Picton site have no near-equivalent in our data base, and no estimate of a more accurate location of the source of this galena can be made. The lead isotopic composition of the many small lead-zinc mineral prospects in northwestern New York–southeastern Ontario are variable and possibly distinctive. Further sampling of these minerals might reduce the uncertainty.

Our data demonstrate conclusively that lead isotope measurements can serve to identify the mineralization districts at which Indian burial and habitation site galenas have originated. For those regions for which a sufficient density of lead isotope data enables one to define isotopic zoning, the boundaries of possible source regions can be narrowed.

The data currently available for grave and habitation sites in southern Ontario indicate that at the time of the late Archaic culture some samples of galena were reaching the area from the Upper Mississippi Valley, 1100 km away. The lead isotopic differences that we observe among the Finlan site galenas suggest that more than one mineral deposit in that region was being exploited for galena. Indians of the region were aware of the existence of the lead-zinc mineralization there at the time when the area was first explored by Europeans (*8*), and it is possible that the locations of many mineral outcrops were known in much earlier times. Galena sources closer to the Ontario sites were also exploited. Because of the small number of sites for which we presently have isotopic data, it is not possible to discern any temporal change in galena sources, but both local and distant sources existed and they are clearly distinguishable on the basis of this technique. Further lead isotope measurements may therefore provide us with a means of investigating possible short- and long-term changes in trading patterns, if galenas can be obtained from a sufficiently large number of dated archeological sites.

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References and Notes

1. I. L. Barnes, W. R. Shields, T. J. Murphy, R. H. Brill, *Adv. Chem. Ser. 138* (1974), p. 1; R. H. Brill and W. R. Shields, *R. Numismatic Soc. London. Spec. Publ. No. 8* (1972), p. 279.
2. A. V. Heyl, M. H. Delevaux, R. E. Zartman, M. R. Brock, *Econ. Geol.* **61**, 933 (1966).
3. B. R. Doe, *Lead Isotope Data Bank, Lead Isotopes and Ore Deposits Project* (U.S. Geological Survey, Denver, 1975).
4. I. R. Fletcher, thesis, University of Toronto (1979).
5. Most of the data fields in Fig. 1 are adequately defined by relatively recent lead isotope ratios determined to better than ± 0.15 percent (2σ, where σ is the standard deviation). Only five data points are available for samples from Appalachian mineral occurrences (*3*). To obtain a geographically broader set of data, early isotopic analyses of lower precision (± 0.1 to 0.8 percent) have been included, and some expansion of the data field for this area has undoubtedly occurred. The high-precision data suggest that, when additional measurements for lead minerals from the area are available, the improved definition of the data field will enable us to unambiguously distinguish most Appalachian lead minerals from those in the southeastern Ontario–northwestern New York area.
6. We obtained the isotopic data by using direction-focusing mass spectrometer (15-cm radius of curvature) calibrated for lead mass discrimination by repeated analyses of National Bureau of Standards common lead standard SRM-981 or by double spiking. Uncertainties quoted for the isotopic ratios for each sample are approximately 95 percent confidence limits and include the uncertainties within analyses and in the mass fractionation correction. The lead contamination introduced in sample preparation is 0.2 ng per microgram of sample lead.
7. C. F. Austin and W. F. Slawson, *Am. Mineral.* **46**, 1132 (1961); R. S. Cannon, A. P. Pierce, J. C. Antweiler, K. L. Buck, *Econ. Geol.* **56**, 1 (1961).
8. R. G. Thwaites, *Wis. Hist. Collect.* **13**, 271 (1895).
9. We thank B. R. Doe for the Bautsch Mine sample, M. W. Spence for the Bruce Boyd galena, J. V. Wright for the remaining samples and for helpful discussion and guidance, and P. R. Kuybida for sample preparations. This research was supported by a grant from the National Research Council of Canada.

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Benjamin Franklin and Timothy Folger's First Printed Chart of the Gulf Stream

Abstract. *A print of the Benjamin Franklin and Timothy Folger 1769–1770 chart of the Gulf Stream, all copies of which have been "lost" for nearly 200 years, was found in the Bibliothèque Nationale in Paris. This is the first chart of the Gulf Stream and continues today to be a good summary of its strength, course, and breadth.*

Benjamin Franklin had printed in about 1769–1770 the first chart of the Gulf Stream in order to help the captains of the British packets avoid this swift current and to speed their passage to New York (*1–3*). Partly because the British captains slighted it and partly because of Franklin's role in the confrontation between the American colonies and England, this chart became very rare. Despite considerable effort by many people to find a copy of the Franklin-Folger chart in England and America, not one has been found until now. The chart that most people associate with Franklin, the 1786 version (*4*), was published nearly two decades after the first chart and is really a copy of a copy of it. What may seem surprising is that until now the oldest existing chart of the Gulf Stream was not due to Franklin at all but was one published by William Gerard DeBrahm in 1772 (*5*).

