

THE FEDERAL COAL MINE HEALTH PROGRAM
IN 1973

FOURTH ANNUAL REPORT
OF
HEALTH ACTIVITIES
UNDER THE
FEDERAL COAL MINE HEALTH AND SAFETY ACT
OF 1969



U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

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SUMMARY

The Federal Coal Mine Health and Safety Act of 1969 authorizes the National Institute for Occupational Safety and Health to conduct programs related to the health, protection of life, detection of respiratory impairment, and prevention of disease in coal miners and others who work with or around the products of coal mines.

The coal mine health program was expanded and strengthened during calendar year 1973. Funded for \$5,317,000 in fiscal year 1973, the program was budgeted for \$9.1 million in fiscal year 1974. Significant increases in funds were allocated for legislatively mandated medical examinations, engineering research, and autopsies. Approximately \$3.5 million was obligated for development of clinical facilities for the diagnosis and treatment of respiratory impairment among coal miners.

By the end of 1973, NIOSH's Receiving Center at the Appalachian Laboratory for Occupational Respiratory Diseases (ALFORD), Morgantown, West Virginia, had processed 71,446 chest X-rays of active underground coal miners, including 15,844 roentgenograms from new miners. These examinations were offered to all coal miners under the 1969 Act. Coal workers' pneumoconiosis (CWP) was observed in 125 of each 1,000 (or 12.5 percent) of the miners examined. Of these, 80 had Category 1 (early) CWP, 33 had Categories 2 or 3 (established) CWP, and 12 had complicated or severe CWP (also known as progressive massive fibrosis, PMF).

During 1973 when the second round or cycle of examinations began, ALFORD changed the program by publishing revised specifications for giving, reading, classifying, and submitting roentgenograms. All X-ray facilities that participated in the first round were again required to demonstrate their ability to take high quality chest X-rays before being reapproved.

The second round relies heavily on specially

tested, proficient readers for final decisions regarding pneumoconiosis. By December 31, 1973, 990 physicians (A readers) had demonstrated their competence in the use of the UICC/Cincinnati and/or ILO-U/C Classification Systems for X-rays of pneumoconiosis, and 60 physicians (B readers) had passed a special proficiency test for final readers.

The scope of the examination was expanded by adding an occupational history questionnaire.

By the end of 1973, the National Coal Workers' Autopsy Service had accepted 672 post mortem examinations — 291 in 1973, 313 in 1972 and 68 in 1971, the year of the program's inception.

Autopsies of miners whose bodies were recovered after being sealed in mines for up to 1½ years demonstrated that death from carbon monoxide could be determined even after a prolonged time.

Coal mine health research included community surveys to determine the prevalence and progression of CWP and to evaluate its impact on the life expectancy of miners, development of biochemical techniques as a diagnostic aid for the early detection of respiratory impairment prior to irreversible changes taking place, and investigations of the following: (a) the mechanism by which lung function is altered by CWP; (b) possible genetic predisposition or biologic sensitivity in the development of CWP and other occupational respiratory diseases; (c) the relationship of infectious diseases, such as viral infections, to disability in coal miners; and (d) coal mine dust and the reactions of individual cells and tissues to the dust.

Major accomplishments and findings of the coal mine health program in 1973 include:

- Estimation of the prevalence of CWP among all working coal miners — 15 percent — based on the results of the first round of examinations in the national

study of CWP, and in the service study.

- Publication of final results of the first round of medical examinations under the Federal Coal Mine Health and Safety Act of 1969.
- Demonstration that complicated CWP shortens life.
- Demonstration that exposure to dust in-

hibits the ability of cells to produce a virus-fighting compound (interferon).

- Application of the scanning electron microscope in the relationship of coal dust and tissues in CWP.
- Demonstration of a reaction in the lower respiratory airways to upper respiratory irritation in hay fever victims.

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ADMINISTRATION

INTRODUCTION

Under Public Law 91-173, the Federal Coal Mine Health and Safety Act of 1969 (as amended by P.L. 92-303), the Secretary of Health, Education, and Welfare conducts programs related to the health, protection of life, detection of respiratory impairment, and prevention of diseases of coal miners and others, who work with or around the products of coal mines. The National Institute for Occupational Safety and Health (NIOSH) has been delegated operational authority for all aspects of these Department of Health, Education, and Welfare responsibilities except the payment of Black Lung Benefits, which is carried out by the Social Security Administration. The Mining Enforcement and Safety Administration of the Department of the Interior has responsibility for coal mine safety research and for enforcement of both health and safety standards for coal mines. The duties of NIOSH can be described as assuring that every coal miner, so far as it is possible, has healthful working conditions.

In 1973, NIOSH continued its progress in fulfilling the responsibilities of the Department of Health, Education, and Welfare under the Act.

A close working relationship was maintained with the Mining Enforcement and Safety Administration, Department of the Interior, and with the Interim Compliance Panel in aiding them to carry out their duties. NIOSH's activities under the Act were undertaken for the most part at the Appalachian Laboratory for Occupational Respiratory Diseases (ALFORD) at Morgantown, West Virginia; however, significant work was also carried out in the NIOSH laboratories at Cincinnati, Ohio.

PROGRAM COSTS AND PROJECTIONS

The funding levels for fiscal year 1972 and fiscal year 1973 were \$6,138,000 and \$5,317,000 respectively. NIOSH's budget in fiscal year 1974 provided \$9,100,000 directly attributable to activities under the Federal Coal Mine Health and Safety Act of 1969. Of this amount, \$3,582,000 was a one-time appropriation for the development of clinical facilities for the analysis, examination, and treatment of respiratory and pulmonary impairments in active and inactive coal miners as authorized by section 427(a) of Public Law 92-303.

The program areas funded in fiscal years 1973-1974 were as follows:

	1973		1974	
	<u>Dollars</u>	<u>Percent</u>	<u>Dollars</u>	<u>Percent</u>
Support of Interim Compliance Panel and Advisory Council	295,000	6	270,000	3
Medical Examinations and Autopsy Program	1,712,000	32	2,050,000	23
Clinical and Rehabilitation Research	1,741,000	33	1,567,000	17
Engineering Research	500,000	9	600,000	7
Laboratory Research (e.g., Bio-chemistry, Toxicology, etc.)	1,069,000	20	1,031,000	11
Development of Clinical Facilities	—	—	3,582,000	39
TOTAL	5,317,000	100	9,100,000	100

Based on the fiscal year 1975 Presidential budget, it is anticipated that the amount provided for activities under the Federal Coal Mine Health

and Safety Act of 1969 will total \$4,900,000 in fiscal year 1975.

MEDICAL SERVICE PROGRAMS

Two important medical service programs for miners and their families — the medical examination program for active underground coal miners and the autopsy service program — were established by the Federal Coal Mine Health and Safety Act of 1969 and are the most visible of the responsibilities assigned to NIOSH.

EXAMINATIONS FOR UNDERGROUND COAL MINERS

To protect the health of the man who is now working underground and to evaluate the effectiveness of current coal mine health standards (in particular the air-borne dust standard) section 203 of the Act provides that coal mine operators will provide periodic medical examinations for employees in or at underground mines. Also, section 203 provides that every new miner be given a chest X-ray at the time he enters coal mining and at intervals thereafter. It is NIOSH's responsibility to assure each coal miner the opportunity to be examined and to provide the results of these periodic medical examinations to the miners and their physicians.

By the end of December 1973, NIOSH's Receiving Center at the Appalachian Laboratory for Occupational Respiratory Diseases (ALFORD) in Morgantown, West Virginia, had processed over 71,000 X-rays collected in the first round of medical examinations of active underground coal miners made under the Act, including examinations of new miners.

First Round X-ray Data Evaluated

The rate at which X-rays were submitted to the receiving center (see Table 1) fluctuated not

only according to the cycle of examinations provided for in the Act, but also according to the rate at which new miners were hired. It is believed that a substantial portion of the new miners were replacements for miners retired on "Black Lung" benefits.

The distribution of States of the prevalence of CWP among the miners examined is presented in Table 2.

The results of the 71,446 X-rays (55,602 of which were from active underground coal miners and 15,844 of which were from new miners) reveal that 125 out of every 1,000 active underground coal miners examined has CWP to some degree. That is, out of every 1,000 active underground coal miners 80 have category 1, which is early CWP; 33 have categories 2 or 3, established CWP; and 12 have complicated or severe CWP, which is also called progressive massive fibrosis (PMF). These data are illustrated in Figure 1.

These data do not necessarily reflect the current nationwide prevalence of CWP for two reasons. (1) Participation in the first round examinations was about two thirds of the eligible miners in the country. (2) Many of the older men who would be expected to have more CWP either did not participate in the first round or left the industry, having qualified for "Black Lung" benefits. However, even these data which are biased toward young men confirmed that the longer a man works in or at an underground coal mine, the greater his chances of having CWP. (See Figure 2) For further reference to estimated and actual CWP prevalence, see Chapter 3 (National Study of Coal Workers' Pneumococniosis, Results of the First Round).

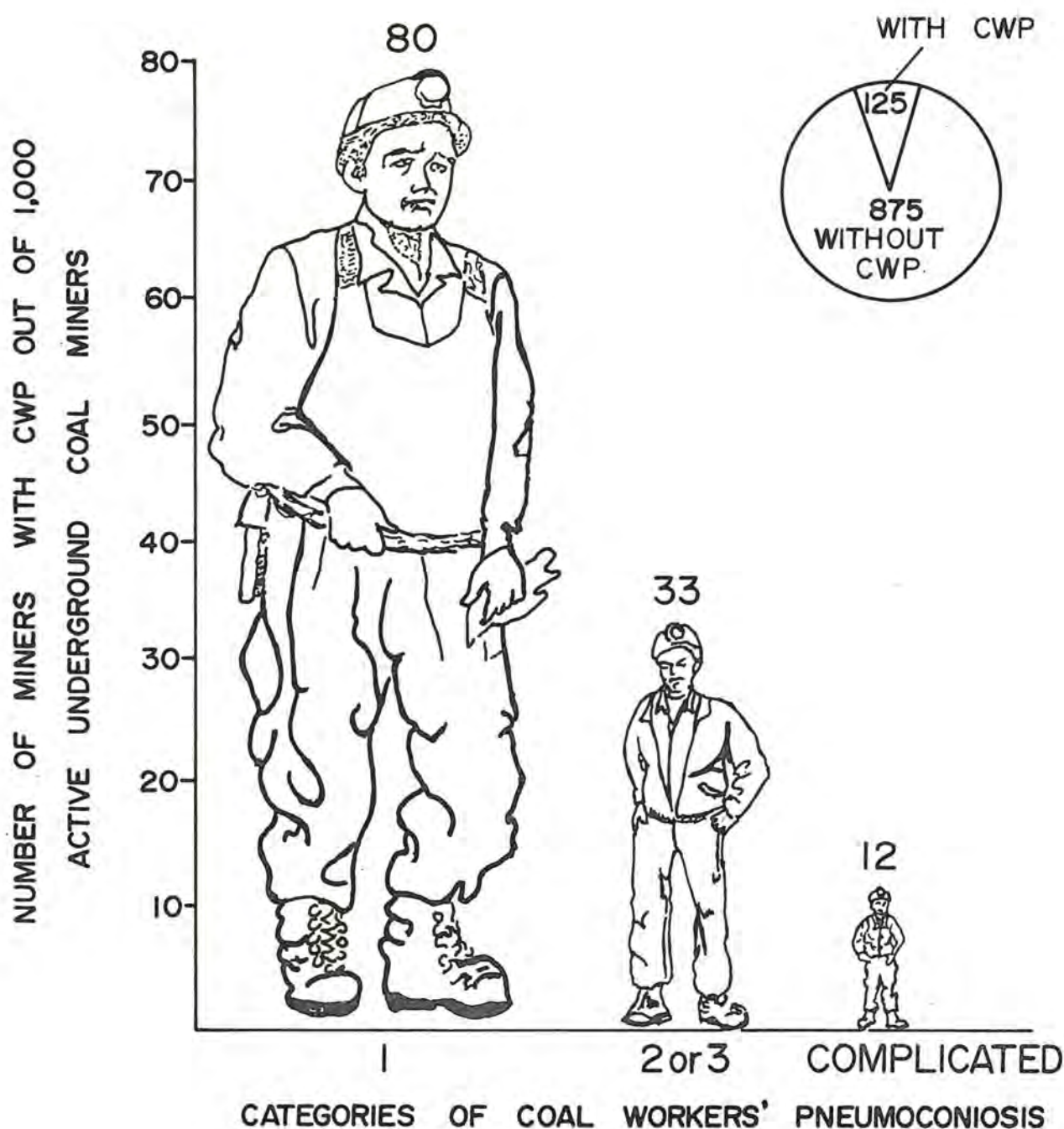


Figure 1. Relative occurrence of CWP, by category, among the 125 affected miners out of every 1,000 miners examined under the Act.

