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REPORT ON STUDIES CONDUCTED IN BOLIVIA  
BY DONNER LABORATORY

The purpose and nature of the studies undertaken in Bolivia are contained in the proposal submitted to the Atomic Energy Commission in July, 1957. The present report summarizes the activities of and work performed by William E. Siri and Dr. Charles Webster in carrying out the proposed studies during the interval from September 6, to October 10, 1957, at La Paz, Bolivia.

The plan of work set forth in the original proposal was adhered to, both with regard to the studies and technical assistance rendered to Bolivian scientific personnel, largely because of the effective cooperation and assistance given by Bolivian personnel. The scope of the work actually performed, however, was considerably expanded beyond that which was originally thought to be the capacity of the two members of the Donner Laboratory team for the limited time allowed for the project.

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Work Performed

On arrival in La Paz on September 8, 1957, we began discussions immediately with Bolivian personnel to outline the nature and scope of proposed studies, and to arrange details of collaboration, laboratories, equipment, subjects, and schedules. In the course of the first week, inspection tours were made of the General Hospital, the Labor Hospital, private clinics, and laboratory facilities of the Public Health Service, Point 4, and the High Altitude Cosmic Ray Laboratory at Chacultaya. All arrangements for equipment, personnel, and subjects were completed by the end of the week, and we had established a laboratory in the Hematological Wing of the General Hospital, which we selected as the most favorable site in La Paz for the studies.

During the subsequent three and one-half weeks of our stay in La Paz, studies were performed on volunteer medical students and Indian miners in accordance with the original proposal submitted to the Atomic Energy Commission. Four clinically normal medical students were selected as test subjects from a group to whom physical examinations were given and histories taken. Physical examinations included chest x-rays, EKG, and blood survey. The complete set of studies were then

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made at La Paz during the week of September 15. A week later the four students were transported to the High Altitude Laboratory where they were kept in residence for five days, and the complete set of studies repeated. In order to secure the maximum information with the time and subjects at our disposal, one student a day was studied on four successive days so that the length of exposure to 17,000 ft. ranged from one day to four days.

Identical studies on four Indian miners were also undertaken at the High Altitude Laboratory concurrently with work on the medical students. The miners were known to have lived at an elevation near 17,000 ft. for at least the preceding four years. They were, consequently, fully acclimatized and presumably were maintaining a steady state with regard to erythropoiesis. As in the case of the medical students, the miners were selected on the basis of histories and physical examinations. It was not possible, because of the extreme limits on time and equipment, to repeat these studies on the miners in La Paz.

Each set of studies included the following tests:

- p32 blood volume
- Fe<sup>59</sup> turnover in plasma
- Fe<sup>59</sup> plasma volume
- Fe<sup>59</sup> red cell uptake
- Plasma iron content

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Tritium total body water

Arterial oxygen content,  
capacity and saturation

Blood survey

Urine collection and ultra-  
filtration for erythropoietic  
stimulent

Complete history and physical  
examination

At the time of this report, analysis of samples and data are incomplete; however, a few preliminary observations may be noted. The anticipated transient hemoconcentration in subjects taken to 17,000 ft. did not appear in the repeat  $P^{32}$  blood volume of the medical students. Red cell volume showed a slight tendency to increase even after one day exposure but plasma volumes remained essentially constant. Moreover, plasma volumes (cc/kgm) were very nearly identical in both groups of subjects (unacclimatized and acclimatized) at 17,000 ft., and were also equal to plasma volumes found in similar groups in the Peruvian studies at lower elevations.

Plasma radioiron turnover rate exhibited the expected increase at 17,000 ft., but it was of interest to note that the increase in rate was essentially the same after 24 hours, as it was after 4 days exposure to the change in altitude. At 17,000 ft. the half time for  $Fe^{59}$

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disappearance was the same in the medical students and the fully acclimatized miners, namely, about 11 1/4% per hour. This observation in the latter group is at variance with our earlier finding in Peru where the high altitude miners appeared to have a turnover rate comparable to that found at sea level.

The first two assays of erythropoietic stimulant activity in residues from ultrafiltered urine have yielded negative results. However, the remaining samples have not yet been assayed, and additional material is to be sent from Bolivia as it is processed by the group that is continuing the studies.

