Biological Basis of Human Behavior

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I. INTRODUCTION

THE PIONEER research carried out on life in the Andes showed from the beginning that remarkable physiological deviations exist in acclimatized men and that striking changes, such as temporary infertility, as clinical observations pointed out in a few cases, occur in the newcomers. Later on, through biological experimentation, a period of infertility during adaptation to high altitude was found in different animals. Considering these strange facts, the possibility occurred to me of a historical approach to the problem which arose during the conquest of the highlands by the Spaniards, which would be facilitated by the fact that the Crown of Spain fortunately used to send the conquerors accompanied by learned secretaries who recorded the events. Were this guessing to prove useful, we would be able to correlate biological information obtained in the laboratory and social facts gathered from the analysis of the documents of the colonial writers. And, in fact, the truth of this assumption has been confirmed.

In starting the work on man and altitude we had in mind Galen's sentence: "'Man is a whole with his environment," so well pointed out by Hutchins as regards investigation and research in medicine. Man is not an abstraction; he is a part of the environment in which he lives and outside of which he cannot exist. Thus there is "no doubt that physiology lies at the base of behavior," as Coon suggested in regard to anthropology. "As a matter of fact," he says, "very few of the findings of social scientists lend themselves to scientific treatment with the precision which may be accorded to physical aspects of race." It can be added that there is also a lack of interest on the part of biologists in the problem of men and the outside world. Not enough attention has been paid to functional differences among men; it is supposed that they are all physiologically equal. It is not so, indeed! The equation does not hold true, at any rate, for dwellers of the high plateaus. With this idea as a research directive, applied physiology can provide many useful data on biological variations due to environmental changes as they have been found in animals. Research on this subject—heat, cold, and altitude—was started by Dill. Anthropology awaits biological data to further knowledge in this direction.

Correlation between form and function—physical and physiological anthropometry—and comparative physiological research on the so-called "definite" racial groups may prove to be useful by gathering information about respiratory and circulatory functions and other physiological factors. For instance, physical measurements of Andean men allow us to predict a con-

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siderable increase over the normal of the "below function" (Peabody) of the thorax, a greater size of the lung, a larger pulmonary blood bed, and consequently a greater quantity of work for the right chambers of the heart. Physiological research has demonstrated this to be the case. The plasticity of bone structure is well adapted to every influence of the external environment. Of course, we have been fortunate enough to work with people adapted to the most extreme limits of altitude environment, and this has permitted us to record extreme deviations.

II. ENVIRONMENT

Three important climatic elements of profound influence can be briefly discussed: altitude, temperature, and atmosphere.

ALTITUDE

According to Bowman, altitudes of 17,000 feet are fit for human living in Peru, as pointed out in his work, *The Andes of Southern Peru*. Places located higher up are inhabited for industrial reasons relating to mining work. Up to 17,000 feet there are ecological conditions to maintain life. There is a diminishing barometric pressure from sea-level to 17,000 feet, at which altitude it is about half the value of that at sea-level, 380 mm. The effect of this general lowering of pressure upon the body is unknown, since the research has been carried out only on diminished oxygen pressure.

TEMPERATURE

Several facts deserve attention. As the land is located in the tropics, the predominant type of climate should be tropical. However, this is not so. Because of the altitude, the weather is, in certain aspects, similar to that found in the arctic regions. The climate is of glacial type, but it is warm during the daytime because of the sun's tropical rays. This makes for a strange combination of climatic factors—heat and cold acting simultaneously—not yet studied in the determination of the resultant weather. It is always cold in the shade, and this is another element to be integrated. There is a marked difference between the extreme day and night temperatures. From approximately 6,000 to 15,000 feet altitude, the climate is cold but has the solar influence we have pointed out. Precipitation is abundant, dryness predominates. At sea-level, tropical or subtropical weather is the rule. The coastal climate is mild, and there is very little rain. Tropical weather and high humidity are notorious in the jungles of central Peru.

ATMOSPHERE

The rarefied atmosphere at high altitude impresses upon the climate a special characteristic of utmost significance in its tremendous influence on the living body. There is a gradual decrease of oxygen pressure from sea-level to the highest altitudes. We will see in the chart the oxygen pressure of the places where our research has been carried out.

At present we will limit ourselves to stating that at sea-level there is an oxygen pressure of 156 mm., one-fifth of the 760-mm. barometric pressure; in Huancayo there is 104 mm. oxygen pressure (518 B.P.); in Morococha there is 89 mm. oxygen pressure (446 B.P.); and in the highest inhabited places there is about 78 mm. oxygen pressure, half the sea-level value (Table 1).

