The "Now" Effects of Smoking

By **GARLAND E. JOHNSON**

One of the most difficult concepts to get across to students and the general public concerns the cause and effects of events where there is a large gap of time between the two. People are not often sufficiently motivated by warnings of possible damage to their health 10, 20, or 30 years from now to change their behavior and give up the habit of smoking. But the carcinogenic and emphysema-producing effects of smoking have been well documented in cases of continuous smoking over a long period of time.

The idea of trying to present to students some of the immediate physiologic effects of smoking was stimulated by a laboratory exercise developed by Harry Fierstine, called "The Measurement of Carbon Monoxide in the Expired Air of Smokers and Nonsmokers." It was presented during a "Short Course on Air Pollution," held in August 1970 and sponsored by the U. S. Department of Health, Education, and Welfare; the National Air Pollution Control Administration; and the Environmental Engineering Dept., California State Polytechnic College, San Luis Obispo.

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Table 1. Health effects of carbon monoxide. Adapted from a table by D. M. Snodderly, Jr. (Scientists' Institute for Public Information, 1970).

Concentration of CO in air	*Carbomonoxy-hemoglobin in blood (COHb)*	*Symptoms*
300–400 ppm	30–40% and above	Severe headache Dim vision Nausea Collapse
100 ppm	Up to 20%	Headache Impaired performance on tests
50 ppm and below	2–4% and above; maximum about 8%	Impaired visual threshold Impaired ability to judge time Errors on psychologic tests
15 ppm	Up to 2.4%	Could cause some effects on vision Could cause loss of time judgment

Effects of Carbon Monoxide

The "now" effects of smoking that can be presented to science students center on the effects of carbon monoxide, produced during the burning of a cigarette, on the physiology of the smoker.

Carbon monoxide cannot be tasted, smelled, or otherwise detected by the body; nor does it directly affect the eyes, nasal passages, or lungs. Instead, it diffuses unchanged through the membranes of the lungs into the bloodstream, where it combines with hemoglobin, the component in the red blood cells normally responsible for carrying oxygen to all the tissues of the body. This binding of carbon monoxide

Fig. 1. Students collect a breath sample. Note poster, pertinent to demonstration.

to hemoglobin is about 210 times stronger than the binding of oxygen to hemoglobin; therefore a small amount of carbon monoxide in the ambient air has a greatly magnified effect on the capacity of the blood to transport oxygen. All of the cells of the body may suffer from this oxygen deprivation, but the organs most sensitive to low concentrations of oxygen are the heart and the brain (Scientists' Institute for Public Information, 1970).

By measuring the concentration of carbon monoxide in the exhaled breath of a smoker and of a nonsmoker an indirect approximation of the portion of the hemoglobin tied up as carbomonoxyhemoglobin (COHb) can be made. From this information it is possible to predict the symptoms that might be experienced (see table 1).

It must be kept in mind that in addition to the accumulation of COHb from smoking, a significant amount of CO is found in the air we breathe. Table 2 illustrates the CO buildup at places of heavy motor-vehicle traffic where concentrations of CO have been measured in excess of 50 ppm. It has been estimated that 102 million tons of CO were emitted in the United States in 1968; this amounted to half of all major air pollutants that year. Vehicles using internal-combustion engines were the major contributor: 58% (National Air Pollution Control Administration, 1970).

Fig. 2. Transferring sample to indicator tube by means of gas-detector pump.

Details of the Experiment

Measurement of the amount of carbon monoxide in the expired air can be made with a Unico gas detector kit, commonly used by industry and public health agencies for measuring small concentrations of gases. Indicator tubes for measuring a variety of gases are available. The tubes cost about 50 cents each; the detector kit is around $75 complete. Teachers who have a good working relationship with their county environmental health officers may be able to borrow the gas-detector kit and purchase the gas-indicator tubes. Of the two types of CO-indicator tubes available, the length-of-stain (Kitagawa No. 100) has proved to be the most useful.

Table 2. Carbon monoxide levels at various locations. (Scientists' Institute for Public Information, 1970).