The Franklin-Folger chart is important for several reasons. First it is the first good chart of the Gulf Stream. Before 1768, charts showed only the most rudimentary pictures of currents; only much later were chronometers used to determine ship drift velocities and maps of the surface currents. Second, the chart is a summary of the Nantucket whalers' knowledge of the Gulf Stream. These seamen frequently hunted whales along the edges of the Gulf Stream and learned a lot about its speed, course, and breadth. Third, the Franklin-Folger chart remains today a good summary of the mean path and width of the Gulf Stream and the speeds in its high-velocity core. The Gulf Stream is a large and complex current system that fluctuates energetically in space and time. Even today, the system is difficult to measure and interpret; the measurements that we have agree with the Franklin-Folger chart (*6*).

The creation of the first Gulf Stream chart has been described in Franklin's own hand (*2, 4*). While he was in London as Deputy Postmaster General for the American colonies, Franklin was consulted on the question of why the mail packets took a fortnight longer to sail to America than the merchant ships. In October 1768 Franklin discussed this problem with his cousin Timothy Folger, a Nantucket ship captain then visiting London. Folger told him the packet captains were ignorant of the Gulf Stream and frequently sailed in this current, stemming it. Folger sketched the Gulf Stream on a chart and added written notes on how to avoid the Gulf Stream, and Franklin had the chart printed in 1769 or 1770. However, the British captains slighted the chart, probably because they did not appreciate the implication that American fishermen knew more about ocean currents than the British did. During the early 1770's, the colonies began to revolt against England and Franklin may have suppressed the chart to keep it out of the hands of the British Navy.

In September 1978, I found two prints of the Franklin-Folger chart in the Bibliothèque Nationale in Paris (Fig. 1) (*7*). It

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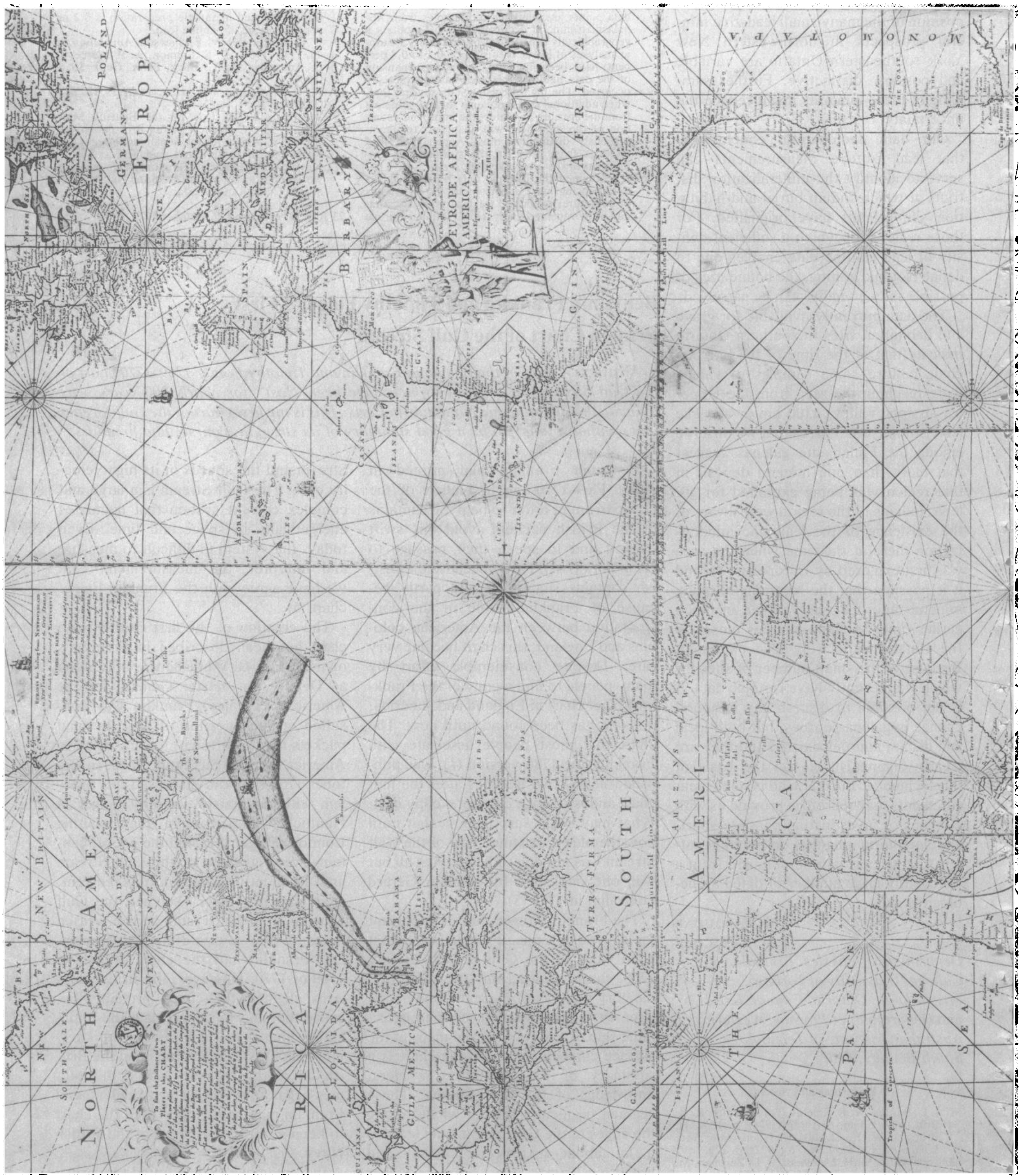
EUROPA
AFRICA
NORTH AMERICA
SOUTH AMERICA
GERMANY
POLAND
FRANCE
SPAIN
BARBARY
GUINEA
MONOMOTAPA
AZORES or WESTERN ISLES
CANARY ISLANDS
CAPE DE VERDE ISLANDS
TERRA FIRMA
FLORIDA
GULF of MEXICO
BAHAMA ISLANDS
NEW BRITAIN
SOUTH WALES
BRASIL
THE PACIFICK SEA
Equinoctial Line
Tropick of Capricorn