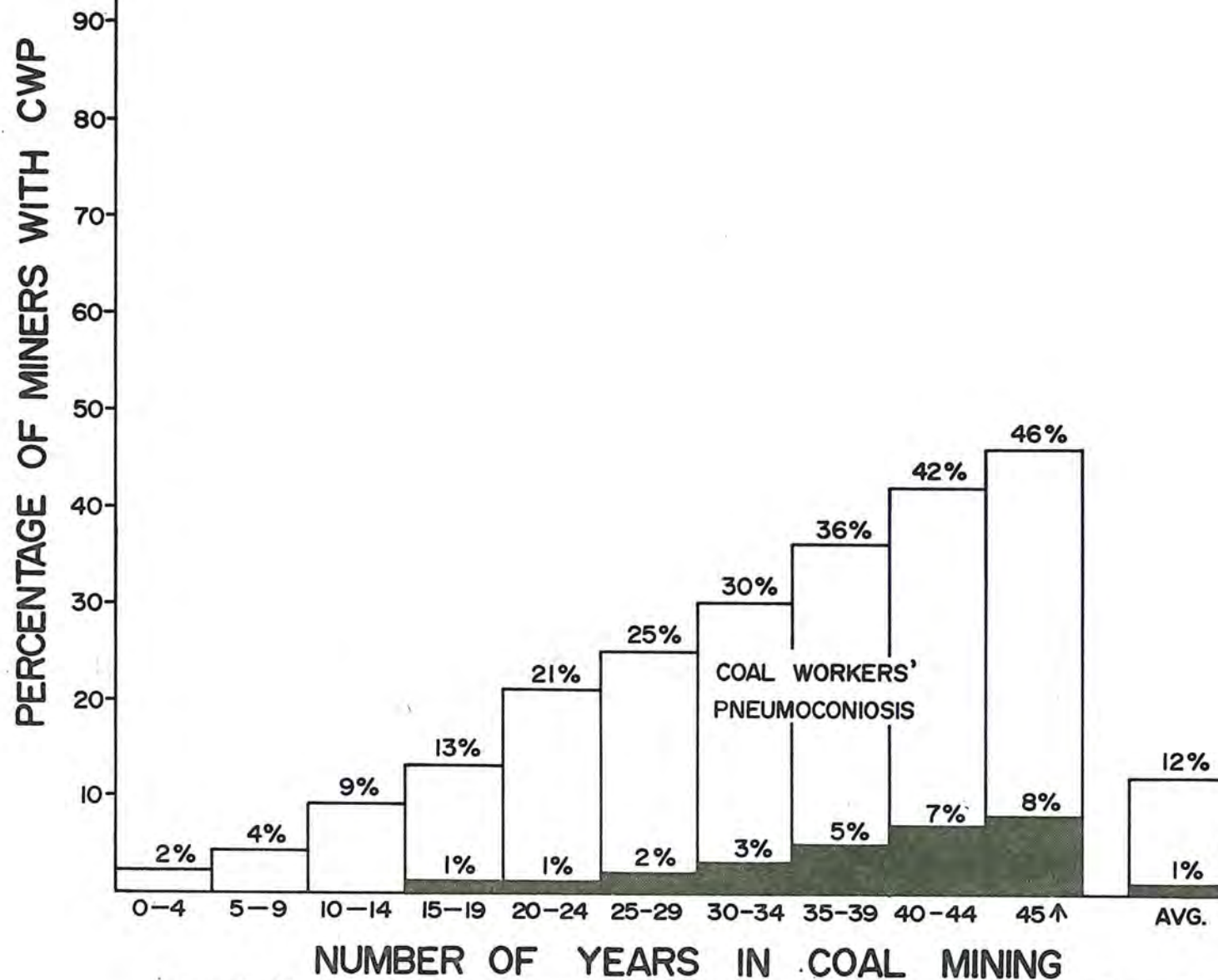


Figure 2. Number of years in underground coal mining related to the percentage of miners with simple and complicated CWP.

Table 1. X-rays Made as Part of the Medical Examination Program and Sent to the NIOSH Receiving Center, 1969-1973.

Round (inclusive dates of examinations)	X-rays		Miners examined, number ^{1/}		
	Year taken	Number	Total	Active miners	New miners
First (Dec. 30, 1969 to Dec. 1, 1971) ^{2/}	1970 ^{3/}	7,238	7,229	6,675	554
	1971	48,563	47,221	41,223	5,998
Interim (Jan. 1972 to July 1973)	1972	16,184	15,406	8,695	6,711
	1973	7,355	7,132	3,636	3,496
	Jan. to July				
Second (July 1973 to Dec. 1973) ^{4/}	1973 July to Dec.	665	662	338	324

^{1/}Duplicate X-rays have been submitted for some miners; thus, the total number of X-rays received is larger than the total number of miners examined.

^{2/}The Act, which was signed on Dec. 30, 1969, requires that all coal miners be offered the opportunity to be examined within 18 months of its passage. Thus, the first round of examinations included any X-rays taken on Dec. 31, 1969.

^{3/}Includes X-rays taken on Dec. 31, 1969.

^{4/}The second round of examinations will probably conclude Dec. 30, 1974.

Table 2. Coal Workers' Pneumoconiosis by State as determined in the first round of examinations under the Act

State	Coal Worker's Pneumoconiosis							Total
	Category 1/ 0	Simple, category			Complicated, stage			
		1	2	3	A	B	C	
Alabama	1,182	109	15	3	6	1	—	1,316
Arkansas	22	5	—	—	—	1	—	28
Colorado	991	21	8	1	2	1	—	1,024
Illinois	3,758	337	78	7	17	11	1	4,209
Indiana	152	12	6	—	1	—	—	171
Iowa	66	2	—	—	—	—	—	68
Kentucky	12,117	793	186	15	33	17	1	13,162
Maryland	41	8	4	—	—	—	—	53
Montana	14	—	—	—	—	—	—	14
New Mexico	26	3	1	1	—	—	—	31
Ohio	2,917	126	31	1	9	1	—	3,085
Oklahoma	21	1	—	—	—	—	—	22
Pennsylvania:								
Anthracite	698	190	77	8	26	26	7	1,032
Bituminous	12,617	1,380	558	36	156	71	8	14,826
Tennessee	254	20	15	—	1	—	—	290
Utah	661	35	7	—	4	1	—	708
Virginia	5,188	305	100	12	29	10	4	5,648
Washington	22	—	—	—	—	—	—	22
West Virginia	22,763	1,760	818	61	73	97	24	25,696
Wyoming	35	1	1	—	—	—	—	37
Unknown	4	—	—	—	—	—	—	4
Total	63,549	5,108	1,905	145	457	237	45	71,446

1/ No CWP.

Second Round of Examinations Begun

In 1973, ALFORD began preparing for the second round of medical examinations of active underground coal miners as required by the 1969 Act. On July 27, 1973, the revised regulations — a subpart of part 37 of Title 42, Code of Federal Regulations, entitled "Chest Roentgenographic Examinations" — was published in the *Federal Register* (38 FR 20076). This subpart contains the specifications for giving, reading, classifying, and submitting chest roentgenograms in the second round of medical examinations of coal miners. Interested persons were invited to participate in the rule-making procedure through the submission of comments. Due consideration was given to all material presented, with the result that a number of changes were made in the proposed version of the rules.

Occupational History Questionnaire. On the basis of its experience with the first round, ALFORD made several major changes in the program for the second round of examinations. The scope of the examination itself was expanded by the addition of an Occupational History Questionnaire. The questionnaire is optional for the miner, but the procedures provide that, when an Occupational History Questionnaire exists, it be made available to the physician who interprets the miner's X-ray. This increased knowledge of his patient will not only help the physician to interpret the roentgenogram more effectively for occupational disease, but also will allow him to be alert for other important conditions which may be revealed in the X-ray.

X-ray Quality. The revised regulations include several specific provisions to insure the high quality of X-rays in the second round. Under the revised regulations, all X-ray facilities which participated in the first round are required to be re-approved to take chest roentgenograms in the second round. To be eligible to participate in the second round, an X-ray facility must demonstrate its ability to take high quality diagnostic chest X-rays for pneumoconiosis.

The unique aspect of the revised regulations is the requirement that the facility submit an X-ray of a plastic test-object (stepwedge) which is available on loan from ALFORD. The radiograph of the plastic step-wedge readily and reliably reveals several specific and vital characteristics of the X-ray machine and the manner in which it was used, characteristics which immediately affect the quality of the X-ray made.

This plastic test-object was developed under contract for NIOSH.

A total of 232 X-ray facilities applied for approval to participate in the second round by December 31, 1973. Of these, 125 had been approved. The remainder were either disapproved, or their approvals were still pending into 1974. *Interpretation Procedure.* The revised regulations also contain a major change in the method of obtaining interpretations of the X-rays for CWP. In round two, no X-ray will receive more than two readings; three readings of each X-ray were often required in round one. Under the revised regulations, interpretations are made by two types of readers. The first or "A" reader must have demonstrated his proficiency in the use of the International Labour Organization system for X-rays of pneumoconiosis. He may do so either by completing a course of instruction approved by ALFORD on the ILO-U/C Classification System or by submitting to ALFORD six sample X-rays classified by him which are considered properly classified by a panel of expert radiologists assembled by ALFORD. The last or "B" reader must pass a specifically designed proficiency examination given by ALFORD.

To obtain definitive interpretations of second round chest X-rays, all X-rays submitted to ALFORD which have been interpreted at the X-ray facility by "A" readers will be submitted to "B" readers, whose interpretations shall be final.

By December 31, 1973, approximately 990 physicians had taken the necessary steps to become first or "A" readers and 60 physicians had passed the test and been approved as final or "B" readers. As in the first round, each miner and his physician are advised of the results of his examination.

Examination Plans. The revised regulations require all coal mine operators to submit a plan for providing each miner employed by him the opportunity to have a chest X-ray in the second round ending June 30, 1974. These operator plans were to be submitted within 120 days of the July 27, 1973, effective date of the regulations. By the year's end, ALFORD had approved 602 operator plans for the second round of examinations.

AUTOPSY SERVICE

By the end of 1973, the autopsy service required by the Act has assisted the widows and

families of 672 deceased coal miners to determine (1) the cause of the miners' death, (2) the relationship of CWP to the cause of death, and (3) the degree of pneumoconiosis suffered by the miner at the time of his death. In many cases the autopsies paid for by this program have enabled the miners' dependents to establish eligibility for "Black Lung" Benefits.

The protocol for this autopsy service was published in the *Federal Register* on May 14, 1971 and amended on June 22, 1973, to establish a 180 day time limit within which the report of the autopsy must be submitted. The major effect of this change was administrative; however, it has expedited the final notification of the results of the autopsy to the next-of-kin.

Participation

Participation in the autopsy service program since its inception in 1971 is shown in Figure 3. Many of the autopsies performed are of men who died at home or in accidents.

Tissue Classification System

In 1973, a major accomplishment of the autopsy service was the development of a method standardizing the degree of CWP revealed through the microscopic slides submitted by autopsy surgeons. This is the first such classification system ever developed for tissue samples of CWP, and its use will make possible the classification of the tissue samples collected

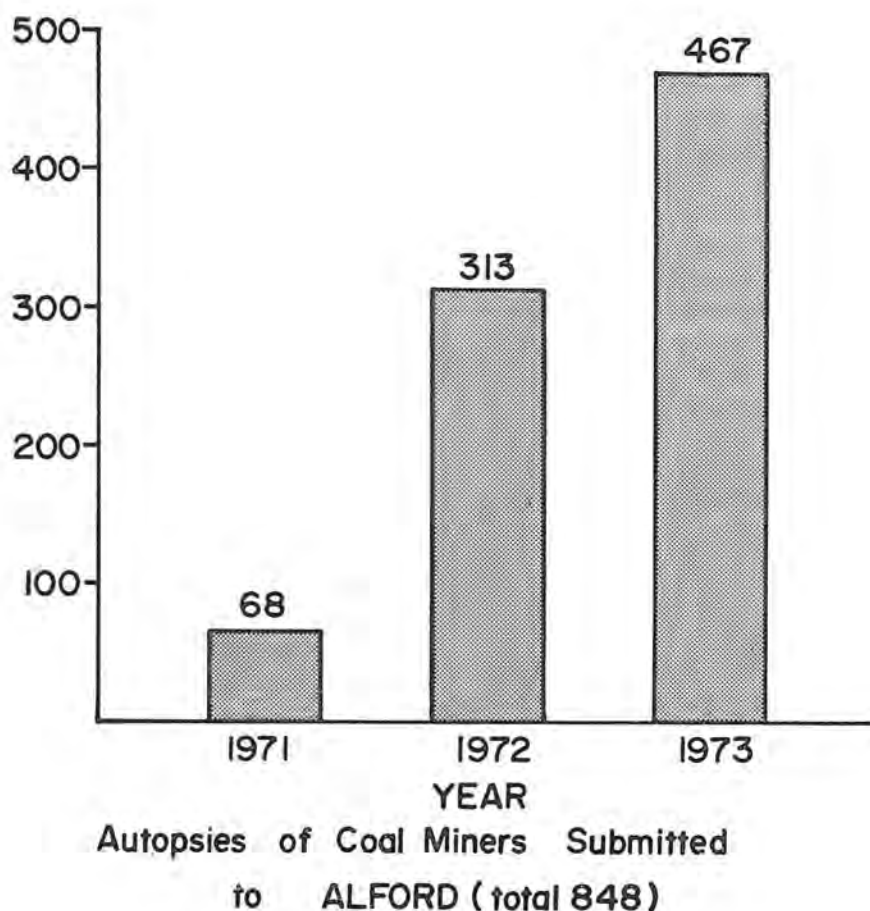


Figure 3. Participation in the autopsy service established by the Act, 1971-1973.

through the autopsy service program. When the standardized classification system has been applied to a sufficient number of autopsies, the data will be evaluated statistically.

The degree of CWP is classified in the system according to the size of the coal macule, the characteristic CWP scar formation, on the slide; the proportion of the tissues the macules comprise is also considered. Based on this classification, the 400 autopsies studied by the end of 1973 were classified for degree of CWP as follows: none to minimal, 16 percent; mild, 20 percent; moderate, 28 percent; severe, 27 percent; and complicated CWP or PMF, 10 percent.

These histologic classifications correspond generally to the X-ray categories for CWP. A similar system is now being developed for characterizing the CWP revealed in very thin sections of whole lungs, called Gough sections.

Mine Accidents or Disasters

In order to help the Department of Interior and other investigators reconstruct the sequence of events which precede a fatal accident, NIOSH pathologists perform or assist in the interpretation of post mortem examinations.

In 1973, the autopsy program included 10 miners who were killed in mine accidents or disasters. Two of these miners were removed from a mine 1½ years after the mine was sealed

to extinguish the mine fire. Seven were removed from another mine 6 months after that mine was sealed for the same reason, and one was removed from a mine immediately after the accident. In each case, tissue was obtained for carbon monoxide analysis, and it was determined that all of the men had died from carbon monoxide inhalation.

This was the first demonstration that carbon monoxide determination can be made on miners whose bodies are removed months, even years after death.

Cause of Death Data to be Studied

Aside from the benefit derived by the families of the miners autopsied, the autopsy service has proved to be a source of useful (and previously hard to obtain) information about the causes of death of coal miners. The cause of death data collected through the autopsy program will be statistically evaluated when sufficient data have been collected.

The data collected by December 1973 are presented in Table 3. Note the overall similarity for all cause of death categories except lung cancer. The group of men with lung cancer died the earliest and smoked the most, while the men who died of chronic lung disease were older and had the most severe CWP.

Table 3. Degree of Coal Workers' Pneumoconiosis Related to Cause of Death From 400 Autopsy Cases.

Cause of death	Percentage of total cases	Degree of CWP, percent				
		None	Mild	Moderate	Severe	PMF ^{1/}
ASHD ^{2/}	46	15	24	32	22	7
Lung diseases ^{3/} (including CWP)	16	5	13	27	35	20
Cancer:						
Lung	8	17	14	28	28	14
All others	12	14	14	38	19	14
Other cases	18	29	29	17	17	8
Totals	100	16	20	28	27	10

^{1/}PMF = progressive massive fibrosis, complicated CWP.

^{2/}ASHD = arteriosclerotic heart disease.

^{3/}Lung diseases = includes all diagnoses of chronic bronchitis, emphysema, pulmonary fibrosis, and CWP.