Location	*CO levels (av. ppm)*
Los Angeles freeways	37
Los Angeles freeways: slow, heavy traffic	54
Los Angeles: severe inversion	30 (for over 8 hours)
Parking garage	59
Cincinnati intersection	20
Detroit, short peak	100
Detroit, residential neighborhood	2
Detroit, shopping center	10
Manhattan intersection	15 (all day long)
Allowed industrial exposure for 8 hours (for comparison)	*50 (recently lowered from 100)*

In this demonstration, three samples of expired air are obtained: from a nonsmoker, from a smoker who is between cigarettes, and from a smoker who is exhaling cigarette smoke. The exhaled breath can be collected in a toy balloon (fig. 1), and with a little care the end of the indicator tube can be inserted into the balloon opening. To prevent the escape of all the expired air a heavy rubber band is wrapped around the balloon opening and the end of the indicator tube (fig. 2). The sample can then be taken by pulling out and locking the calibrated vacuum pump. The instructions included with the gas detector kit tell how long to wait before withdrawing the tube from the balloon.

The concentration in parts per million is read by comparing the length of stain in the indicator tube (fig. 3). The brown stain is produced by the reaction of CO with reagents within the tube, not by the accumulation of tobacco tars.

Each of the students can check the length of stain;

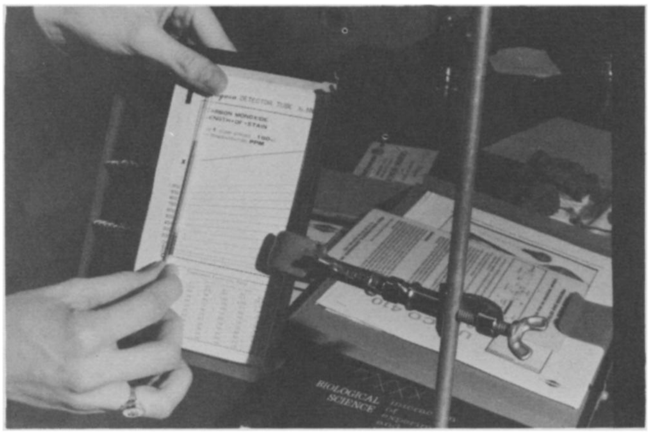

Fig. 3. Reading the length of stain.

or, if the classroom is equipped with closed-circuit TV, the entire class can record the data from the screen (fig. 4). The indicator tubes can be resealed with wax and kept for reference. Fig. 5 shows the comparison of the results of the test of three breath samples. The range of results that might be expected are given in table 3.

Implications of the Data

During the demonstration the students were asked to record the data and to estimate therefrom the amount of hemoglobin bound up with carbon monoxide and the potential physiologic effects.

One student who was a smoker volunteered to give up smoking because of the results of the demonstration and the discussion of the physiologic effects of smoking. His carbon monoxide concentration dropped from 250 ppm to a background of 20 ppm within two weeks after he had quit.

The reduction in oxygen-carrying capacity caused by smoking has been related to the stress placed on the heart. For example, Spain and Bradess (1970) noted that cigarette-smoking has an exceptionally close statistical correlation with sudden acute coronary deaths and was associated with shorter survival time of acute coronary episodes.

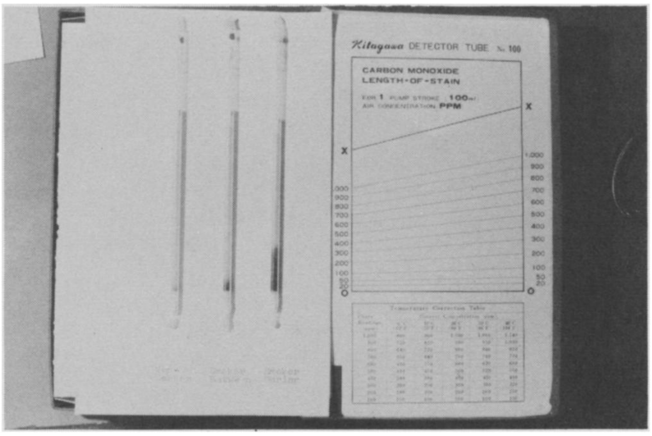

Fig. 5. Comparison of results. Tubes are (left to right) from nonsmoker, smoker between cigarettes, smoker while smoking.

Another illustration of the immediate physiologic effects of smoking can be found by looking at the differences in the oxygen–hemoglobin disassociation curves of smokers and nonsmokers (fig. 6). Not only does the smoker's blood carry less oxygen; it does not release it to the tissues as readily as does the blood of a nonsmoker. This effect (not fully understood) can be passed on to the recipient of a blood transfusion from a smoker. The homeostatic mechanism of the hemoglobin–oxygen transportation system is affected by smoking (American College of Cardiology, 1970).