Fig. 1. The Benjamin Franklin and Timothy Folger chart of the Gulf Stream printed by Mount and Page in London in about 1769–1770. Two prints of this chart were found in the Bibliothèque Nationale in Paris. [Courtesy Bibliothèque Nationale, Paris]

occurred to me that a copy of the chart might have been saved by the French because Franklin was envoy to France from 1776 to 1785 and both Franklin and his ideas were highly regarded by the French. It was clear that the two charts that I found were examples of Franklin and Folger's 1769–1770 chart for three reasons. First, the Gulf Stream has the same characteristic configuration seen in later versions. Second, the legend, the speeds of the Gulf Stream, and the printed remarks agree with Franklin's 1768 correspondence concerning the chart. Third, a later version of the chart printed by Le Rouge in Paris, which was also in the Bibliothèque Nationale, matches the first chart perfectly and therefore is a direct copy of it. The 1786 American version, frequently referred to as the 1769–1770 chart, is not a direct copy of the original chart; the projection is different, the Gulf Stream has been modified, and there are inaccuracies such as the position of Bermuda.

The Franklin-Folger chart measures 86 by 96 cm; it consists of four separate subcharts joined together along 16°N and 32.5°W. The prime meridian falls through Lizard Point on the southwest coast of England, 5.2° west of Greenwich. The legend on the chart is as follows:

A New and Exact Chart of
Mr. E. Wrights projection, rut: Mercators
Chart, con: the Sea Coast of
EUROPE, AFRICA, &
AMERICA, from the Isles of Orkney to Cape
Bona Esperance, & Hudsons Bay to the
Straits of Magellan
According to the Observations of
Capt. E. Halley, fellow of the R: S.
To the Rt. Honorable and Principle Officers &
Commissioners of his Majesties
Navy, This chart is most humbly dedicated
and presented by
their most obedient faithfull servants
John Mount & Th. Page.
Sold by
Jno. Mount and Tho. Page at
The Postern on Great Tower Hill London

Located east of Newfoundland on the chart are Folger's instructions on how to avoid the Gulf Stream and banks and shoals when sailing westward. These remarks were clarified and amplified by Franklin and were included with his 1786 chart.

