GENETIC EFFECTS OF BISULFITE:
IMPLICATIONS FOR ENVIRONMENTAL PROTECTION

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INTRODUCTION

Sulfur dioxide is unique among environmental substances because of the many routes of human exposure to it. Combustion of coal and oil releases SO₂ into urban atmospheres. It is added to foods, beverages, and pharmaceuticals and we produce it within our bodies as a product of the catabolism of sulfur containing amino acids. It is short-lived within us, as it is rapidly oxidized to sulfate by sulfite oxidase.

The many ways in which this substance reaches us are matched by the many names used to describe it. It exists as sulfur dioxide in the gaseous state. In water it hydrates to form H₂SO₃, sulfurous acid. This substance is too acidic to persist as such within living cells. At neutral pH, it dissociates to a mixture of bisulfite (HSO₃⁻) and sulfite (SO₃²⁻). In more concentrated solutions, it dimerizes to some extent to metabisulfite (S₂O₅²⁻), also called pyrosulfite. It can exist in the solid state entirely as metabisulfite, and is sometimes sold commercially in this form. The mixture of forms present in a solution will depend on the pH, ionic strength, and other conditions of the solution, but not on the route used to prepare it. In this paper, I will refer to the gaseous form as sulfur dioxide, and the forms in solution as bisulfite, whatever the actual composition present.

The regulation of our exposure to sulfur dioxide and bisulfite (in the United States) is also divided into many parts. Exposure to atmospheric sulfur dioxide is controlled by the Environmental Protection Agency, which sets permissible levels under the terms
of the Clean Air Act. Ingestion of bisulfite in foods and pharmaceuticals is regulated by Food and Drug Administration, and consumption in wines and beer by the Bureau of Alcohol, Tobacco Products, and Firearms, Department of the Treasury. Each of these forms of exposure to sulfur dioxide is a matter of economic importance, and its regulation has been a subject of controversy. The various agencies have responded to different sources of information on the health effects of sulfur dioxide, and taken contrasting regulatory positions.

In this review, the sources of our environmental exposure to sulfur dioxide will be surveyed briefly, and the information on its health effects provided by epidemiology and toxicology studies. Genetic and biochemical studies will be brought up to date. In a final section, the implication of the genetic studies for future regulatory policy will be discussed. Only selected references of importance will be cited. A fuller, more completely documented account may be obtained by consulting my earlier review (1), and the recent one by Gunnison (2).

SULFUR DIOXIDE IN THE AIR (3)

Coal and oil contain organic sulfur compounds and inorganic sulfides. When they are burned as fuel, sulfur oxides are released into the atmosphere. Electrical power plants are the most important source of sulfur dioxide emissions. The amount of $S_2O_2$ released can be limited by using coal and oil of lower sulfur content, desulfurization of fuel prior to combustion, or scrubbing $S_2O_2$ from the emissions. Each of these alternatives is expensive, and the selection of a method of choice involves a balancing of costs with the degree of desulfurization that is desired (4). Heated controversy has accompanied the enactment, enforcement, and revision of the Clean Air Act, with its attendant costs amounting to billions of dollars (5).

A number of considerations have provided the motivation for removing sulfur oxides from the air: the adverse ecological impact of acid rain, damage to vegetation, and corrosive effects on materials. However, the threat to human health has always been put forward as the matter of greatest importance (5,6).

HEALTH EFFECTS OF INHALED SULFUR DIOXIDE

Sulfur dioxide is only one substance in the complex mixture of pollutants that exists in urban atmospheres. Epidemiological studies have indicated that air pollution can lead to increased deaths and illnesses among those affected. Excess deaths in the thousands, and hundreds, respectively were associated with short-