Table 3. Range of carbon monoxide in expired breath.

Subject and occasion	*Ppm*
Nonsmoker	5 to 20
Smoker: between cigarettes	50 to 150
Smoker: while smoking	250 to 600

Fig. 4. Student presents data on closed-circuit TV (screen at left).

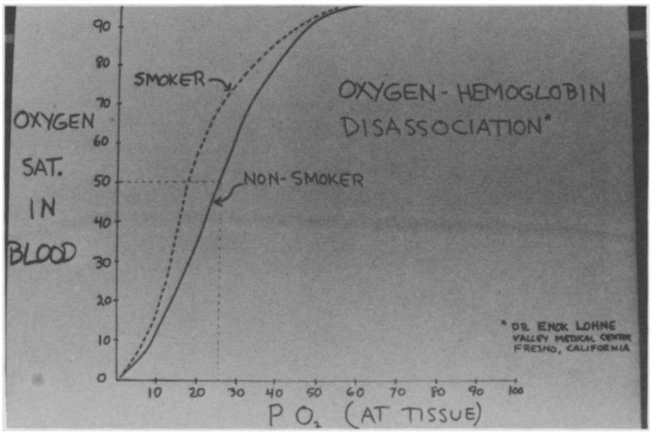

Fig. 6. Depression of oxygen release in smokers; chart by Enok Lohne, Valley Medical Center, Fresno.

The acute effects of inhalation of cigarette smoke on pulmonary function have been demonstrated (Chiang and Wang, 1970). Although no difference was measured in the lung volumes and flows of smokers and nonsmokers, breath wash-out studies indicated significant differences of residual volume, lung clearance index, nitrogen wash-out time, size of lung compartments, and alveolar dilution factors. In fact, these authors recommended that no pulmonary-function test be conducted until at least an hour after the patient's last cigarette.

These three "now" effects of smoking—oxygen-carrying capacity of the blood, depression of the oxygen–hemoglobin disassociation curve, and acute effects on pulmonary function—can be effectively used to show the cause-and-effect relationship of smoking on the physiology of the smoker.

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NEW STATE RESPONSIBILITIES

The Woodrow Wilson Center for Scholars, at the Smithsonian Institution, has published *Managing the Environment: Nine States Look for New Answers*. Prepared by Elizabeth Haskell and Smithsonian staffers, the report tells how nine representative states—Illinois, Minnesota, Washington, Wisconsin, New York, Vermont, Maine, Maryland, and Michigan—have begun to modernize their governmental structures to deal with ecologic problems. New responsibilities are being undertaken by land-use and waste-management agencies, the state courts, and consolidated environmental departments. *Conservation News* calls the report "a valuable document for any group . . . interested in environmental problems and the practical details of modifying 'the system' to solve them." A who-does-what feature is a list of persons interviewed in each state. The report is available from the Woodrow Wilson Center for Scholars, Smithsonian Institution, Washington, D.C. 20560.

Bio-de-grade-able . . . . . . **from p. 70**

dents in this particular class believed that the experiment was a worthwhile experience and that it should be repeated with future classes is some indication of its success.

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LIFE ON THE SEABED

Ecologic theory says a stable environment should lead to the presence of many kinds of life. The ocean floor is a highly stable environment. It is constantly dark, constantly cold, and constantly low in available food. Such an environment, stable or not, has been thought to be relatively inhospitable to life; the ocean floor has even been called a biologic desert.

But Howard L. Sanders, a Woods Hole (Mass.) Oceanographic Institution scientist, working with National Science Foundation support, has been writing even the deep-ocean floor into ecologic theory. He has been finding that even though the density of life may be low, the diversity of species on the deep-ocean floor "is about the same as that in the physically stable, shallow, tropical marine environment," where life abounds.

Earlier efforts to sample life forms from the seabed 450 to 4,500 m beneath the surface met with relatively little success; the limited number of samples brought up in dredges led inevitably to the conclusion that there were few kinds of life to find. But through the use of improved collecting equipment of their own design, Sanders and his colleagues have been able to find tens of thousands of organisms where their predecessors found few or none at all. In 19 samples, for instance, they retrieved 3,257 specimens of a single bivalve species, only one specimen of which had ever been seen before. Of another almost unknown species, they retrieved 255 specimens in 10 samples. Sanders has found that deep-sea-floor species, of which there appear to be thousands, vary far more with depth than they do with geography, and that the sea-floor temperatures are often far more critical to their survival than are pressures.