In the course of the work outlined above, a number of patients were examined who had been diagnosed as primary and/or secondary polythemics. Blood volumes in such patients were determined with radiophosphorus and radiochromium.

A search was made to secure statistical data on the incidence of cancer, and leukemia particularly, that might have some bearing on the effect of the higher level of cosmic radiation at 12,000 and 17,000 feet, but such data are virtually non-existent. There appeared, in fact, to be no reliable data on even crude death rates, since vital statistics have not been recorded for the bulk of the population.

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Technical Assistance to Bolivia

Our arrival in Bolivia appeared to stimulate an intensive, and I believe sincere, interest in a segment of the professional people in La Paz in medical research. Aside from the isolated effort of several physicists engaged in cosmic ray studies, research in general has been dormant in Bolivia for the past ten years. Medical practice, as well, appears to have suffered from want of stimulation, contact with more advanced countries, and a poor national economy. In the past year, however, conditions generally in Bolivia have shown evidence of steady improvement, to the point where technical assistance is not only eagerly sought after but can be assimilated.

Our visit, which brought to Bolivia a well defined research project and an invitation to participate in studies with radioisotopes, was, consequently, greeted with considerable enthusiasm. We received the fullest cooperation from the University Mayor de San Andres, the two major hospitals, the Public Health Service, Point 4 (I.C.A.), a number of doctors in private practice, and the High Altitude Cosmic Ray Laboratory. Dr. Jorge Ergueta, Director of the General Hospital, placed his hematology laboratory, staff, and equipment at our disposal. Similarly Prof. Ismael Escobar, Director of the

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Cosmic Ray Laboratory at Chacaltaya (17,000 ft.) made all necessary arrangements for our work and stay at his installations. The Public Health Service Office, the local Point 4 administration, and others provided personnel, equipment, and transportation. It may also be noted that through the efforts of Dr. Machicao, Professor of Pathology in the Medical School, and Vice Rector, Dr. Penilla, a substantial part of the expenses incident to our studies was covered by the University.

As a result of many discussions with the people with whom we collaborated, a permanent research group has been formed in La Paz under the leadership of Dr. Ergueta and Dr. Machicao. The group consists mainly of physicians from several institutions but includes several biochemists, and it will have the cooperation of the physics department of the University of San Andres. Professor Escebar has expressed great interest in cooperating with the local medical research group and will undertake to equip a substantial part of the High Altitude Laboratory for biological research. This is to include ample floor space, facilities, and quarters.

In the course of the four weeks in Bolivia, technical assistance was rendered in the following way:

1. Direct laboratory training in the use of radioisotopes and in a variety of current laboratory procedures was given to ten professionally qualified persons.
2. Daily discussions were held on problems in medical

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- research and techniques.
3. A series of formal lectures were presented on radio-isotopes, tracer applications in medical research, and high altitude investigations.
  4. Dr. Ergueta, as head of the local group, was provided with a collection of reprints and other technical literature to assist in familiarizing them with recent developments in the medical uses of radioisotopes.
  5. The group was provided with detailed descriptions of all procedures used in our studies.
  6. Discussions were held relevant to equipping the High Altitude Laboratory for biological research, and on means of securing support for the research group.
  7. Further assistance of an advisory nature is being rendered by correspondence.

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Bolivian professional personnel who collaborated actively in the research program are listed below:

Dr. Jorge Ergueta, Director  
The General Hospital (Hematologist)

Dr. Nicanor Machicao, Prof. of Pathology  
University of San Andres

Dr. Ismael Escobar, Prof. of Physics  
and Director of the High Altitude Cosmic Ray Laboratory

Dr. Ovidio Suarez, Biochemist, Consultant

Mr. Mario Iturralde, Medical Student

Dr. Luis Felipe Hartmann, Internal Medicine  
Santa Isabel Clinic

Dr. Penilla, Vice Rector,  
University of San Andres

Dr. Luis Alexander, General Hospital

Dr. Harold Fredericksen, Director,  
Point 4 Program, Bolivia

Dr. Luis Calderon, Labor Hospital

Dr. Alberto Gumiel, Director, S.C.I.S.P.  
(Public Health Laboratory)

Mr. Carlos Cardoza, Biochemist for S.C.I.S.P.

