membership Recruitment: Gwendolyn Huddle
Member and Subscription Records: Ann Ragland
Guide to Biotechnology Products and Instruments Editor: Richard G. Sommer

ADVERTISING REPRESENTATIVES
Director: Earl J. Scherago
Production Manager: Donna Rivera
Advertising Sales Manager: Richard L. Charles
Marketing Manager: Herbert L. Burklund
Sales: New York, NY 10036: J. Kevin Henebry, 1515 Broadway (212-730-1050); Scotch Plains, NJ 07076: C. Richard Callis, 12 Unami Lane (201-889-4873): Chicago, IL 60611: Jack Ryan, Room 2107, 919 N. Michigan Ave. (312-337-4973); Beverly Hills, CA 90211: Winn Nance, 111 N. La Cienega Blvd. (213-657-2772); San Jose, CA 95112: Bob Brindley, 310 S. 16 St. (408-998-4690); Dorset, VT 05251: Fred W. Dieffenbach, Kent Hill Rd. (802-867-5581).

Instructions for contributors appears on page xi of the 27 June 1986 issue. Editorial correspondence, including requests for permission to reprint and reprint orders, should be sent to 1333 H Street, NW, Washington, DC 20005. Telephone: 202-326-6500.

Advertising correspondence should be sent to Tenth Floor, 1515 Broadway, NY 10036. Telephone 212-730-1050.

Gold

Economic geologists are experiencing a severe depression in demand for their services. The bright spot in an otherwise gloomy picture is gold. The selling price of this metal (about $11 per gram) is sufficient to justify an eager and expanding global search for it.

Many people have the impression that gold occurs as nuggets in streambeds and being a noble metal is only dissolved by aqua regia, a mixture of concentrated hydrochloric and nitric acids. But gold occurs in other environments and is quite mobile under some natural conditions. The concentration of gold in the earth's crust is about 5 parts per billion. Yet a combination of natural chemical and physical processes has led to chunks of gold weighing as much as 30 kilograms. Economic geologists are still arguing about the mechanisms leading to ore formation, but their fund of knowledge and new tools are leading to successes in finding ore. Much of the new gold being found is not in placers but in stratiform deposits. In many of the latter, the gold is disseminated in host rocks in such a way that it is invisible to the naked eye.

The outlines of how gold is extracted from sedimentary or volcanic rocks in which it is present at levels of 5 parts per billion are generally agreed on. Some kind of complexing agent is involved that renders the gold soluble in a hot (175° to 450°C) aqueous fluid. The fluid under great pressure finds its way to a plumbing system, for example, a fault, leading toward the surface. On the way to the surface the complexing agent reacts with wall rock or in some other way loses its solubilizing capability. Gold is not the only element mobilized by this process. Other elements include antimony, arsenic, copper, lead, mercury, molybdenum, silver, and zinc. A number of different complexing agents have been proposed, but the likeliest candidates are those involving sulfur. For example, T. M. Seward conducted experiments with 0.5 molar NaSH at 1000 bars pressure. One kilogram of a solution having a *p*H of 7.47 at 20°C dissolved 150 milligrams of gold at 300°C. At 175°C about 11 milligrams dissolved. The complex formed was probably $Au(HS)_2^-$.

Much of the gold being mined today around the world was mobilized and processed to form placer deposits about 2800 million years ago. The largest occurrences are located at an unconformity between Archean and Proterozoic strata. In the United States the new gold being found was emplaced much later.

The Canadians have been using tools that could be applicable elsewhere.* They have been taking advantage of the fact that vegetation takes in gold. The presence of the element in leaves and woody material can be detected by neutron activation analysis. As little as 1 part per billion can be found in 10 grams of wood ash. This procedure is particularly applicable in Canada because most of the solid rock is covered by glacial till. However, roots of the trees reach deep into the soil. Apparently the roots contain or exude complexing agents that dissolve gold. At any rate, when the sap rises in the spring it carries with it the element. Subsequently during the growing season the concentration of gold diminishes somewhat and varies in different parts of the tree. Some remains at the end of the season. Extensive measurements have been made of trees over gold deposits. The gold concentrations found in the ash of samples from trees growing in glacial till above mineralization often exceed 100 parts per billion when the specimens are collected in early spring. The ash of trees not above mineralization has concentrations about a third as much. One informant was especially enthusiastic about this method. He pointed out that sampling the ground during the winter was difficult and that in summer "the flies eat you." But the vegetation could be harvested at any time. Another informant told of sampling trees from a helicopter.

Although most of the gold known in the United States is in the west, a recent find at Cobalt, Connecticut, indicates that the resources of the east may be substantial. A student field party from the University of Connecticut, led by Professor A. R. Philpott, has found a gold-containing specimen assaying at the level of 190 grams per ton. The find is located at a fault a short distance from an ancient cobalt mine.—PHILIP H. ABELSON

*See D. Carlisle, W. L. Berry, I. R. Kaplan, J. R. Watterson, Eds., *Mineral Exploration: Biological Systems and Organic Matter* (Prentice-Hall, Englewood Cliffs, NJ, 1986).