COAL MINE HEALTH RESEARCH

In 1973, the NIOSH Appalachian Laboratory for Occupational Respiratory Diseases (ALFORD) in Morgantown, West Virginia, continued to be the focal point for coal mine health research in the United States.

ALFORD's coal workers' pneumoconiosis research program is a broad-based investigation of the disease and its impact on the coal mining community. The various phases of the investigation are characterized generally as follows:

- Community surveys to determine the prevalence and progression of CWP and to evaluate its impact on life expectancy of today's coal miners.
- Development of early diagnostic tools — both clinical and biochemical — which will detect respiratory impairment before irreversible changes occur.
- Investigations of the mechanism by which lung function is altered in CWP.
- Investigations of the possible role of genetic predisposition or biologic sensitivity in the development of CWP and other occupational respiratory diseases.
- Investigations of the relationship of infectious diseases, such as viral infections, to disability as it occurs in coal miners.
- Investigations of coal mine dust itself and the reactions of individual cells and tissues to the dust.

NIOSH also conducts limited coal mine health research at its Cincinnati, Ohio, laboratories where it calls upon the unique collection of facilities and scientific expertise which it has developed primarily for activities now covered under the Occupational Safety and Health Act of 1970. These activities are in the fields of toxicology, physical and analytical chemistry, ergonomics, noise, and environmental control and personal protection.

NIOSH conducts its coal mine health research program through in-house projects, grants, contracts, and agreements with other Federal

agencies, and through special foreign currency agreements with foreign countries (Public Law 83-480). All 1973 NIOSH contracts, interagency agreements, and grants in the area of coal mine health are tabulated in appendices A through C.

COMMUNITY SURVEYS

ALFORD is evaluating the effect of CWP on the coal mining community through two different types of studies in which samples of the coal miner population are surveyed: (1) The National Study of Coal Workers' Pneumoconiosis, a long-term epidemiological, medical study of working underground coal miners designed to determine the prevalence and progression of CWP, and (2) four demographic studies designed to determine the effect of CWP on the death rates of bituminous and anthracite miners. Each of these studies produced significant findings in 1973.

National Study of Coal Workers' Pneumoconiosis

The National Study of Coal Workers' Pneumoconiosis began in August 1969, prior to enactment of the Federal Coal Mine Health and Safety Act of 1969. The purposes of the Study are (1) to relate CWP progression to levels of respirable dust exposure, (2) to provide a scientific basis for determining the progression of the disease by use of serial X-rays, and (3) to estimate the industry-wide prevalence of CWP.

The miners are examined at each participating mine by medical teams from ALFORD. Each examination includes an occupational history, two standard chest X-rays, a simple test of lung function, and a short questionnaire on chronic bronchitis developed by the Medical Research Council of Great Britain. The examinations provided through the Study completely satisfy the periodic medical examination requirements of

the Federal Coal Mine Health and Safety Act of 1969. Operators who offer their miners the opportunity to be examined through the Study are considered to have satisfied the regulations.

The mines were chosen for the Study to represent varying geographical regions, coal seams, and mining methods. Since follow-up studies of miners' health at 3 to 5 year intervals are planned, the mines chosen employed at least 100 miners and had an expected working life of about 10 years. The availability of prior dust exposure information on each mine was another factor used in selecting mines for the Study.

Results of the First Round

By July 1971, the first round of the National Study of Coal Workers' Pneumoconiosis was completed; 9,076 miners had been examined at the 31 mines in the sample (an average of 90.5 percent participation).

CWP Prevalence. The X-ray and the analysis of the data from the first round of the Study have been completed. On the basis of the data, the total prevalence of CWP among working miners in the United States was estimated to be 30 percent. When these Study results are combined with those from the service program (see Chapter 2), the actual prevalence of disease among all miners examined appears to be about 15 percent. It is important to note, however, that all newly hired miners who received compulsory examinations were included in the service program. About 20 percent of the examinations in that program were of new miners.

Marked regional differences in prevalence were observed. The highest prevalences were generally in eastern states; with the highest overall prevalence in the anthracite area of Pennsylvania. The data reveal a marked decline in the estimated prevalence by States from east to west, with the lowest prevalence found in Utah and Colorado where underground coal mining is relatively new.

Lung Function. The data from the Study show that simple CWP does not affect lung volumes or ventilatory capacity. However, there is a marked decline in ventilatory capacity (the inhaling-exhaling capacity of the lung) when complicated CWP, progressive massive fibrosis (PMF), develops.

Industrial Bronchitis. Analysis of the data also reveals that a form of industrial bronchitis exists among working coal miners. Bronchitis, the inflammation of the mucous membrane which line the lung's bronchial tubes associated with the frequent coughing up of phlegm, is related to the level of airborne dust to which a miner is exposed on the job. The presence of bronchitis is not related to the existence or category of CWP experienced by the miner nor is it associated with any substantial ventilatory defect.

Second Round

In the first round of the Study, miners were examined at 31 underground coal mines selected for the Study by the U.S. Public Health Service and the Bureau of Mines, Department of Interior. Four of the original 31 mines were no longer active; therefore 10 new mines were added to the sample for the second round of examinations, which began in July 1972. The increased sample includes 37 mines (36 bituminous and one anthracite), a sufficient number to allow for the continuation of the Study.

Participation. During 1973, ALFORD field units examined 2,659 miners at nine mines in the second round of the Study, bringing the totals for the second round of the Study to 3,890 miners at 16 mines. Fourteen of these mines were visited in the first round of the Study, and participation at these 14 mines in the two rounds is compared in Table 4. The two X-rays for each man examined in both the first and second rounds are compared side-by-side to determine if there has been any progression of CWP since the first round and, if so, how much.

Table 4. Participation at the 14 mines studied in both rounds of the National Study of Coal Workers' Pneumoconiosis

Round	Employees, number		Participation, percent
	Total	Examined	
First	3,976	3,761	94
Second	4,253	3,472	82

Participation in the Study is entirely voluntary. However, the accuracy of the data collected in a sampling-type study such as this is dependent in large part upon the thoroughness with which the sample is canvassed. For this reason, a vigorous effort has been made to inform the miners involved about the Study and its purposes and to, thereby, obtain the fullest possible participation. The reasons for the reduced participation in the second round are not apparent.

Determining CWP Progression. Each X-ray taken in the Study is classified for CWP independently by three experts. All interpreting physicians in the Study are qualified "B" readers with extensive professional experience. The first interpretation is made soon after the field examination to insure that any miner with a health condition in need of immediate attention is notified promptly. The category of CWP found in the first reading is confidentially reported to the miner through the Secretary of the Interior, who also advises him of his rights under the Federal Coal Mine Health and Safety Act of 1969. Any other significant medical findings from the examination are reported by NIOSH directly to the miner and to his personal physician.

For research purposes, the X-ray is read a

second and third time; a final consensus interpretation for CWP is obtained when two of the three readings agree. In a very few cases more than three readings are needed to arrive at a final interpretation. Next, the two X-rays for each man examined in both the first and second rounds are compared side-by-side to determine if there has been any progression of CWP since the first round and, if so, how much. The side-by-side comparison method was decided upon after detailed studies (at ALFORD) to identify the inherent biases in the various methods of comparison and to determine the best method for determining CWP progression using serial films.

The data on CWP progression obtained through the Study will be used in conjunction with dust exposure measurements (supplied by the Department of Interior) to determine the relationship between CWP progression and dust exposure (the concentrations of air-borne coal mine dust a miner has been exposed to).

Progression studies were underway at the end of 1973, but the data are not complete enough to report. However, in Table 5 the prevalence of CWP from the first round is compared with the prevalence from the second round for the miners at the 14 mines studied in both rounds.

Table 5. Prevalence of CWP found in the first and second rounds of the National Study of Coal Workers' Pneumoconiosis at the 14 mines studied in both rounds.

Round	Miners examined, number	Category CWP, percent				
		0 ^{1/}	1	2	3	PMF
First	3,760	61	25	9	1	4
Second	3,465	86	9	2	1	2

^{1/}No CWP.

The changes in the prevalence of CWP at these mines may be related to miners with CWP leaving the industry since round one, to the employment of new men who are presumably normal, and/or to the reduction or expansion of the work force at these mines. What part the results of the first round examinations may have played in a man's decision to leave coal mining is difficult to know.

CWP, BRONCHITIS, AND EXCESS MORTALITY

In four continuing studies, ALFORD demographers are investigating death rates and causes

of death among more than 12,000 coal miners. The study groups include anthracite and bituminous miners drawn from miner populations in the Appalachian Region. (See Table 6 through 8.)

Studies of death rates in 3,726 Appalachian coal miners in 1963 and 4,000 other coal miners compensated in 1967 by the State of Pennsylvania for dust-related respiratory disability have shown that miners with complicated CWP have a death rate which is 30 to 40 percent greater than that expected for all U.S. males. Airway obstruction, defined as FEV₁/FVC less than 70 percent (this is the ratio of the amount of air which can be expired in one second to the total

amount of air which can be forced out of the lungs) leads to an earlier death regardless of the category of CWP. Such airway obstruction is associated with cigarette smoking (which also correlated with higher death rates for all categories of CWP) although the inhalation of coal dust may play a role. Miners with simple CWP but without airway obstruction did not show a decrease in longevity; however, shortness of breath (an indicator of both heart and lung disease) did correlate with higher death rates among these men.

In 1974, various aspects of lung dysfunction will be evaluated in terms of their effect on the life span of coal miners, and death rates for the nation's bituminous and anthracite coal miners will be estimated for causes of death related to lung dysfunction. Also, the death rates for coal miners found through these studies will be compared to Standard Mortality Ratios (SMR) derived from all males in the Appalachian region, all males in the coal counties of Appalachia, and a general population of males in several industries. Other aspects of the methods used will be investigated as well.

EARLY DIAGNOSIS

A major goal of the coal mine health research program is to detect altered lung function before

the individual has begun to notice respiratory symptoms, when the altered function is still potentially reversible. ALFORD is, therefore, working to develop, standardize, and validate tests for detecting early disease within the lungs and for revealing the mechanisms by which occupational exposures effect the lungs. These activities fall into two broad categories: studies of lung function and studies of biochemical indicators.

LUNG MECHANICS

The mechanical properties of the human lung can be analyzed in terms of three variables — pressure, flow, and volume. Early alterations in these three variables can be measured directly, and certain inferences about their alteration can be made by indirect measurements.

The flow-versus-volume curve of the forced vital capacity maneuver is one rapid and useful way to quantifying the relationship between flow and volume in order to detect early alteration of lung function.

Early Changes. In 1973, the flow-volume curves in some 200 working coal miners were analyzed in ALFORD's laboratories. The earliest detectable change from normal appears in the terminal half of the flow-volume curve and may be present when standard tests of lung function, such as

Table 6. Mortality of Appalachian bituminous coal miners, by radiographic category and cigarette smoking, 1963-1971.

Cigarette smoking history	Miners without CWP			Miners with CWP					
	Miners Number ^{1/}	Deaths	SMR, ^{2/} percent	Simple			Complicated		
				Miners Number ^{1/}	Deaths	SMR, ^{2/} percent	Miners Number ^{1/}	Deaths	SMR, ^{2/} percent
Employed Miners:									
Never smoked	414	31	72 ^{3/}	36	2	39 ^{3/}	20	0	0
Smoked only in past	393	23	55 ^{3/}	49	3	41 ^{3/}	18	4	125
Smoker when examined	1,318	130	111 ^{3/}	94	15	115 ^{3/}	34	11	244 ^{3/}
Ex-miners:									
Never smoked	224	37	73 ^{3/}	32	7	95	23	7	125 ^{3/}
Smoked only in past	254	60	103	27	7	115	45	14	138 ^{3/}
Smoker when examined	446	136	158 ^{3/}	57	19	148 ^{3/}	35	16	198 ^{3/}

^{1/}136 employed and 13 ex-miners whose vital status at end of 1971 was not determined are excluded from tabulations; 26 employed and 4 ex-miners without X-rays are also excluded from tabulations by CWP. An additional 11 employed and 17 ex-miners are excluded from the data on smoking due to incomplete response.

^{2/}Standard mortality rate (SMR); expected = 100%

^{3/}Level of significance (probability that SMR = 100%) ≤ .05

Table 7. Mortality of Appalachian bituminous coal miners, by radiographic category, FEV₁/FVC, dyspnea, and chronic bronchitis.

Work category	Miners without CWP			Miners with CWP					
	Miners Number ^{1/}	Deaths	SMR, percent ^{2/}	Simple			Complicated		
				Miners Number ^{1/}	Deaths	SMR, percent ^{2/}	Miners Number ^{1/}	Deaths	SMR, percent ^{2/}
FEV ₁ /FVC, percent									
Employed miners:									
≤69.9	584	76	115 ^{3/}	64	7	69 ^{3/}	36	11	192 ^{3/}
≥70.0	1,465	105	82	108	12	85 ^{3/}	33	4	86
Ex-miners:									
≤69.9	402	120	134 ^{3/}	53	17	140 ^{3/}	59	23	168 ^{3/}
≥70.0	405	83	103	53	11	93	29	7	98
Dyspnea (shortness of breath)									
Employed miners:									
None or slight	1,881	144	85 ^{3/}	136	15	81 ^{3/}	54	11	142 ^{3/}
Moderate, marked severe	244	41	130 ^{3/}	43	5	71 ^{3/}	20	4	113
Ex-miners:									
None or slight	427	82	91 ^{3/}	50	11	91	24	11	186 ^{3/}
Moderate, marked severe	463	143	144 ^{3/}	62	21	156 ^{3/}	79	27	152 ^{3/}
Employed miners:									
Non-persistent	1,523	116	84 ^{3/}	117	11	67 ^{3/}	51	5	72 ^{3/}
One or both persistent	611	74	115 ^{3/}	62	9	99	23	10	231 ^{3/}
Ex-miners:									
Non-persistent	457	100	102	57	15	126 ^{3/}	41	18	177 ^{3/}
One or both persistent	480	138	140 ^{3/}	66	19	131 ^{3/}	65	21	147 ^{3/}

^{1/}136 employed and 13 ex-miners whose vital status at end of 1971 not determined are excluded from tabulations; 26 employed and 4 ex-miners without X-rays are also excluded from tabulations for CWP.

^{2/}Standard mortality rate (SMR); expected = 100%.

^{3/}Level of significance (probability that SMR = 100%) ≤.05.

the volume exhaled in one second (FEV_{1.0}) or the resistance to air flow within the large airways (airways resistance), are within normal limits.

Analysis reveals that the early alterations resulting in reduced flow over the terminal half of the flow-volume curve are easily qualified by measuring either the flow at specified low lung volumes or the change in the slope of the terminal part of the curve.