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References and Notes

1. For a description of the history and significance of the Franklin-Folger chart see: F. Bache, *Proc. Am. Philos. Soc.* **76**, 731 (1936); L. Brown (*2*); L. De Vorsey (*3*).
2. L. Brown, in *Essays Honoring Lawrence C. Wroth* (Anthoensen, Portland, Maine, 1951), p. 69.
3. L. DeVorsey, *Imago Mundi* **28**, 105 (1976).
4. B. Franklin, *Trans. Am. Philos. Soc.* **2**, 294 (1786).
5. W. G. DeBrahm, *The Atlantic Pilot* (T. Spilsbury, London, 1772). See (*3*).
6. H. Stommel, *The Gulf Stream: A Physical and Dynamical Description* (Univ. of California Press, Berkeley, 1958); F. C. Fuglister, in *Progress in Oceanography* (Pergamon, London, 1963), vol. 1; L. V. Worthington, in *On the North Atlantic Circulation* (vol. 6 of the Johns Hopkins Oceanographic Series, Johns Hopkins Univ. Press, Baltimore, 1976); C. Mann, *Deep-Sea Res.* **14**, 337 (1967).
7. The address of the Bibliothèque National is 58 rue Richelieu, 75084 Paris, Cedex 02, France. The charts are located in the Department des Cartes et Plans and are identified as follows: Portefeuille 117, Division O, Pièces 7 and 7′, Mount and Page: A New and Exact Chart. Photographic copies of the chart may be obtained from the Service Photographique of the Bibliothèque Nationale, which provided several copies for me, one of which is shown in Fig. 1. Since this report was written, L. DeVorsey has identified a third copy of the Franklin-Folger chart in the Naval Library, Ministry of Defence, Empress State Building, Lillie Road, London, S.W. 6, England.
8. I thank F. C. Fuglister, who suggested to me that the Franklin-Folger map of the Gulf Stream was a very good summary of the Gulf Stream and who spent many hours discussing various aspects of this body of water with me. I thank the librarians at the Bibliothèque Nationale who were very helpful in my search for the Mount and Page chart and the Le Rouge chart. Funds for this work were provided by the Office of Naval Research under contract N00014-74-C-0262, NR 083-004, and the United States–France Exchange of Scientists Program, which is funded by the National Science Foundation and the Centre National de la Recherche Scientifique. This report was written during a year that I spent at the Muséum National d'Histoire Naturelle in Paris. I thank H. Lacombe and J. Gonella who helped arrange my visit and all the members of the Laboratoire d'Océanographie Physique who made my stay a pleasant one. Contribution 4421 from the Woods Hole Oceanographic Institution.

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β-Adrenergic Regulation of α_2-Adrenergic Receptors in the Central Nervous System

Abstract. *Incubation of rat cerebral cortical slices with the β-adrenergic agonist isoproterenol causes an increase in α_2-adrenergic receptor binding in addition to a decrease in β-adrenergic receptor binding. The effects are rapid and reversible, show a parallel time course, and are blocked by sotalol, a β-adrenergic receptor antagonist. The β-mediated regulation of α_2-receptor sensitivity at brain norepinephrine synapses may be a mechanism for the homeostatic control of central noradrenergic activity.*

Modification of receptor sensitivity appears to be one of the methods by which hormone action, or synaptic chemical transmission, is regulated. At norepinephrine (NE) synapses, long-term receptor stimulation in vivo desensitizes receptors, whereas transmitter depletion, NE terminal destruction, or long-term receptor blockade supersensitizes both α- and β-receptors (*1–3*). Furthermore, a rapid and reversible β-receptor desensitization occurs in rat brain tissue in vitro after it is exposed to agonist (*4*). With regard to localization and function, α-adrenergic receptors have been subdivided into those mediating the postsynaptic or postjunctional response to NE (α_1-receptors), and those controlling the release of NE from presynaptic NE terminals at peripheral sympathetic junctions and at central noradrenergic synapses (α_2-receptors) (*5*). We have studied alterations in brain α_2-receptor sensitivity in response to in vitro pharmacological manipulation of central noradrenergic synaptic function. The results indicate that long-term activation of the β-adrenergic system, while decreasing the number of β-receptors, rapidly and reversibly increases the number of α_2-receptors at central noradrenergic synapses.

Cerebral cortical slices (0.26 by 0.26 by 2.0 mm) from adult male Sprague-Dawley rats were transferred in gauze bags from ice-cold oxygen-saturated buffer (*6*) to vials containing fresh buffer at 37°C. After initial incubation (with one change of buffer) in drug-free medium for 40 minutes (in an atmosphere of 95 percent O_2 and 5 percent CO_2) in a shaking bath, 100 μM (−)-isoproterenol was added to the medium, and incubation was maintained at 37°C. At various times after the addition of isoproterenol, slices were transferred to ice-cold tris-saline buffer and centrifuged three times at 1200*g* for 30 seconds at 4°C, with intermediate resuspension in fresh cold buffer. The slices were then resuspended in cold 0.05*M* tris-HCl buffer (*p*H 7.7 at 25°C), disrupted with a Brinkmann Polytron, and the resulting membranes washed twice by centrifugation.

Assays for β-receptor binding, using [^{3}H]dihydroalprenolol (New England Nuclear, 58.5 Ci/mmole) as a ligand, and α_2-receptor binding, using *p*-[^{3}H]aminoclonidine (New England Nuclear, 46 Ci/mmole) as a ligand, were performed (*2, 7*). Membranes derived from slices were incubated at 25°C in triplicate with various concentrations of [^{3}H]-dihydroalprenolol for 20 minutes or

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