III. MAN UPON THE ANDES

The interplay of the following climatic elements—heat under the tropical sun rays, cold, diminished barometric pressure, diminished pressure of oxygen, increased ultraviolet rays, etc.—has produced a variety of climate where

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once was developed one of the greatest civilizations of the world. Let us now consider Andean man in his own environment, or, in other words, man as a function of the environment. Who may be called a "high-altitude man"? Does such a man exist as a biological entity? Strictly speaking, we cannot scientifically describe a man at 15,000 feet as a sea-level man has been described, without regard to his highlands environment. If pursuit of knowledge had started in the highlands and a scientist had discovered a sea-level man, how, then, should he describe him?

In order to discuss the matter and for descriptive reasons, however, we will describe the biological characteristics found in our places of research: Lima, sea-level; Huancayo, 10,170 feet; Oroya, 12,300 feet; and Morococha, 14,900 feet. To do this we have to imagine, for the time being, the outside world as a static environment (Tables 2, 3, 4).

For the sake of brevity, man acclimatized to the high plateaus will be called by us "altitude man." Perhaps there are other reasons, as we will see later on in the course of this discussion.

TABLE 1

Place	Altitude (Feet)	Longitude	Latitude	Pressure		Temperature				Precipit.	Relative Humidity	Climate
				Baromt.	O_2	Max.	Min.	True An. Ave.	Oscil. 24 h.			
Morococha	14,900	76°08'–	11°37'–	446	89	.....	.....	6.25	.....	1,189.5	59.60	*Puna:* cold, high steppe, near glacial
Huancayo	10,170	71°12'44"	12°04'20"	518	104	30.9	−10.0	12.05	40.9	754.84	77.54	Andean high plateau
Lima	500	77°02'14"	12°03'02"	750	156	37.5	9.6	18.40	22.9	39.37	86.80	Dry coast
Iquitos	347	73°11'24"	3°45'23"	752	157	37.0	17.8	31.80	13.26	2,878.8	80.10	Humid jungle

IV. MAN AND ALTITUDE ENVIRONMENT

At the base of the problem is the necessity of placing Andean men in a dynamic relation with the impact and stress produced by the physiological changes of environment. Life dynamics in the Andes are rather complex because, with each change in the environment, there occurs a change in the physiology of the body. At sea-level the external milieu is a constant, and physiology expresses itself in only one dimension, horizontally; at high altitudes physiology works out in two dimensions, horizontally and vertically, the outside environment being a variable. The "wisdom of the body" of the acclimatized man is unknown to the sea-level man. While considering man in a static environment, we have gathered some physiological data, but we can only guess the biological responses to the alterations of the environment. This is a promising new field of original research for the development of the science of man.

We have, then, to integrate the biological data supposedly belonging to a fixed milieu with the clinical knowledge of everyday life in the Andes.

Many millions of people have found a permanent residence in the South American high plateaus since prehistoric time. They live, they work, they reproduce. Possibilities of life at high altitude for acclimatized races are exactly the same as for man at sea-level. There is no limit to human development. Some facts need to be emphasized. The vertical geography of the country is the reason for continuous mass movements of population from the highlands to the lowlands and vice versa. Up to the time of the Incas,

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these migrations occurred chiefly from the high steppes to the coast, always with a return to the place of origin. At present, mass movement operates both ways. However, this form of Andean migration most of the time is only temporary, causing a kind of permanent nomadism either up to the mines or down to the low agricultural lands. As a matter of fact, traveling in Peru is vertical, as it is horizontal in the rest of the world.

This vertical distribution of man in the plateaus of South America has developed in the Andeans special biological devices of adaptative significance which allow them to be in equilibrium with their environment up to 18,000–20,000 feet, as can be seen in altitude flights of Peruvian aviators without oxygen masks. The highest inhabited place in the world was found by Bowman in Peru at 17,400 feet altitude (*op. cit.*). Of course, there is a ceiling of tolerance for any man, above which life is not possible. It is fair to state that human ecology for Andean people may be traced up to 17,400 feet altitude.

Clinical observations show that at these altitudes Andean man is able to perform a most strenuous amount of work in the mines. Indeed, it has been demonstrated (Monge) by clinical tests