ALFORD researchers have developed a computer program to perform these analyses, and it is now used to evaluate the flow-volume curves of forced vital capacity maneuvers performed on a spirometer. The tests are performed and tape recorded in the laboratory and in the field and later evaluated on the computer.

Resistance in Small Airways. The mechanisms by which CWP alters the terminal half of the flow-volume curve are a premature loss of lung elastic tissue or an abnormal increase in the resistance to air flow in the small airways (less than about 2 millimeters in diameter), which are within the gas exchanging part of the lungs.

In 1973, a follow-up study was made of 17 miners, from an original group of 25 working underground miners with category 2 or 3 simple CWP which was studied in 1969. The follow-up study found that terminal expiratory flow had declined in the 17 miners significantly more over the course of 4 years than it had among six age-matched control subjects. Interestingly, the decline in terminal flow occurred for the most

Table 8. Mortality of Appalachian bituminous coal miners, by radiographic category of coal workers' pneumoconiosis

Radiographic category	Miners number ^{1/}	Death, number		SMR ^{2/} percent
		Observed	Expected	
Employed miners:				
Entire group	2,413	225	241.9	93 ^{3/}
Category 0 ^{4/}	2,413	186	202.5	92 ^{3/}
Simple	179	20	25.6	78 ^{3/}
Complicated	74	15	11.4	132 ^{3/}
Ex-miners:				
Entire group	1,164	308	248.5	124 ^{3/}
Category 0 ^{4/}	937	235	196.9	119 ^{3/}
Simple	117	34	26.3	129 ^{3/}
Complicated	106	39	24.6	159 ^{3/}

^{1/}136 employed and 13 ex-miners whose vital status at end of 1971 was not determined are excluded from tabulations; 26 employed and four ex-miners without X-rays are also excluded from tabulations by CWP.

^{2/}Standard mortality rate (SMR); expected = 100%.

^{3/}Level of significance (probability that SMR = 100%) ≤ 0.05 .

^{4/}No CWP.

part in miners who demonstrated increased resistance to air flow within small airways in 1969.

In 1974, a definitive study will be made of the pressure, flow, and volume relationship. Simultaneous measurements of these three variables will be made in order to precisely determine which of the two possible mechanisms (loss of elastic recoil or increased resistance in small airways) are responsible and also to determine whether or not these changes are reversible or represent permanent damage to the lungs and/or airways.

GAS EXCHANGE

One important factor in determining the lung's ability to properly exchange the respiratory gases, oxygen and carbon dioxide, is the evenness with which the inspired atmospheric air is distributed throughout the lungs.

Single-breath tests. Recently, it has been demonstrated that a slightly different analysis of an old test — known as the single-breath nitrogen test — gives important indirect evidence of the behavior of the small airways. It has been determined that this single-breath test may detect premature airway closure before the standard tests commonly in use in pulmonary function laboratories.

The single-breath nitrogen test for premature airway closure has been extensively evaluated in the ALFORD laboratory using healthy control subjects. It has been found to be a reproducible technique that can be applied to a field testing

situation among untrained subjects. The test, when done under controlled conditions, is relatively reliable in a screening situation.

Also, ALFORD researchers have developed a computer program to measure and calculate the results of the single-breath nitrogen test from tape recordings of the test. This program should make it possible to analyze large numbers of tests on groups of subjects without an inordinate increase in time and effort.

Field tests of the single-breath nitrogen test for detecting premature airway closure are planned for 1974 at a mine near the laboratory. Both manual and computer-measured tracings will be used in the field test which will be designed to determine the feasibility of applying the single-breath nitrogen test in an epidemiological study of a larger population, several hundred coal miners.

Premature airway closure. Studies of 83 working underground coal miners and 58 reasonably aged-matched non-miner controls conducted during 1973, indicate that premature airway closure (an early manifestation of lung dysfunction) does occur more frequently among miners than among non-miners. The phenomenon of premature airway closure was not accounted for by difference in cigarette smoking or by the presence of pneumoconiosis among the miners. Further, this abnormal function of the small airways in miners was not readily detectable by standard pulmonary function tests and most likely was related either to loss of lung recoil as a con-

sequence of focal emphysema or to increased resistance to airflow within the small airways. *Effect of one shift underground.* The single-breath nitrogen test and measurements of the terminal flow-volume curve (spirometer) will be used in 1974 to re-study a group of approximately 63 miners, working at a northern West Virginia mine, who formed part of a cohort that was originally investigated in 1968. The acute effects of one underground shift on ventilatory capacity as well as the decline in ventilatory capacity that has occurred with time in this group will be determined. Samples of airborne dust in the mine will be taken during the shifts for which pulmonary function was measured, in order to correlate these changes with actual dust exposures. Personnel from the Department of the Interior will take and analyze the dust samples.

Estimating airway diameter. In 1973, final analysis was made of data collected in a 1971-72 evaluation of a method for estimating the size of lung airways. The estimation is based on measuring the persistence of an inhaled aerosol within the lungs. This study was undertaken in collaboration with the New York University Environmental Health Center. Studies of 48 subjects, using this indirect method of estimation, demonstrated that the size of the intrapulmonary airways varies significantly among presumably normal subjects. The method provides an objective way of estimating airway diameters and could prove useful in determining when early enlargement or narrowing of these airways occurs during life. Comparisons of the values obtained in healthy subjects tested by ALFORD agreed with direct measurements made by others on autopsied normal lungs.

Exercise capacity. Severe lung disability interrupts the supply of oxygen to the rest of the body as well as the removal of carbon dioxide and other gases produced by the body, and thus it affects the amount of work a person can do. ALFORD researchers are studying tests of exercise (work) capacity in an effort to develop a test which will measure or indicate full exercise capacity before the heart is making its maximum effort.

Not only would such an indicator make it possible to determine work capacity of coal miners and others with serious heart-lung disorders, but it might also serve as an early diagnostic indicator of developing heart-lung disease.

Preliminary exercise studies were begun in 1973 and will be further developed in 1974.

Bubbles in lungs. Measurement of the lungs' closing volume (the amount of air in the lungs when the small airways cease participation during exhalation) has been shown to be very sensitive to changes in small airway resistance. Thus, a systematic study was undertaken by ALFORD physiologists in order to understand the relationship between the two. These completed experiments, carried out on excised rat lungs, were part of a larger investigation of respiratory mechanics carried out to develop new approaches to the early detection and measurement of small airway disease, such as CWP. The lungs were cycled — inflated and deflated — from a minimum transpulmonary pressure to a maximum transpulmonary pressure and back again. The pressures and rate of ventilation were varied between cycles. The ratio of the amount of air trapped within the lung at a minimum pressure to the maximum lung volume for the same cycle increased during successive inflation-deflation cycles. This indicates an increased amount of trapped gas and, thus, an increased closing volume.

The results of these experiments are consistent with the hypothesis that bubbles are formed within the air spaces of the lungs and that the bubbles are mainly responsible for the increased amount of trapped gas.

Heretofore, closing volume measurement has been explained in terms of the collapse of the small airways, but these results would indicate that bubbles formed in the air spaces would produce the same effect physically. Thus, bubble formation, which has never been demonstrated in an intact lung, might explain the mechanism responsible for closing volume.

The experiments also showed that the bubbles were formed on inflation and that there was an increased amount of bubble formation as the rate of inflation was decreased. Extrapolating these results to the measurement of closing volumes in humans, it seems imperative to control the inspiratory flow rate (which is not usually done) as well as the expiratory flow rate, which has also been shown to affect the measurement.

BIOCHEMICAL INDICATORS

While tissue or organ response to a particular disease process may not be specific, the levels of biochemical constituents or metabolite found in body fluid may be of significant diagnostic

value when used in conjunction with physical diagnoses. ALFORD biochemists have, therefore, been evaluating the use of selective biochemistries in order to obtain scientific data not only in support of clinical diagnoses but also as early indices of disease processes.

A recent study of the humoral (blood) levels of nine proteins in serum samples obtained from a group of coal miners including miners with CWP was concluded; the study was part of an effort to develop techniques for the early diagnosis of CWP. The protein (biological constituents) studies are associated with antigen-antibody reactions of the cells to foreign substances. The humoral level of these nine proteins were found to fluctuate widely amongst individuals. However, three of the nine showed greater variations and are being further investigated for possible use in differential diagnoses.

BASIC LUNG FUNCTIONS

Diagnosis, treatment, and rehabilitation of coal miners and others with lung disease is not possible without knowledge of the mechanisms by which normal lung function has been altered. Knowledge of these mechanisms, hopefully, may lead to development and use of drugs both to affect the basic functions of the lung and to counteract and treat lung disease.

ALFORD researchers are attempting to delineate mechanisms by which occupational exposure can result in impairment of lung function. The effects on the lung of a broad variety of occupationally related stimuli are being examined.

Since the lung is one of the body's first-line defense mechanisms against the external environment, it has built-in mechanisms for survival in environments which might be radically different from normal. The major advantage of studying basic mechanisms is that the information from a particular study should be applicable to a wide range of similar problems associated with occupational health.

HAY FEVER AND SMALL AIRWAY DISEASE

In a study of the relationship of the hay fever symptoms and small airway disease within the lungs, 20 subjects who had only upper respiratory tract symptoms (itching eyes, nasal stuffiness and secretion) but no symptoms of airway obstruction within the lungs, underwent a test

for detecting increased resistance to airflow in the small airways (frequency dependence of dynamic compliance). They were tested during the hay fever season and again when their symptoms had cleared up in collaboration with researchers from the Department of Medicine, West Virginia University Medical Center.

When symptomatic, eight of the subjects demonstrated evidence of small airways obstruction not detected by standard lung function tests. The obstruction had disappeared when the upper respiratory (hay fever) symptoms had cleared.

This study provides evidence of a direct link between the upper and lower respiratory tract, of a mechanism whereby particles deposited in the upper airways trigger responses (disease) in the lower airways. Further investigation of this relationship in coal miners exposed to nonspecific irritants of the upper respiratory tract are indicated.

CHANGES IN AIR AND BLOOD DISTRIBUTION

Since 1972, ALFORD physiologists have been measuring changes in the distribution of air (ventilation) and the distribution of blood (perfusion) within the lung caused by changes in airway resistance. The knowledge gained through these investigations is applicable to any lung disease in which airway resistance is increased, including CWP, asthma, bronchitis and emphysema.

Studies, thus far, have identified the changes that occur in both the obstructed areas of the lung and the normal areas when obstruction is present. Both perfusion and ventilation are decreased significantly in lung areas with experimentally produced airway obstruction, and increased in the normal lung areas. However, blood flow to the obstructed lung area was decreased more than air flow. Lung volume also increased in the obstructed half and remained constant in the normal half of the lung. In addition, arterial and venous oxygen tension and cardiac output decreased significantly, while carbon dioxide tension, pH, and the respiratory rate remained unchanged.

Investigations designed to identify the basic mechanisms by which these changes in lung function occur were initiated in 1973. At various levels of expiratory airway resistance, air and blood pressure within the lungs are measured along with the air flow to both lungs, the oxygen

and carbon dioxide content of both air and blood, and the amount of blood in the lungs and pumped by the heart. Since the changes that occur in ventilation and perfusion of the lung are already known when the studies are complete, the basic mechanism for those changes can be identified using these measurements.

HYPERSENSITIVITY

Genetic Determinants

In recent years, studies of individual susceptibilities to bronchopulmonary diseases have led to a consideration of various genetic factors. Of particular interest is the genetically determined levels of proteinase inhibitors found in the blood. The levels of these anti-proteolytic factors have been associated with incidences of varied pathologies and, in particular, chronic obstructive pulmonary disease. These inherited (genetic) abnormalities could possibly reflect a predisposition to various disease processes including occupationally-related respiratory disease. While a correlation between these genetic determinants and the prevalence of bronchopulmonary disorders is debatable, the possibility exists that extrinsic factors (occupational environment; external stimuli) may exacerbate individual susceptibility.

During 1973, a screening program to determine the levels of various proteinase inhibitors — primarily inhibitors of proteolytic enzymes that may be relevant to connective tissue disorders, such as CWP — in serum samples from coal miners and others was begun. (See Early Diagnosis, Biochemical Indicators.)

As a further refinement, the serum levels of these genetically related factors (anti-proteinase compounds) were correlated to the phenotype of the individual in a series of selected samples. The phenotype is a further expression of this inheritable genetic trait and is presently being evaluated with the levels of various proteinase inhibitors. Approximately 750 samples had been examined for the concentrations or level of inhibitors in serum by the end of 1973; however, it will take some time to have many of these phenotyped as well.

The Sensitization Process

In an earlier study, ALFORD biochemists found that a worker's exposure to the extraction of metal (beryllium) from ore results in a possible sensitization due to metal binding with various biological constituents. The high im-

munoglobulin protein fraction found in the serum of such workers as well as the incidence of dermatitis and other clinical disorders, including a lung disease (berylliosis), which these workers experience may be due to a binding phenomena and subsequent sensitization.

Studies of metal binding to cell membranes and various humoral proteins made in 1973 indicate that for the most part, the cellular integrity is highly susceptible to beryllium salts. However, it is difficult to relate this action to clinical events.

Many investigators have concluded that the cellular mechanism of sensitization is more likely than humoral sensitization, i.e. the binding of metals to tissue cells rather than to humoral proteins. Cellular sensitization, however, would require some means of transport for the metal within the body. The available information on the transport of some trace metals (including beryllium) is still ambivalent and is being considered as the investigation of humoral versus cellular sensitization in beryllium-associated disease continues. (See Cells, tissues, and dust, Cell membranes.)

INFECTIONS AND IMMUNITIES

Complicated colds, viral pneumonia, and other influenza infections which cause fluid to collect in the lungs damage the structure of the lungs and may cause scars. They are among the leading causes of respiratory disability, and present a serious danger to persons with other lung diseases, such as CWP. Moreover, there is a possible synergistic relationship between infectious lung diseases and other lung diseases, such as CWP. It is possible that one disease weakens the lungs for the other while the damage (scarring) of one compounds that of the other. Thus, it is a goal of NIOSH's coal mine health research to assess the interactions of coal dust, infectious agents, and immune mechanisms in the lungs: to assess the susceptibility of the coal miner, his family, and his community to repeated infectious diseases (relapses); and to develop techniques for finding and treating those in the community who are or might become subject to repeated infections.

Cell's Defense Mechanism Depressed

ALFORD researchers assessing the interactions of infectious agents, immune mechanisms, and coal dust in the lungs of humans have determined that a basic defense mechanism is de-

pressed in cells exposed to a variety of substances, including coal dust.