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William E. Siri  
Donner Laboratory  
November 27, 1957

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3 from left, Dr. Webster; 4th, Ambassador Bonsal; 5th, Dr. Hartmann; 7th, Dr. Machicao,



High altitude cosmic ray  
laboratory

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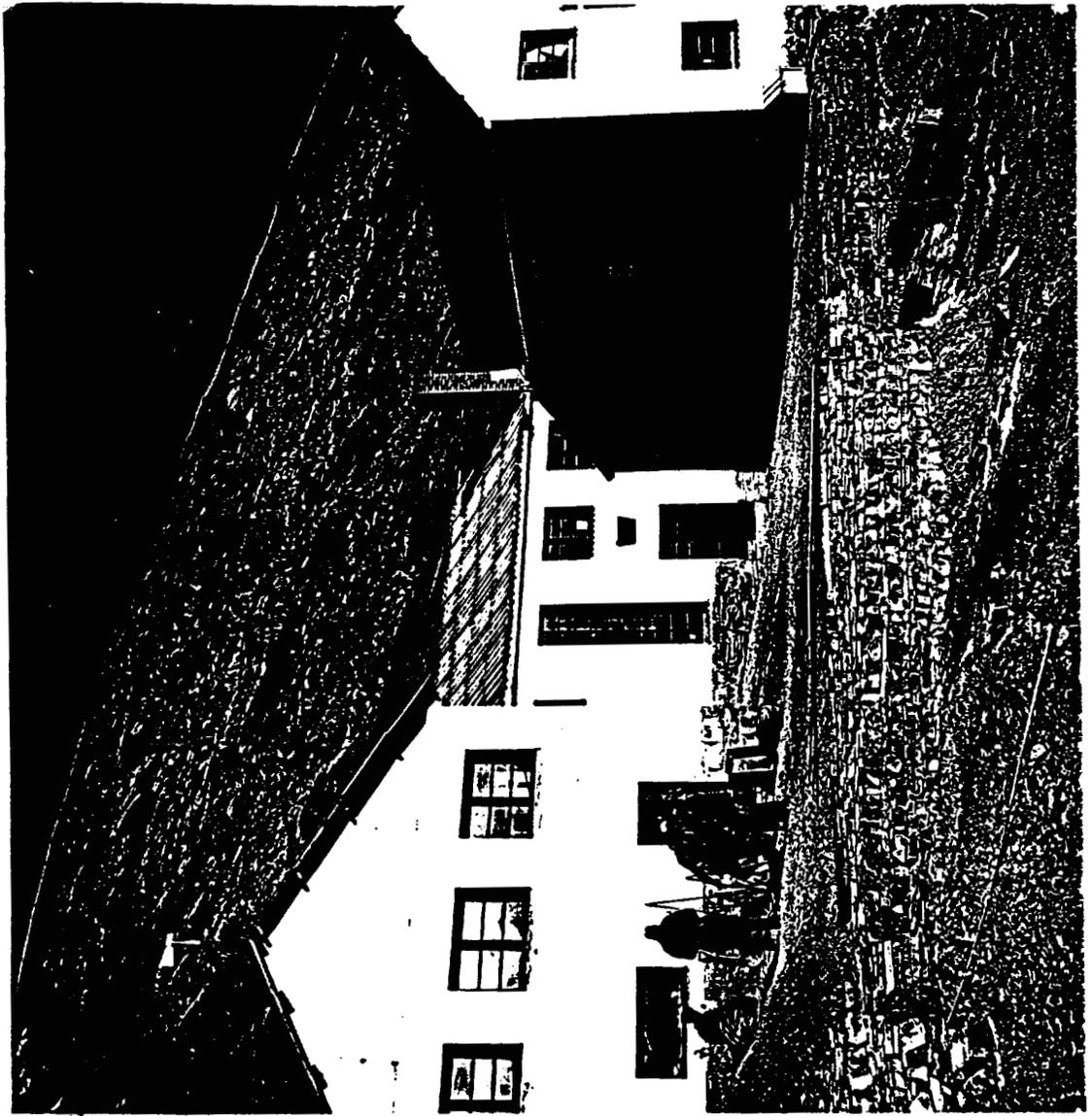
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