The controversy over the Science in American Life exhibit at the Smithsonian Institution, funded by the American Chemical Society, reflects conflicting approaches to understanding and explaining the history of science. Until very recently, scientists virtually owned the history of science. The History of Science Society was founded by practitioner-historians (that is, working scientists who also wrote the history of science). Practitioner-historians shared the values of their scientific colleagues. In their hands, the history of science glorified the activities of great scientists (mostly male) and the inevitable progress of scientific knowledge, as well as technological control over the natural world. However, as more and more Ph.D.-trained historians of science entered the field, conflict became inevitable. Historians of science and practitioner-historians frequently have very different approaches to the subject. Take one critical example. As part of graduate education, historians of science are trained to recognize and appreciate a variety of historiographical perspectives. Historiographical diversity includes a range of methods, theoretical concerns, and interpretative frameworks. There is no single canonical interpretation of the past. The subject is too vast; the cast of characters too great.

The task of the historian is not to discover ultimate truth, but rather to construct a carefully researched, coherent, and convincing explanation of selected aspects of human behavior. In short, historians write (and organize museum exhibits) from a clearly defined historiographical perspective. They explain and interpret the development of science as a social, political, economic, and intellectual process in a carefully defined context. They do not feel compelled to justify the ways of scientists to the rest of humanity.

Neither scientists nor their professional organizations can be allowed to practice censorship over the activities of historians of science. If the American Chemical Society wanted a "better living through chemistry" celebratory exhibit, they should have hired a hall. However, practitioner-historians and their patrons should put aside claims of special privilege and enter the market place of ideas, where explanations and interpretations openly compete for approval and support.

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Beta-Carotene and the Prevention of Cancer

In her 22 April News & Comment article (p. 500), Rachel Nowak comments on the Finnish study (*1*) on the effects of supplements of beta-carotene on the incidence of lung cancer among heavy smokers in Finland. Beta-carotene appeared to markedly increase the incidence of the cancer, and she notes that "the Finnish study has triggered calls for a moratorium on health claims about antioxidant vitamins." Moreover, a similar conclusion has been widely published in the general press, one that has probably confused many readers who had been told by scientists for several years that beta-carotene is among the best candidates for the prevention of cancer.

However, the dosage schedule of the supplementation of beta-carotene and the additive used in the Finnish study (*1*) might have been far from optimal. First, Finnish volunteers received a daily supplement for several years, which resulted in an increase in the concentration of beta-carotene in their serum, from a median value of 0.18 milligram per liter to 3.0 milligrams per liter (*1*). It is well known that beta-carotene is converted to vitamin A (retinol) in the body. Even very high doses of beta-carotene supplementation do not result in a significant increase in the concentration of retinoids in the serum under normal conditions. Moreover, it has been suggested, on the basis of experimental and clinical studies, that retinol is an anticarcinogen (*2*). This suggestion has led to the study of vitamin A in lung cancer chemoprevention (*2*). But there is also some evidence that dietary vitamin A can increase the risk of cancer at some sites (*3*). Thus the supplementation of beta-carotene could result in a significant increase in the concentration of retinoids in the serum of heavy smokers, because smoking can result in a disturbance of the metabolism of beta-carotene and retinoids. Furthermore, it is known that, at high concentrations, retinoids can promote, rather than prevent, the development of lung cancer in experimental animals (*4*). Thus, a question arises concerning the concentration of vitamin A in the serum of the studied people before and after supplementation.

Second, some exogenous antioxidants could convert into pro-oxidants, and to avoid such conversion, it is necessary to stabilize them. Beta-carotene stabilized in different mixtures of nontoxic antioxidants (*5*) has been found to decrease the frequency of cancer in hamsters and rats. In addition, the stabilized form of beta-carotene

prevents the formation of precarcinogenic DNA lesions in the liver of rats exposed to human hepatocarcinogens (6).

Combining beta-carotene with other carotenoids, such as lycopene (the red pigment in tomatoes), might result in an increase in the anticarcinogenic effectiveness of the carotene. Lycopene is not converted to vitamin A, and it is the best quencher of singlet oxygen (this reactive form of oxygen can induce precarcinogenic DNA lesions). Support for the use of lycopene also comes from epidemiological studies in which serum lycopene was associated with a lower risk of cancer for some sites (7). To protect nuclear genes, such as antioncogenes, against oxidative precarcinogenic damage, lipophilic antioxidants need to be combined with natural hydrophilic antioxidants (5), which can protect DNA against the damage induced by hydroxyl radicals. Centenarians are relatively resistant to cancer, perhaps because their antioncogenes, such as the p53 gene, and their products are better protected against oxidative damage. Clear guidelines for intervention trials could be developed based on improved rationales for the prevention of common chronic diseases, and the organization of a committee responsible for such development might be necessary.

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In Nowak's article, carotene and vitamin A are classified as "antioxidants." Chemists classify vitamins E and C, as well as many other compounds with "active" hydrogens, as antioxidants because they quickly terminate chain reactions involving free oxygen. Carotenes and vitamin A do not terminate such reactions and, in fact, may propagate them. Therefore they have long been classified as "pro-oxidants," although this terminology is not commonly used.

An increase in the rate of occurrence of lung cancer (assuming it is not a statistical fluke) is one possible outcome of the Finnish experiment (*1*). The Finnish epidemiological results (*1*) are in support of, not in opposition to, the oxygen radical theory of carcinogenesis. The study is also of great value in that it suggests we may eliminate consideration of singlet oxygen (a highly active form of oxygen, but not a radical) as crucial to the initiation of lung cancer.

The results of the Finnish study (*1*) should not be taken as a reason to discourage other investigations into the possible carcinogenicity of singlet oxygen. A more likely place than the lungs to look for singlet oxygen effects is the stomach. The acidity of the stomach ensures that any imbibed hydrogen superoxide (a radical) would be quickly converted to hydrogen peroxide and oxygen, of which some would be in singlet form. Reasonably pure water contains superoxides resulting from continuous radiolysis by background radiation or by contained radioactive substances (*2*). A change of pH by one unit or a 10-fold change in background radiation rate changes the steady state concentration of superoxide in water by 3.16-fold. Accumulated superoxide, by conversion to singlet oxygen (at least under certain circumstances) may