Production of interferon, an intrinsic cellular defense material, is significantly depressed in human or simian tissue culture cells treated with various types of dust, according to research undertaken in 1973. The deposition of dust does not destroy the cells, or interfere with their ability to multiply, or permanently alter their capability of producing interferon when the dust is removed. However, virus production is significantly increased in cells exposed to dust.

Greater depressions of interferon induction were found to be associated with smaller coal dust particles (ranging from respirable size, under 5 micrometers, up to 19 micrometers), with longer periods of contact between the cells and the coal dust before the inducer is added, and with higher concentrations of coal dust.

ALFORD investigators also found marked depressions in interferon induction when cells are exposed to lampblack; animal and sugar charcoal; graphite; the metals — cobalt, iron, cadmium, manganese, copper, zinc, nickel, and uranium; the compounds — calcium fluoride, aluminum oxide, tremolite, calcium sulfate, Montana talc, and California talc; the silica preparations — Fuller's earth and kaolin; crocidolite, and Canadian and Rhodesian chrysotile. Interferon induction was lesser or minimally affected by exposure to tin, beryllium, barium, mica, alpha quartz silica gel, and diatomaceous earth.

The mechanism for the depression of interferon induction is not understood. On-going research has eliminated the possibility of a physical or biological interference with the normal action of the inducer or of a direct interferon antagonistic effect by coal dust. Research, in 1974, to explain this phenomenon will concentrate on investigations of the dust-cell membrane relationships. Higher level models, including experimental animals, will be used to assess the consequences of interferon depression by dusts.

Autoimmune Antibodies in CWP

Antibodies suggestive of an autoimmune process — antinuclear antibody (ANA) and rheumatoid factor (RF) — were found by previous ALFORD research to be significantly more prevalent in the sera of coal workers with progressive massive fibrosis than in normal subjects. In 1973, similar tests were conducted on the sera of diseased workers exposed to other

dusts to determine whether a similar autoimmune process is detectable.

Among 145 asbestos workers being studied by the Harvard University School of Public Health, four had definite evidence of pulmonary fibrosis; however, none of the sera from these workers displayed ANA activity in any of the immunoglobulin fractions (G, M, A).

Sera from 68 beryllium workers who manifested a wide spectrum of disease was also tested for ANA. In a high proportion of the sera, the globulin count was elevated; however, only in three of these workers was ANA activity (in the immunoglobulin M fraction) demonstrated. Tests for RF in the same sera will be completed in 1974.

Assessment of Influenzae Antibodies in Persons with Colds

The standard serologic test for the bacterium *Haemophilus influenzae* is qualitative, and its results represent only extremes in antibody response. However, an antibody, not found in normal control subjects, has been found in the sera of persons with chronic bronchitis — a chronic obstructive lung disease. If a test antigen for the specific antibody could be isolated without a loss in its activity, a quantitative *H. influenza* serum test is feasible. A quantitative test, it is believed, would better define the intermediate stages of the disease and would make possible the detection of persons who will be most amenable to treatment (to prevent relapse or reinfection) particularly following episodes of acute infection. In 1973, ALFORD research concentrated on the cultivation of two sources of *H. influenzae* organisms in preparation for the production of a suitable antigen.

Respiratory Infections Survey in a Mining Community

Viruses are generally believed to be responsible for the respiratory complications which accompany other diseases, especially in persons with underlying lung diseases. Except for influenza, the identification of the more virulent agents (those which are more likely to cause problems) has remained confusing and obscure. Therefore, viral identification technology has been applied only to those with critical respiratory problems which required hospitalization or outpatient visits.

In 1973, a short-term longitudinal viral and respiratory disease survey was initiated to evalu-

ate the experience of a coal mining community over one winter. This field investigation has several advantages. The subjects are being studied in their natural environments. It is a study of a stratified community population with an expected greater than normal prevalence for underlying respiratory disease (CWP). The inclusion of both household adults makes it possible to assess the communicability of viral agents, and the community structure is such that attack rates in two generally defined occupations (coal mining and non-mining) can be compared.

From a defined boundary encompassing the Central Guyan Valley of Wyoming County, West Virginia, couples whose male members were approximately 40 years of age or older, were enumerated and randomly (without replacement) selected to provide pre-winter and post-winter blood samples and to answer questionnaires about respiratory symptoms and CWP. The male subjects represent a spectrum of work experience; however, if they had worked 10 or more years in an underground coal mine or at the tippie, they were considered miners. If they had worked less than 5 years as a miner and had a "non-dusty" career occupation, they were considered non-miners.

Between October 15 and December 14, 1973, 92 miner couples and 60 non-miner couples participated in the study. In each category, only one person participated from six additional families. Overall cooperation in the pre-winter part of the study (fall 1973) was 81.3 percent (including 1-participant families).

In 1974, the post-winter part of the study will take place, serology determination will continue, and questionnaire and serology data will be analyzed to develop a unique profile of the viral and respiratory disease experience of an entire community and of its coal miner members.

CELLS, TISSUES, AND DUST

Basic research into the biochemical and physiological reactions of individual cells and small groups of cells to external stimuli is continuing at the laboratory. By working to understand the cell's basic process and to determine its normal response to external stimuli, ALFORD researchers are pursuing the fundamental process which, as a reaction to inhaled coal dust, eventually result in the physiological change called CWP. In addition, the behavior of inhaled dust inside the lung is being investigated in a further effort

to relate basic processes to the development of disease such as CWP.

SCANNING ELECTRON MICROSCOPY

The scanning electron microscope has received a unique application to biological and medical research in some of these ALFORD studies; techniques are being developed and refined which utilize the scanning electron microscope to examine specifically the structure and location of individual cells in tissue samples as well as their relationship to other cells and to foreign substances. ALFORD researchers have developed means of impregnating reticulin, collagen, and chromatin with silver salts. Using the scanning electron microscope to distinguish the silver stained tissue from unimpregnated tissue, the investigator is able to identify cell nuclei and connective tissue. A modification of this technique will distinguish micro-organisms such as fungi and protozoans, which are frequently involved in lung infections. This technique has enormous value both in studying the reaction of lungs to dust and as a new technique for general pathology.

Another application of the scanning electron microscope's ultramicroanalytical techniques is the quantification of the silver impregnated in the connective tissues. The amount of silver impregnated is proportional to the amount of reticulin and collagen and should aid in the quantitation of the tissue reaction to dust. Techniques are also being developed for quantitative pathology by means of a computer-assisted image-analysis instrument. This instrument is capable of counting and sizing dust particles and of doing measurements on lungs to quantitate the amount of chronic bronchitis, emphysema or pulmonary fibrosis present.

Coal Dust in the Lungs

A unique dust exposure chamber constructed and tested for ALFORD by the Bureau of Mines, Morgantown Energy Research Center, U.S. Department of the Interior, was employed in 1973 to initiate an investment of the deposition and clearance of coal dust in the lungs of mice. After repeated exposures to respirable coal dust in various concentrations, the dust retained in the lungs and the rate of dust clearance from the lungs are being measured.

These studies include not only histologic examination of the dust in the tissue but also measurements of the dust itself freed from the

tissue. The fact, only recently demonstrated, that pressure filtration of dust suspensions produces a random distribution of dust particles on a translucent membrane is being utilized in this investigation to provide more precise counting of particles and measurements of dust-mass. The knowledge of coal dust deposition and clearance gained through this investigation will be used in future investigations to study both the changes in retention and clearance related to virus infection and the changes in severity of viral diseases related to dust exposure.

Effect of Lung Geometry

CWP and several other occupational diseases develop as a result of the deposition of particles in the gas exchanging region of the lung. ALFORD physiologists are using respirable particles of known composition, concentration and geometry in an attempt to learn more about the effect of lung geometry on particle deposition and clearance. The results should be applicable to asbestosis, berylliosis, byssinosis, and silicosis, as well as to CWP, and should contribute to reducing the incidence and severity of injuries and diseases from occupational hazards by providing early detection of individuals predisposed to increased particle deposition by the nature of their lung geometry.

The study is designed to determine the patterns of particle deposition and clearance as a function of changes in lung volume and geometry. If these functions are understood, it should reveal the effect of the differences in lung geometry within individuals and how best to evaluate these differences on an early detection basis. Such individual variations have been shown to exist in previous NIOSH studies.

There is much speculation concerning the deposition sites of dust in the human lung. Various experimenters have used human subjects and non-toxic non-radioactive dust to determine the deposition sites. These experiments fell short of their goals because they were unable to look at the deposition sites in the lung, but had to determine the sites indirectly, based on the average shape and structure of the lung. Since the lungs vary considerably from individual to individual, the same experimental results on two individuals of different lung geometry can actually represent differences in deposition sites unknown to the investigator.

In order to study the effects of lung geometry, three types of experiments are underway: (1) using human subjects and non-toxic, non-radio-

active aerosols, (2) using dogs and radioactively tagged particles, and (3) using post mortem lungs and radioactively tagged or heavy metal tagged particles. The implementation, completion and success of these studies relies on the combined talents of engineers, physiologists, and pathologists.

CELLULAR SYNTHESSES IN LIVING CELLS

The physiological integrity of an organ, such as the lung, is dependent upon the syntheses and normal turn-over of a variety of biological components. Thus, an examination of the cell's ability to provide normal tissue components under a variety of factors will reflect the organ's basic ability to function under altered physiological conditions.

In studies based on this concept, ALFORD biochemists are studying the effects of environmental factors on a cell's metabolic activity and the effects of metabolites and anti-metabolites on cellular syntheses. The studies involve a mechanistic evaluation of the changes in biological constituents (tissue components) synthesized by living cells.

The tissue (cell) cultures for these studies were initiated in 1973; they include cultures of a human embryonic lung cell and other fibroblast (connective tissue) cells. Cellular metabolic studies progressed in 1973 and will continue in 1974.

Properties of Cell Membranes

Heavy metals and their derivatives are significant sources of industrial poisoning. One project is underway to determine how heavy metal ions affect living cells and at the same time reveal and characterize two of the cell's basic processes. (Red blood cells are plentiful, convenient to study, and one way to assess their function is to study the properties of the cell membrane which enable sodium to pass through it.)

In 1973, the effects of mercury, copper, lead, nickel, zinc, and cobalt on sodium transport in red blood cells were studied. The results indicate that all of these heavy metals increase the sodium permeability of the membrane by combining chemically with certain groups in the sodium channel, the pathway for sodium movement through the membrane. Mercury, cobalt, and nickel were found to combine with sulfhydryl groups in the membrane in a ratio of two

ions per channel, while zinc combines with amino groups in a ratio of one ion per channel. Thus, in addition to determining how heavy metals effect the cell membrane, the sodium channel is being characterized. In the coming year other heavy metal ions will be tested and further experimentation will be pursued to localize the sulfhydryl and amino groups within the membrane.

Effects of Particle Rejection and Assimilation

In another investigation an effort was made to develop a procedure by which the transport of sodium and potassium ions across the membrane in alveolar macrophage cells could be studied. The primary function of these cells is to engulf bacteria and other foreign particles in the lung; thus, understanding their basic functions is a pre-requisite to understanding the changes in cell function associated with CWP. The fluxes of both sodium and potassium ions were found to be much too fast to measure using conventional transport techniques. Another method, using radioactive tracer ions was employed. This method allowed sampling within one second of the start of the experiment and revealed that the transport of sodium and potassium across the membrane of alveolar macrophage cells takes less than one second. Further study of this phenomenon must, therefore, await the development of suitable techniques.

Effects of Drugs. In order to determine if inhalation of coal dust and other toxic materials in any way modifies the cell membrane transport channels, the interaction of drugs with receptor molecules located on the membrane of airway smooth muscle cells is being studied. In 1973, the interaction of one drug, acetylcholine (Ach), with receptors in normal trachealis muscles was studied, specifically the kinetics of this interaction and the effect of varying the pH of the extracellular fluid on these kinetics. The results of experiments conducted thus far are being used to characterize the Ach-receptor complex, that is, identify the number of drug molecules which interact with one receptor molecule. Furthermore, it has been determined that decreasing the pH of the extracellular fluid causes the affinity to increase. Some drugs and chemical modifiers have been found to inhibit Ach action by combining with specific chemical groups (e.g., sulfhydryl or amino groups) on the receptor molecule. As the investigation con-

tinues, data from several similar experiments will combine to yield a model for the Ach receptor molecule in a normal airway smooth muscle cell. Once this normal receptor molecule has been characterized, inhalation studies can be started to determine the effect of toxic materials on this receptor.

PHYSICAL AND ANALYTICAL CHEMISTRY

The chemical composition of lungs taken at autopsy from coal miners and selected non-miners are being studied in order to understand the relationship between chemical changes in lung tissue and observe pneumoconiotic changes and, thus, the nature of coal workers' pneumoconiosis (CWP). The first phase of the study was completed in 1973. A sampling of lungs from deceased coal miners was evaluated using X-rays and very thin sections of the lungs, called Gough sections; these cases were grouped into 10 categories based on the degree of lung damage from inhaled coal dust. Statistical analyses were used to study correlations between the degree of lung damage and the concentrations of several substances in the lungs. Positive correlations, significant at the 95 percent confidence level, were shown between lung damage and concentrations of beryllium, magnesium, vanadium, total dust, coal dust, and free silica.

The correlations between CWP and the concentrations of these substances in the lungs of coal miners have led directly to the second phase of this project, a study of lung and lymph node tissue from urban dwellers. Information on the chemical composition of "normal" lungs is limited; i.e., that which is available was gathered more than a decade ago.

However, in order to compare the composition of the lungs of coal miners to the composition of the lungs of persons not exposed to coal mine dust, a group of lungs from urban dwellers was obtained for study. These lungs were analyzed in 1973 for total dust, mineral and non-mineral dust, free silica, and hydroxyproline. The results of a contract study to determine the concentrations of 21 trace elements are expected in early 1974.

Information developed through this study has been exchanged with Bureau of Mine researchers at Bruceton, Pennsylvania, who studied trace metals concentration in coal mine dust collected in the same areas in which subjects used in this NIOSH project were employed.

TOXICOLOGY RESEARCH

In 1973, NIOSH toxicologists continued the experimental animal inhalation studies in bituminous coal dust and the animal inhalation and bioassay studies of coal tar begun in 1972 and initiated in 1970.

Development of Criteria for Coal Dust Standard

Animal inhalation experiments, using Pennsylvania and Utah bituminous coal dusts which are associated with high and low CWP incidence respectively, had continued for more than 182 weeks of daily, 7 hours per day inhalation exposures by the end of 1973. Of the four animal species (monkey, rabbit, rat, and mouse) included in the experiment, monkeys are the only animal still being tested. The results of comprehensive cardio-pulmonary function studies obtained from the exposed monkeys have produced the most significant results thus far. In 1973 the seventh and eighth evaluations in this series of tests substantiated the earlier observation of a statistically significant decrease in the compliance of small pulmonary airways in some of the animals exposed to each coal dust.

Histologic evaluation of lung tissues from exposed and control animals and further pulmonary function studies are planned in order to develop data for a review of the present coal dust standard of 2 milligrams per cubic meter (mgs/m^3) of air. A status report of this project was presented in 1973 to the Secretary's Coal Mine Health Research Advisory Council.

Effects of Environmental Pollutants

A second animal inhalation study was completed in 1973 under a grant. Tissue was collected from germ-free rats exposed for 6 months to $10 \text{ mgs}/\text{m}^3$ of Pennsylvania coal dust. This tissue was submitted to the University of Notre Dame for histologic preparation and interpretation. In 1974, the histologic data will be used to evaluate the dose-response effects of coal dust in this unique germ-free animal model and to evaluate the contribution (if any) of the absence of bacterial flora in the animals to the dose-response effect.

Removal of Coal Dust from the Lungs

The number and functional integrity of alveolar macrophages in rats exposed to high concentrations of Pennsylvania and Utah coal

dusts was further delineated in studies which continued under contract in 1973. Data collected in 1973 supported the earlier finding that a biologic compensation and effective clearance mechanism, within limits, is maintained for removal of the inhaled coal dusts. Rats breathing the high CWP incidence Pennsylvania sample showed an initial increase in the number of macrophages followed by a leveling off. Animals exposed to the Utah coal showed an initial increase in macrophages and then a decrease below the control value. However, no corresponding positive compensation in the macrophages' phagocytic capacity (ability to engulf microorganism, cells, foreign particles) was demonstrated.

Macrophages from rats exposed to $15 \text{ mg}/\text{m}^3$ concentrations of the coal dusts showed distinct changes in phagocytic activity and in bacteria killing efficiency. Using viable staphylococcus organisms, the percentage of viable bacteria increased in animals exposed to the dusts as compared to the control animals. Effective phagocytosis of the bacteria per macrophage was also observed to be reduced.

Metals in Coal

A study was continued to determine which serum fractions from the lungs of coal dust-exposed rats bind and transport the metallic elements (particularly nickel) eluted from coal samples. The data thus far indicate that there is a higher ratio of these metallic elements in the globulin protein.

Immunologic Aspects of Experimental Pneumoconiosis

A study conducted under contract in 1973 to investigate the relationship of CWP to an increased production of immunoglobulin A (IgA) in humans reaffirmed earlier findings that it is not possible to quantitate IgA in the coal dust-exposed rat or the evolution of histologic changes in the lung provoked by the coal exposures. Negative results in this area appear to be due to the low IgA concentration in the rat serum for which the radial diffusion method for detection does not have sufficient sensitivity.

Using radioactively labeled bacteria to assess the effect of coal dust exposures on the airway clearance capacity of mouse lungs, exposures up to 6 months have shown no effect in reducing the clearance capacity.

Bioassay and Inhalation Evaluations of Coal Tars

Investigations related to the products of coal mines and the prevention of diseases in workers exposed to such products have involved bioassay and inhalation evaluations of coal tars. Research, through contract and interagency agreements, on the significance of coal tar in the production of lung and skin tumors or cancer, involved studies using coal tar obtained from eight different coke oven operations. Results produced in 1973 demonstrated that the primary toxic response to coal tar is the production of skin tumors. These tumors were produced by air concentrations of the tar as low as 2 milligram per cubic meter of air, but were not produced by concentrations of 0.2 milligram per cubic meter of air. It also has been shown that there is an incidence time-related dose-response relationship for the protection of this skin tumor reaction in mice.

ERGONOMICS RESEARCH

Research activities in ergonomics encompassed assessment of human tolerance limits to several stress factors imposed on the worker by the job and its environment, factors such as weight lifting, static work, shift work, noise, and vibration.

In 1973, both surface and underground mines were examined as part of a comprehensive multi-industry walk-through survey, to inventory jobs where workers are exposed to either hand tool or whole body vibration. Hand tool vibration was found to occur mainly underground in jobs like preparation of shot holes and insertion of roof suspensions. The operation of continuous mining machines underground and heavy equipment (such as shovels, bulldozers, scrapers and trucks) in surface mining, as well as working in the processing plant involves whole body vibration.

In 1972, NIOSH and the Bureau of Mines began a joint study of mining noise and its effect on the hearing of coal miners. The purpose of this study is to determine the prevalence of hearing impairment among coal miners and to provide environmental noise and hearing test data as a basis for evaluating the present coal mine noise standard. The collection of data from the noise and hearing survey (conducted at 11 mines and involving 1,494 miners) was com-

pleted in 1973. The accumulated data are being analyzed by NIOSH to determine the cause-effect relationship between noise exposure and hearing loss. The computer analysis is similar to that used in the development of the NIOSH recommended standard for occupational noise exposure submitted to the Department of Labor in 1972.

The evaluation of the environmental noise levels obtained from the Bureau of Mines showed that a very small percentage of the miners are exposed to amounts of noise which should be hazardous to hearing, as defined by the current NIOSH recommended criteria on noise; however, the analysis of the data obtained from the hearing testing does not yield the results one would predict based on the environmental noise measurements. When compared with non-noise exposed workers, miners (even those with relatively few years of mining experience) may exhibit significant hearing losses in all age groups. The hearing of coal miners deteriorates more rapidly with age than does the hearing of the general population. In an additional investigation, the effects of exposure to firearm noise on the hearings of the miners was determined; the results indicate that recreational firearm use is probably not a significant factor in the hearing acuity of the coal miners.

COAL-RELATED WORKER HEALTH RESEARCH

Section 501(d) of the Act requires the Secretary of HEW to conduct studies and research involving the protection of life and the prevention of diseases in connection with persons who, although not miners, work with or around the products of coal mines in areas outside of such mines and under conditions which may adversely affect the health and well-being of such persons.

A contract study with the Commonwealth of Pennsylvania to determine the prevalence of CWP and the related environmental exposure in coal-related industries was completed in 1973. The data are currently being statistically evaluated to compare exposure levels and existing health standards; to determine prevalence of CWP as related to age, cumulative exposure expressed as "milligram years," and years of coal handling; and to relate exposure to disease where sufficient exposure history is available. It is expected that definitive conclusions on coal handlers will be available in 1974.

GRANTS

NIOSH plans, directs and coordinates a program of grants for support of research at universities, state and local agencies, and other public and non-profit institutions on problems related to the health of the individual coal miner and the maintenance of a safe work environment. This effort receives further support from the United States Department of the Interior and in order to prevent duplication, close interagency liaison is maintained. In 1973, fundamental and applied research conducted in this area of concern included occupational respiratory disease (CWP); head and body protection; and exposures to carbon monoxide, diisocyanates, noise, and vibration. A total of 17 projects were active during the year and \$347,446 were allocated for that purpose. (See Appendix C for listing of grants.)

Accomplishments of significance were in the following areas:

A cell culture system to examine the toxicity of trace metal components of coal, thought to play a role in CWP, was further tested. The system was developed at the Kettering Laboratory, University of Cincinnati, under three separate but interrelated projects.

The role of bacterial flora in CWP received important clarification.

A systematic approach to the problem of mechanical vibration from hand-held tools was begun in 1973. Previous research has shown a definite correlation between exposure directed to the hand and a disease (Raynaud's phenomenon) in which small arteries and blood vessels in the fingers are destroyed. The information to be obtained should aid in the development of safe exposure levels to hand-arm vibration. In 1973, a NIOSH walk-through survey found that mainly underground coal miners were exposed to this kind of vibration.

SPECIAL FOREIGN CURRENCY PROGRAM

The Special Foreign Currency Program operates under authority of the President in Section 104(b)(3) of the Agricultural Trade Development and Assistance Act as amended (P.L. 83-480). The program is supported by U.S. owned foreign currencies which have been determined by the Treasury Department to be in excess of normal U.S. needs in certain designated countries. These excess currencies were

obtained through the sale of agricultural products and must be used in foreign countries involved; there is no appropriated dollar outflow from the United States in connection with this program.

Evaluation of Isoniazid

The project to evaluate Isoniazid as a prophylaxis against progressive massive fibrosis was conducted at the Serbian Institute of Occupational and Radiological Health, Belgrade, Yugoslavia; it was completed in 1973. Coal miners with categories two and three CWP who were tuberculin positive but without X-ray evidence of tuberculosis, were given Isoniazid (5 milligrams per kilogram of body weight per day) for one year. The results were not conclusive as to progression to PMF; however, Isoniazid was beneficial in significantly reducing the number of miners who developed tuberculosis positive X-rays during the five years of the study.

NIOSH has requested copies of all original data and X-rays for study by epidemiologists and radiologists and is considering the possibility of having the project extended to include another examination of the miners in the control and treated groups during 1977-78.

Chest Diseases in Coal Miners

The Institute of Occupational Medicine in the Mining and Metallurgical Industries in Sosnowiec, Poland, is determining the role of all factors in the coal miner's work environment which relate to the rate and pattern of morbidity, mortality, and absenteeism with special reference to respiratory tract disorders. During 1973, data collection was started on the miners in two coal mines; plans are to include the entire work force for the two mines, about 9,000 miners. The information obtained for each worker includes demographic, environmental, and residential data, absenteeism record (due to sickness or accidents); and a detailed medical examination including laboratory analysis, chest X-ray, electrocardiograms, and spirometric lung function data. About 500 underground miners were examined during the first 6 months of 1973.

Cardiopulmonary Functions

A study of cardiopulmonary function in coal miners exposed to coal dust of differing composition was completed in 1973 by the Serbian Institute of Occupational and Radiological Health in Belgrade, Yugoslavia. Miners working hard coal

mines and miners working soft coal mines with appropriate control groups were studied for a period of 5 years to determine whether the type of coal was associated with differences in morbidity or mortality experiences or with differences in pulmonary function or pathology. A total of 860 coal miners and 638 controls were included in the study.

An observed increased incidence of chronic cough and dyspnea (shortness of breath) among coal miners, whether they were smokers or not, was determined to be occupationally related. As in other studies, smoking was positively correlated with an increase in reported cough. Chronic cough and dyspnea were associated with a reduction in pulmonary function. The presence of bronchospasm and wheezing was more pronounced in the miners, and appeared to be related to the coal dust factor. Progressive de-

crease, during the five years, in the forced expired volume in one second was observed in the miner-smoker group.

EFFECTS OF DIURNAL RHYTHM UPON HUMAN PERFORMANCE

Data collection on the effects of diurnal rhythm on human performance continued in 1973 at the Institute of Occupational Medicine in the Textile and Chemical Industries in Lodz, Poland. During the first six months of 1973, 20 male and 5 female subjects were tested on a battery of pulmonary function, work capacity, psychomotor performance and mental tests at times comparable to morning, afternoon, and night work shifts. Earlier preliminary studies indicate that many of the functions included in the test show a poorer capacity during the night shift testing time.

COOPERATIVE AND RELATED COAL MINE HEALTH ACTIVITIES

COAL MINE HEALTH RESEARCH ADVISORY COUNCIL

The Secretary's Coal Mine Health Research Advisory Council was established in 1970, under the Federal Coal Mine Health and Safety Act of 1969, to consult with and make recommendations to the Secretary of HEW on matters involving or relating to coal mine health research. The Council membership includes the Director of Bureau of Mines or his delegate, the Director of the National Science Foundation or his delegate, the Director of the National Institute Of Health or his delegate, and 14 additional members appointed by the Secretary of HEW. (See Appendix D for list of members.)

The Council met three times during 1973 - March 16 in Rockville, Maryland; June 11 in Washington, D.C.; and October 31 through November 1 in Morgantown, West Virginia. The Council received reports at each meeting on the status of current research and cooperative activities and gave specific attention to the following:

- (1) Legislation concerning coal miners' health.
- (2) Progression of coal workers' pneumoconiosis as determined from the initial data from the National Study of Coal Workers' Pneumoconiosis.
- (3) Comparison of United States and British interpretation of X-rays as related to the National Study of Coal Workers' Pneumoconiosis.
- (4) Prevalence studies of coal workers' pneumoconiosis of the surface miners.
- (5) Results of the study of surface coal mines.
- (6) Review of Public Law 91-173 with respect to allowing more effective research application and control of coal workers'

pneumoconiosis. In this respect, a sub-committee was formed which dealt with the problem of criteria for diagnosis of disability and death from coal workers' pneumoconiosis.

- (7) Proposed regulations including medical examinations.
- (8) Use of diesel power in underground coal mines.
- (9) Use of computers for coal workers' pneumoconiosis X-ray classification.
- (10) Noise survey at selected coal mines.
- (11) Steroids combined with isonicotinic acid as a medical approach to the alleviation of progressive massive fibrosis.
- (12) Differences in volume and ventilatory capacity in black and white miners.
- (13) Lung air space diameter related to dust particle deposition.
- (14) Administrative methods for review and appeal of cases by individual coal miners.

The following grant applications were reviewed during 1973:

- (1) The Fate of Inhaled Coal Dust.
- (2) The Effect of Hazardous Duty on Microphage Metabolism.
- (3) Pathogenesis of Coal Workers' Pneumoconiosis.
- (4) Solubility Studies of Respirable Coal Dust.
- (5) Lung Clearance and Pulmonary Carcinogenesis.
- (6) The Mechanism of Alveolar Proteinosis.

INTERIM COMPLIANCE PANEL

Continuing support was provided to the Interim Compliance Panel (ICP) by NIOSH during 1973 under the terms of an agreement negotiated between the Office of the Secretary, DHEW, and the Interim Compliance Panel in

September 1970. That agreement provided for the provision of personnel ceilings up to a specified number, payment of salary and related costs for filled positions, and payment of 40 percent of all other costs incident to ICP operations.

The Interim Compliance Panel was established as an independent Federal entity pursuant to Section 5 of the Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173). Its function is to provide considered temporary relief for individual underground coal mine operators from the otherwise mandatory standards for mine levels of respirable dust and for the operation of non-permissible electric face equipment. As indicated in the Act, the Panel expects to have completed all of its functions and will cease to exist not later than June 30, 1976.

All underground coal mines must be in compliance with the two milligrams per cubic meter of air dust standard provided by the Act by no later than December 30, 1975. Activities of the ICP associated with carrying out these provisions decreased substantially during the year. The bulk of the work necessitated by the standard was accomplished in the last quarter of 1972 when 807 applications for permits of noncompliance covering 2,254 mine sections were considered and acted upon. During 1973 the Panel considered 207 applications for renewal of previously issued permits for noncompliance with the two milligrams per cubic meter of air dust standard.

It is expected that the Panel's primary workload during 1974 will be concerned with the permissibility of electric face equipment. All face equipment for underground coal mines above the water table must be in permissible condition by no later than March 30, 1976.

MINING ENFORCEMENT AND SAFETY ADMINISTRATION — BUREAU OF MINES

During 1973, the Mining Enforcement and Safety Administration (MESA) and the Bureau of Mines continued to coordinate their coal mine health-related activities with NIOSH. These activities fell roughly into nine categories as follows:

(1) Joint Projects:

National Study of Coal Workers' pneumoconiosis

(NIOSH - medical examinations;
MESA - dust sampling)
Noise and Hearing Survey
(NIOSH - audiograms; MESA - environmental noise)

(2) Complementary Projects (which benefit both agencies)

Development of Instrumentation to Measure Dust, Gases, etc.

Sanitation

(NIOSH will develop good practices manual for use in coal mines)

Diesel Engine Research

(NIOSH - proposed literature search of particulates, criteria documents on nitrogen dioxide, etc.;

MESA - research on engine performance features.)

(3) Cooperative Implementation of Coal Act: NIOSH develops standards for health MESA enforces standards

(4) Informal Contacts Between Program Staffs of Two Agencies

(5) NIOSH Liaison Officer to MESA - Bureau of Mines

Enhance program planning

Exchange of technical information

Coordinate activities

Advise on health matters

(6) Joint Staff Seminars

(Example: Conference on Progress of Coal Act Implementation)

(7) Reciprocal Representation on Advisory Committees:

NIOSH representative on Interior's Advisory Committee on Coal Safety Research

MESA, Bureau of Mines representative on the Secretary's Coal Mine Health Research Advisory Council and on training grant study group.

(8) Joint Discussions of Proposed Hearings and Regulations Regarding Coal Miners' Health

(9) Joint Participation in Field Seminars on Coal Mine Health

SOCIAL SECURITY ADMINISTRATION

During 1973, the Social Security Administration (SSA) provided a liaison officer to the Secretary's Coal Mine Health Research Advisory Council. The liaison officer actively participated in the Advisory Council activities. In addition,

the SSA took part in four conferences on X-ray quality control during the year.

BUREAU OF RADIOLOGICAL HEALTH

NIOSH and the Bureau of Radiological Health have interagency agreements covering two contracts. One of these contracts deals directly with problems of quality control as related to the X-rays taken under the Federal Coal Mine Health and Safety Act. The other contract involves classifying X-rays of coal workers' pneumoconiosis by computer.

DEPARTMENT OF LABOR

On July 1, 1973, the U.S. Department of Labor took over the activities of the Social Security Administration with respect to compensation for coal workers' pneumoconiosis. Since that time, the Department of Labor has supplied a liaison representative to the Secretary's Coal Mine Health Research Advisory Council. In addition, NIOSH has supplied a liaison medical officer to the Department of Labor to assist in the execution of their program.

AIR SAMPLING AND PERSONAL PROTECTIVE EQUIPMENT

NIOSH engineering activities include the development, testing, and certification of air sampling instruments and personal protective equipment for coal mine use.

The coal mine air sampling program consists primarily of research and development of air sampling equipment and methods. The objective of this program is to provide a better means of evaluating the coal workers' exposure to respirable dust and to provide realistic and reliable methods of sampling the coal mine environment to insure compliance with established standards.

Under an interagency agreement with the Atomic Energy Commission's Los Alamos Scientific Laboratory (AEC-LASL) a standard, test coal dust was developed. This dust is available to other laboratories in limited quantities and will be used by NIOSH as part of an instrument evaluation program. Two planned projects involve the testing of a prototype multi-cyclone coal mine dust mass distribution measuring instrument and the evaluation of an improved coal mine dust personnae sampler. The standard, instrument-calibration dust chamber built in 1972 has performed satisfactorily for over a year. The design has been expanded and a large dynamic dust chamber was built in 1973. A report entitled "The Standard Instrument Calibration Aerosol Test System" was prepared by AEC-LASL and NIOSH covering the original smaller dynamic coal dust test chamber.

New requirements for pulsation dampeners in all coal mine dust personal sampler unit pumps became effective December 15, 1973. All pumps with dampeners submitted for testing and certification were approved by August 1973. However, the manufacturers experienced delays in procuring materials for the construction of the dampeners, and the deadline for installation of the dampeners in already purchased units was extended after a public meeting. The installation of dampeners in these pumps requires a

change in the cyclone to a conversion factor currently published in the *Federal Register* (30 CFR 70 and 30 CFR 74).

The Bureau of Mines, MESA, and NIOSH met to discuss the matter and to present data relative to the development of a new factor. The new factor had not been formally established, but it must be published before the pulsation dampeners are installed in 1974.

Another phase of the evaluation of the 10 millimeter nylon cyclone as a preselector was completed. This phase studied the effect of charging on the collection efficiency. The study showed that for conditions of low humidity, cyclones constructed of a conductive material yielded less variation in results than cyclones constructed of a dielectric material. The final results of a contract study at the University of Minnesota further evaluating this instrument are expected in 1974.

The initial evaluation of the instantaneous mass chest monitor was completed and details of the findings are being prepared for publication. An intermediate volume sampler (25 liters per minute) was developed under contract and two prototypes have been delivered. The pump will undergo extensive laboratory and field evaluation prior to its recommendation for use in field surveys.

Section 202 of the Act creates a statutory requirement that mine operators provide respirators for miners exposed to coal mine dust, whenever the dust exceeds the established standard. Section 204 requires miners to be provided respirators when they are exposed for short periods of time to inhalation hazards from gas, dust, fume, or mist. When the exposure is for prolonged periods, other measures to protect such persons, or to reduce the hazard, shall be taken. An applied research and development program is underway to improve coal miner acceptance of respirators through the development of improved devices and more effective

standards for respirator approval. A research project was completed to develop a prototype air-supplied respirator system for use by underground coal mining equipment operators. The purpose of this project was to develop design criteria to overcome the major objections of coal miners to the use of respirators, which are physical discomfort and high breathing resistance. Further performance evaluation of this prototype system in underground coal mines is anticipated.

A continuing interagency agreement is in progress with the Atomic Energy Commission to develop more valid methods and improve equipment for approval and quality control testing of respirators. Included in this research program with the AEC is the development of a Respirator Program Guide providing recommended practices to industry for establishing acceptable programs.

A project is also underway to develop a design guide intended for use by respirator manufacturers which will provide anthropometric data on

the range of facial variability that is inherent in the working population and which must be accommodated in the sizing and design of respirators. To support the needs of the NIOSH Testing and Certification Laboratory, a research program is underway to develop improved methods of testing respirators submitted by manufacturers for approval. An Automated Breathing Metabolic Simulator (ABMS) was obtained and installed in the NIOSH Engineering laboratory. The ABMS can simulate the relevant breathing and metabolic functions required for respirator research. An accurate and complete printed record of pertinent test data can be obtained with this simulator.

Responsibility for testing of coal mine respiratory protective devices for joint certification by the Bureau of Mines and NIOSH was transferred from the Bureau to NIOSH on March 15, 1973. Proposed certification regulations were developed for coal miners' personal protective devices and sound-level meters which are to be promulgated in the future.

APPENDIX A

Coal Mine Health Contracts

<i>Contract</i>	EHS-R-71-001	County, West Virginia, by Dr. I. T. T. Higgins. Mortality, as well as prevalence, incidence, progression, and remission of chronic respiratory diseases will be studied.
<i>Contract Period</i>	01/05/71 - 01/04/74	
<i>Funds to Date</i>	\$47,489	
<i>FY 73 Funding</i>	\$0	
<i>Project Officer</i>	William D. Wagner	
<i>Title</i>	Immunological Aspects of Experimental Pneumoconiosis	<i>Contractor</i> University of Michigan Ann Arbor, Michigan
<i>Abstract</i>	Provide information from experimental animals as to the time or onset of lung reactive antibodies during and following chronic inhalation exposure to respirable coal dust. This data will be correlated with the onset of pathology as evidenced from autopsy data and evolution of experimentally induced pneumoconiosis. Methodology for quantitating secretory immunoglobulin A in experimental animals will also be developed.	<i>Contract Director</i> I. T. T. Higgins
		<i>Contract</i> HSM-99-72-057
		<i>Contract Period</i> 06/15/72 - 05/31/75
		<i>Funds to Date</i> \$127,800
		<i>FY 73 Funding</i> \$0
		<i>Project Officer</i> Earl P. Shoub
		<i>Title</i> Provision or Ancillary Services and Domiciliary Care
		<i>Abstract</i> Reimburse the West Virginia University Medical Center Hospital for ancillary services, laboratory tests, and the use of facilities not available in NIOSH where special clinical studies will be carried out on coal miners with respiratory impairment.
<i>Contractor</i>	University of West Virginia Morgantown, West Virginia	<i>Contractor</i> West Virginia Medical Center Hospital Morgantown, West Virginia
<i>Contract Director</i>	R. Burrell	<i>Contract Director</i> Eugene L. Staples
<i>Contract</i>	HSM-99-71-022	
<i>Contract Period</i>	06/30/71 - 06/29/74	
<i>Funds to Date</i>	\$623,281	
<i>FY 73 Funding</i>	\$0	
<i>Project Officer</i>	Earle P. Shoub	<i>Contract</i> HSM-99-72-081
<i>Title</i>	Follow-up Study of Three Coal Mining Communities in West Virginia	<i>Contract Period</i> 06/19/72 - 02/28/74
		<i>Funds to Date</i> \$45,872
		<i>FY 73 Funding</i> \$0
		<i>Project Officer</i> Richard J. Lewis
<i>Abstract</i>	Follow-up the people who were studied approximately six years ago in Mullens and Richwood, West Virginia by the USPHS and in Marion	<i>Title</i> Testing of Prototype Knee Devices
		<i>Abstract</i> Develop and carry out a test plan to evaluate the proto-

	type knee protective device for low coal miners developed under a NIOSH contract.	<i>Contractor</i>	Mayo Foundation Rochester, Minnesota
<i>Contractor</i>	Century Research Corporation Arlington, Virginia	<i>Contract Director</i>	R. E. Hyatt
<i>Contract Director</i>	Robert B. Sleight		
<i>Contract</i>	HSM-99-72-100	<i>Contract</i>	HSM-99-72-151
<i>Contract Period</i>	06/29/72 - 06/28/74	<i>Contract Period</i>	06/30/72 - 12/31/74
<i>Funds to Date</i>	\$53,250	<i>Funds to Date</i>	\$131,332
<i>FY 73 Funding</i>	\$0	<i>FY 73 Funding</i>	\$0
<i>Project Officer</i>	William D. Wagner	<i>Project Officer</i>	William Kroes & Bruce Margolis
<i>Title</i>	Study of Factors Affecting Removal of Dust from the Lungs	<i>Title</i>	Attitudinal Factors Affecting Coal Miner Safety and Health
<i>Abstract</i>	Study factors affecting removal of dust from lungs including developing data concerning pool size and phagocytic capacity of alveolar macrophages following exposure to high concentrations of coal dust. The serum fractions that bind and transport the metallic elements that have been elicited from coal samples will also be determined.	<i>Abstract</i>	Examine, by means of a survey, the attitudes and motivations of coal mine personnel which influence coal miners' acceptance and participation in established safety and health practices.
		<i>Contractor</i>	Westinghouse Electric Corporation Columbia, Maryland
<i>Contractor</i>	University of Cincinnati, Department of Environmental Health, College of Medicine Cincinnati, Ohio	<i>Contract Director</i>	C. Grether
<i>Contract Director</i>	E. Bingham Mattheis		
<i>Contract</i>	HSM-99-72-133	<i>Contract</i>	HSM-99-73-004
<i>Contract Period</i>	06/30/72 - 06/30/75	<i>Contract Period</i>	10/02/72 - 11/10/74
<i>Funds to Date</i>	\$409,025	<i>Funds to Date</i>	\$303,860
<i>FY 73 Funding</i>	\$0	<i>FY 73 Funding</i>	\$303,860
<i>Project Officer</i>	N. LeRoy Lapp	<i>Project Officer</i>	Larry F. Boyce
<i>Title</i>	Analysis of Maximal Expiratory Flow - Volume Curves Based on an Analytical Model of Lung Mechanics	<i>Title</i>	Information Processing System for the Coal Miner Medical Examination Program
<i>Abstract</i>	Develop, refine, test, and validate an analytical (mathematical) model of the mechanical properties of the lungs in order to better understand the determinants of the maximal expiration flow-volume curve.	<i>Abstract</i>	Provide suitable means to process medical data relative to chest X-rays for coal miners.
		<i>Contractor</i>	West Virginia University Morgantown, West Virginia
		<i>Contract Director</i>	Wayne A. Muth
		<i>Contract</i>	HSM-99-73-6
		<i>Contract Period</i>	06/01/72 - 05/31/74
		<i>Funds to Date</i>	\$100
		<i>FY 73 Funding</i>	\$100
		<i>Project Officer</i>	W. Keith Morgan
		<i>Title</i>	X-ray Interpretation: Second Round National Study of Coal Workers' Pneumoconiosis

Abstract Interpret and classify by the UICC/Cincinnati system, X-ray films from the second round of the National Study of Coal Workers' Pneumococ-niosis and in addition, ex-amine side-by-side pairs of films from the same miners taken approximately three years apart and determine progression, if any, of the dis-ease over that time interval in those subjects.

Contractor Professional Staff Association
Los Angeles, California

Contract Director George Jacobson

Contract HSM-99-73-7

Contract Period 01/01/73 - 05/31/74

Funds to Date \$100

FY 73 Funding \$100

Project Officer W. Keith Morgan

Title X-Ray Interpretation: Sec-
ond Round National Study of
Coal Workers' Pneumoconio-
sis

Abstract Interpret and classify by the UICC/Cincinnati system, X-ray films from the second round of the National Study of Coal Workers' Pneumoco-niosis and in addition, exam-ine side-by-side pairs of films from the same miners taken approximately three years apart and determine progres-sion, if any, of the disease over that time interval in those subjects.

Contractor Johns Hopkins University
Baltimore, Maryland

Contract Director Martin W. Donner and Paul
Wheeler

Contract HSM-99-73-008

Contract Period 12/01/72 - 05/31/74

Funds to Date \$100

FY 73 Funding \$100

Project Officer W. K. C. Morgan

Title X-Ray Interpretation: Sec-
ond Round National Study

Abstract

of Coal Workers' Pneumoco-niosis

Interpret and classify by the UICC/Cincinnati system X-ray films and from the sec-ond round of the National Study of Coal Workers' Pneu-moconiosis and in addition, examine side-by-side pairs of films from the same miners taken approximately three years apart and determine progression, if any, of the dis-ease over that time interval in those subjects.

Contractor John M. Dennis
Baltimore, Maryland

Contract Director John M. Dennis

Contract HSM-99-73-009

Contract Period 12/01/72 - 05/31/74

Funds to Date \$100

FY 73 Funding \$100

Project Officer W. K. C. Morgan

Title X-Ray Interpretation: Sec-
ond Round National Study
of Coal Workers' Pneumoco-niosis

Abstract Interpret and classify by the UICC/Cincinnati system, X-ray films from the second round of the National Study of Coal Workers' Pneumoco-niosis and in addition, exam-ine side-by-side pairs of films from the same miners taken approximately three years apart and determine progres-sion, if any, of the disease over that time interval in those subjects.

Contractor Orlando F. Gabriele
Morgantown, West Virginia

Contract Director Orlando F. Gabriele

Contract HSM-99-73-011

Contract Period 12/01/72 - 05/31/74

Funds to Date \$100

FY 73 Funding \$100

Project Officer W. K. C. Morgan

Title X-Ray Interpretation: Sec-
ond Round National Study

<i>Abstract</i>	of Coal Workers' Pneumocoinosis				which could be used with the proper analytical techniques to evaluate the proficiency of roentgenographic interpreters.
	Interpret and classify by the UICC/Cincinnati system, X-ray films from the second round of the National Study of Coal Workers' Pneumocoinosis and in addition, examine side-by-side pairs of films from the same miners taken approximately three years apart and determine progression, if any, of the disease over that time interval in those subjects.				
<i>Contractor</i>	Eugene P. Pendergrass Philadelphia, Pennsylvania		<i>Contractor</i>		Johns Hopkins University Baltimore, Maryland
<i>Contract Director</i>	Eugene P. Pendergrass		<i>Contract Director</i>		Alvin Lazen
<i>Contract</i>	HSM-99-73-13		<i>Contract</i>		HSM-99-73-40
<i>Contract Period</i>	04/06/73 - 10/31/73		<i>Contract Period</i>		06/01/73 - 05/31/74
<i>Funds to Date</i>	\$192,000		<i>Funds to Date</i>		\$100
<i>FY 73 Funding</i>	\$192,000		<i>FY 73 Funding</i>		\$100
<i>Project Officer</i>	Alan H. Purdy		<i>Project Officer</i>		W. Keith Morgan
<i>Title</i>	Support of Task Force and Training on Pneumoconiosis X-rays		<i>Title</i>		X-Ray Interpretation: Second Round National Study of Coal Workers' Pneumocoinosis
<i>Abstract</i>	Plan, promote, and conduct a series of conferences for physicians and X-ray technologists in preparation for round two of the coal miner examination program required under P.L. 91-173. Additional activities will be provided in support of the second round of examinations.		<i>Abstract</i>		Interpret and classify by the UICC/Cincinnati system, X-ray films from the second round of the National Study of Coal Workers' Pneumocoinosis and in addition, examine side-by-side pairs of films from the same miners taken approximately three years apart and determine progression, if any, of the disease over that time interval in those subjects.
			<i>Contractor</i>		Benjamin Felson, Cincinnati General Hospital Cincinnati, Ohio
<i>Contractor</i>	The American College of Radiology Chevy Chase, Maryland		<i>Contract Director</i>		Benjamin Felson
<i>Contract Director</i>	Edgar L. Dessen		<i>Contract</i>		HSM-99-73-57
<i>Contract</i>	HSM-99-73-14		<i>Contract Period</i>		06/30/73 - 06/29/74
<i>Contract Period</i>	02/12/73 - 02/11/75		<i>Funds to Date</i>		\$72,486
<i>Funds to Date</i>	\$26,263		<i>FY 73 Funding</i>		\$72,486
<i>FY 73 Funding</i>	\$26,263		<i>Project Officer</i>		Robert B. Reger
<i>Project Officer</i>	Robert B. Reger		<i>Title</i>		Digitalized Image Processing of Chest X-rays to Assess Progression and Categorize CWP
<i>Title</i>	Roentgenographic Interpreter Proficiency Evaluation System		<i>Abstract</i>		Investigate the feasibility of the use of digital image change detection techniques for improving the readability and diagnosis of progression of Coal Workers' Pneumocoinosis from chest roentgenograms.
<i>Abstract</i>	Provide for the selection and validation of a series of films				

<i>Contractor</i>	Control Data Corporation Minneapolis, Minnesota	<i>Contractor</i>	Welfare and Retirement Fund.
<i>Contract Director</i>	R. L. Lillestrand	<i>Contractor</i>	University of Pittsburgh Pittsburgh, Pennsylvania
<i>Contract</i>	HSM-99-73-59	<i>Contract Director</i>	Howard Rockette
<i>Contract Period</i>	06/30/73 - 05/31/74	<i>Contract</i>	HSM-99-73-81
<i>Funds to Date</i>	\$100	<i>Contract Period</i>	06/30/73 - 04/29/74
<i>FY 73 Funding</i>	\$100	<i>Funds to Date</i>	\$114,339
<i>Project Officer</i>	W. Keith Morgan	<i>FY 73 Funding</i>	\$114,339
<i>Title</i>	X-ray Interpretation: Sec- ond Round National Study of Coal Workers' Pneumoconio- sis	<i>Project Officer</i>	Frank W. Makison
<i>Abstract</i>	Interpret and classify by the UICC/Cincinnati system, X- ray films from the second round of the National Study of Coal Workers' Pneumoco- niosis and in addition, exam- ine side-by-side pairs of films from the same miners taken approximately three years apart and determine progres- sion, if any, of the disease over that time interval in those subjects.	<i>Title</i>	Investigation of the Sanita- tion Practices Associated with Coal Mine Operations
<i>Contractor</i>	Leonard J. Bristol Saranac Lake, New York	<i>Abstract</i>	Collect and evaluate basic data through a literature re- view and a field survey of 200 mines the sanitation practices in coal mines to appraise the effectiveness of current regu- lations for adequately pro- tecting the health of miners.
<i>Contract Director</i>	Leonard J. Bristol	<i>Contractor</i>	University Science Center, Inc. Pittsburgh, Pennsylvania
<i>Contract</i>	HSM-99-73-80	<i>Contract Director</i>	Alvan W. Leavitt
<i>Contract Period</i>	06/30/73 - 06/29/75	<i>Contract</i>	HSM-99-73-92
<i>Funds to Date</i>	\$160,912	<i>Contract Period</i>	06/30/73 - 12/29/74
<i>FY 73 Funding</i>	\$160,912	<i>Funds to Date</i>	\$138,736
<i>Project Officer</i>	W. Keith Morgan	<i>FY 73 Funding</i>	\$138,736
<i>Title</i>	Mortality Among Coal Min- ers Covered by the United Mine Workers of America Welfare and Retirement Fund	<i>Project Officer</i>	Alan H. Purdy and Robert B. Reger
<i>Abstract</i>	Clarify the extent of health problems associated with em- ployment in coal mines through an examination of mortality patterns among persons covered by the United Mine Workers of America	<i>Title</i>	Automated Chest X-Ray Classification
		<i>Abstract</i>	Develop prototype software support systems for the auto- matic scanning and computer classification of the profusion and extent of coal workers' pneumoconiosis in chest X- rays.
		<i>Contractor</i>	University of Southern Cali- fornia Los Angeles, California
		<i>Contract Director</i>	Richard P. Kruger and Ernest L. Hall

APPENDIX B

Coal Mine Health Interagency Agreements

<i>Agreement</i>	NIOSH-I-71-10	<i>Title</i>	Inhalation Toxicology Research on Coal Tar Volatiles and Low Molecular Weight Fluorocarbons
<i>Funds to Date</i>	\$235,000		
<i>FY 73 Funding</i>	\$50,000		
<i>Project Officer</i>	Alan H. Purdy	<i>Abstract</i>	Investigate the toxicological effects of coal tar volatiles, as from coke oven emissions, on laboratory animals, and evaluate the dose of fluorocarbon required to produce cardiac arrhythmia following inhalation exposure.
<i>Title</i>	X-ray Technician Training		
<i>Abstract</i>	Provides NIOSH support for the continuation of the X-ray Science and Engineering Laboratory project at Oregon State University.		
<i>Agency</i>	Bureau of Radiological Health Food and Drug Administration	<i>Agency</i>	Aerospace Medical Division (AFSC) Wright-Patterson AFB, Ohio
<i>Project Director</i>	E. Dale Trout	<i>Project Director</i>	Anthony A. Thomas
<i>Agreement</i>	NIOSH-I-72-12	<i>Agreement</i>	NIOSH-I-74-06
<i>Funds to Date</i>	\$0	<i>Funds to Date</i>	\$0
<i>FY 73 Funding</i>	\$0	<i>FY 73 Funding</i>	\$0
<i>Project Officer</i>	Jeremiah R. Lynch	<i>Project Officer</i>	Alan H. Purdy
<i>Title</i>	Respirator Testing	<i>Title</i>	Automated Computer Diagnosis of CWP
<i>Abstract</i>	Defines NIOSH - Bureau of Mines roles and relationships in the testing and certification of respirators for use in coal mines.	<i>Abstract</i>	Provides for the transfer of \$20,000 to NIOSH for partial support of NIOSH efforts directed at developing a prototype system for automatic computer diagnosis of coal workers' pneumoconiosis (CWP) from a chest radiograph.
<i>Agency</i>	Bureau of Mines Washington, D.C.	<i>Agency</i>	Food and Drug Administration
<i>Project Director</i>	William R. Wayment	<i>Project Director</i>	William S. Cole
<i>Agreement</i>	NIOSH-I-73-21		
<i>Funds to Date</i>	\$212,500		
<i>FY 73 Funding</i>	\$212,500		
<i>Project Officer</i>	Lester D. Scheel and Trent Lewis		

APPENDIX C

Research Grants Awarded In Calendar Year 1973

Grant Number	Name, Institution, Project Title	Calendar Yr. FY '73 Support	'73 Support FY '74 Support
Occupational Respiratory Disease			
TOXICOLOGIC			
OH 00342-04	M. Pollard, University of Notre Dame, Notre Dame, Indiana, "Effects of Environmental Pollutants in Germfree Rodents"		18,743
OH 00355-03	Harold G. Petering, University of Cinn., Cincinnati, Ohio, "Interaction of Coal Dust with Essential Metals"		47,608
OH 00356-03	Robert Christian, University of Cinn., Cincinnati, Ohio, "Cellular Response to Coal Dust in Vitro"		42,340
OH 00358-02	Gary W. Davis, Ohio State University, Columbus, Ohio, "Pathophysiology of Coal Dust Pneumoconiosis in Equidae"		
MORPHOLOGIC			
OH 00334-05	Juraj Ferin, University of Rochester, Rochester, N.Y., "Air Pollutants and Lung Clearance of Particles"		77,843
OH 00352-04	Eugene D. Robin, Stanford University, Palo Alto, Calif., "Lung Cell Function in Health and Disease"	36,850	
OH 00357-03	E. Bingham Mattheis, Univ. of Cinn., Cincinnati, Ohio, "Fate of Inhaled Coal Dust"		26,232
OH 00396-02	Edward D. Palmes, New York Univ., New York, N.Y., "Aerosol Deposition in Human Subjects"		38,225
DIAGNOSTIC			
OH 00360-03	Robert Burrell, West Virginia Univ., Morgantown, W. Va., "Immune Injury in Occupational Respiratory Diseases"		20,696
<i>TOXICOLOGY</i>			
OH 00322-06	John M. Peters, Harvard University, Boston, Mass., "Health Hazards of Di-Isocyanates"		38,909

Grant Number	Name, Institution, Project Title	Calendar Yr. FY '73 Support	'73 Support FY '74 Support
Occupational Respiratory Disease			
OH 00330-03	Ronald L. Coleman, Univ. of Oklahoma, Oklahoma City, Okla., "Measuring Carbon Monoxide Effect with Trace Metal"		
<i>PHYSICAL AGENTS</i>			
OH 00341-02	Paul L. Michael, Pennsylvania State University, Univ. Park, Pa., "An Objective Method for Evaluating Ear Protectors"		
OH 00350-03	Wallace D. Ward, Univ. of Minnesota, Minneapolis, Minn., "Damage-Risk Criteria for Intermittent Noise Exposures"	30,577	
OH 00364-02	Donald Henderson, State of N.Y. Upstate Medical Center, Syracuse, N.Y., "The Effects of Impulse Noise on Auditory System"	43,938	
OH 00470-01	Douglas D. Reynolds, Univ. of Texas, Austin, Texas, "Vibration Characteristics of the Hand and Arm"		34,998
<i>HEAD AND BODY PROTECTION</i>			
OH 00301-03	George G. Snively, Snell Memorial Fdn., Inc., N. Tarrytown, N.Y., "Head Protection of Industrial Workers"		
OH 00404-01	Alan M. Nahum, Univ. of California, La Jolla, Calif., "Prevention of Accidental Head Injury"		

APPENDIX D

Coal Mine Health Research Advisory Council Members

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APPENDIX E

Selected Publications

- Morgan, W. K. C.: Chronic bronchitis. Current Therapy, ed., H. F. Conn., W. B. Sanders Co., Philadelphia, (1973) Section 2, p. 113
- Morgan, W. K. C.: Coal workers' pneumoconiosis. *J. Occup. Med.* 1973, 15:277
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- DeNee, P. B., Abraham, J. L., Gelderman, A. H.: Methods for a SEM study of coal workers' pneumoconiosis. Proceedings of the Workshop on Scanning Microscopy in Pathology IIT Research Institute, Chicago, April 1973
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- Hahon, N., Booth, J. A., Eckert, H. L.: Quantitative assessment of hemadsorption by myxoviruses: Virus hemadsorption assay. *Appl. Microbio.* 1973, 25:595
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- Reger, R. B., Butcher, D. F., Morgan, W. K. C.: Assessing change in the pneumoconiosis using serial radiographs. *Amer. Journal of Epidemiology* 1973, 98:243
- Trout, E. D., Jacobson, G., Moore, R. T., Shoub, E. P.: Analysis of the rejection rate of chest radiographs obtained during the coal mine "black lung" program. *Radiology* 1973, 109:25
- Kibelstis, J. A., Morgan, E. J., Reger, R. B., Lapp, N. L., Seaton, A., Morgan, W. K. C.: Prevalence of bronchitis and airway obstruction in American bituminous coal miners. *Amer. Rev. Resp. Dis.* 1973, 108:886-893
- Reger, R. B., Amandus, H. E., Morgan, W. K. C.: On the diagnosis of coalworkers' pneumoconiosis. Anglo-American disharmony. *Amer. Rev. Resp. Dis.* 1973, 108:1186-1191
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**DEPARTMENT OF
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