TABLE 2*

Hematology	Morococha Natives Altitude 14,900 feet	Oroya Natives Altitude 12,280 feet	Huancayo Natives Altitude 10,170 feet	Morococha Men from Huancayo	Lima Men from Huancayo 1st W.	Lima Men from Huancayo 3d W.	Lima Men from Huancayo 8th W.	Lima Men from Sea-Level
Red blood cells (mill. per cu.mm.)	6.15	5.67	5.65	6.05	5.57	5.37	4.70	5.14
Hemoglobin (gr. per 100 ml.)	20.76	18.82	16.85	17.98	16.49	15.95	14.30	16.00
Hematocrit (red cells per cent)	59.90	54.10	50.36	54.43	50.67	49.46	43.10	46.80
Reticulocytes (per cent)	1.5	0.8	0.47	1.94	0.77	0.25	0.4	0.5
Total bilirubin (mg. per 100 ml.)	1.56	1.47	0.84	0.84	0.91	.....	0.83	0.72
Direct bilirubin (mg. per 100 ml.)	0.46	.....	0.16	0.38	0.26	.....	0.33	0.37
Indirect bilirubin (mg. per 100 ml.)	1.10	.....	0.68	0.46	0.65	.....	0.50	0.35
Blood volume (liters)	6.98	6.15	5.36	5.58	5.55	5.49	5.17	5.21
Plasma volume (liters)	2.65	2.76	2.55	2.29	2.66	2.67	2.80	2.82
Red cell volume (liters)	4.29	3.36	2.79	3.25	2.87	2.79	2.35	2.34
Blood volume (ml. per kg.)	120.8	108.7	87.21	90.64	89.67	88.11	81.70	86.5
Plasma volume (ml. per kg.)	46.1	48.9	41.46	38.77	42.83	42.67	44.28	47.1
Red cell volume (ml. per kg.)	74.1	59.7	45.45	53.78	46.45	44.75	37.10	38.8
Total hemoglobin (gr.)	1,464.00	1,150.00	905.01	1,002.42	894.32	867.26	737.99	788.00
Total hemoglobin (gr. per kg.)	25.2	20.7	14.73	16.76	14.80	13.91	11.64	13.2

* Average values of a group of 12 soldiers, born in Huancayo (10,170 ft.), taken up to Morococha (14,900 ft.) and, after a period of 15 days, transferred to sea-level in Lima, where they were followed up for a period of 8 weeks. The other values have been taken from the works of Dr. Hurtado, Dr. Merino, and Dr. Delgado (see Bibliography).

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since 1930 that, in general, the work output is higher among the Andeans than that of sea-level people at sea-level.

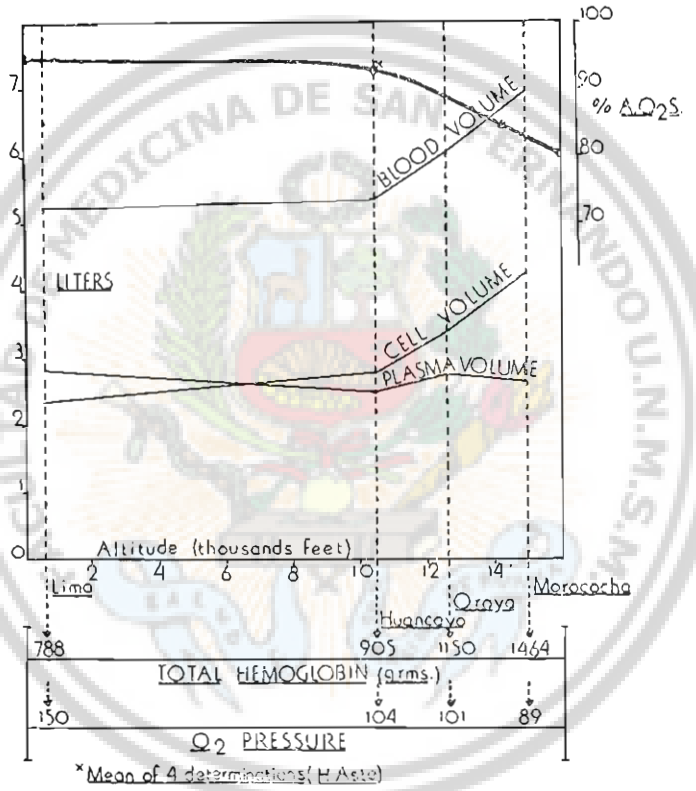
We have to stress the fact that there are places in the high plateaus or located at higher altitudes unsuitable to sustain life. This is evident in the mines located at such altitude that labor is possible only for a few hours a day, and the workers are forced to descend to a lower level to spend the night. Since 1928 we have called the places where life develops in every respect "inhabitable localities," to differentiate them from the unnatural localities created for industrial purposes.

We must anticipate that there are profound differences between the physiology of both groups of dwellers in those localities, a fact which must be borne in mind in anthropology if the problem of life and disease at high altitudes is to be understood. For accuracy, we have stressed that there are two fundamental aspects in high-altitude research applied to man. Both approaches are necessary: altitude outside the ecological milieu applies to a general knowledge and particularly to aviation physiology; man in his ecological surroundings is primarily a subject for anthropology. Much confusion will be avoided if we have these facts in mind.

As starting points related to life in

TABLE 3

RELATIONS BETWEEN BLOOD VOLUME, CELL VOLUME, PLASMA VOLUME, TOTAL HEMOGLOBIN, AND O_2 PRESSURE AT DIFFERENT ALTITUDES



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a changing-altitude environment, the following can be initially established:

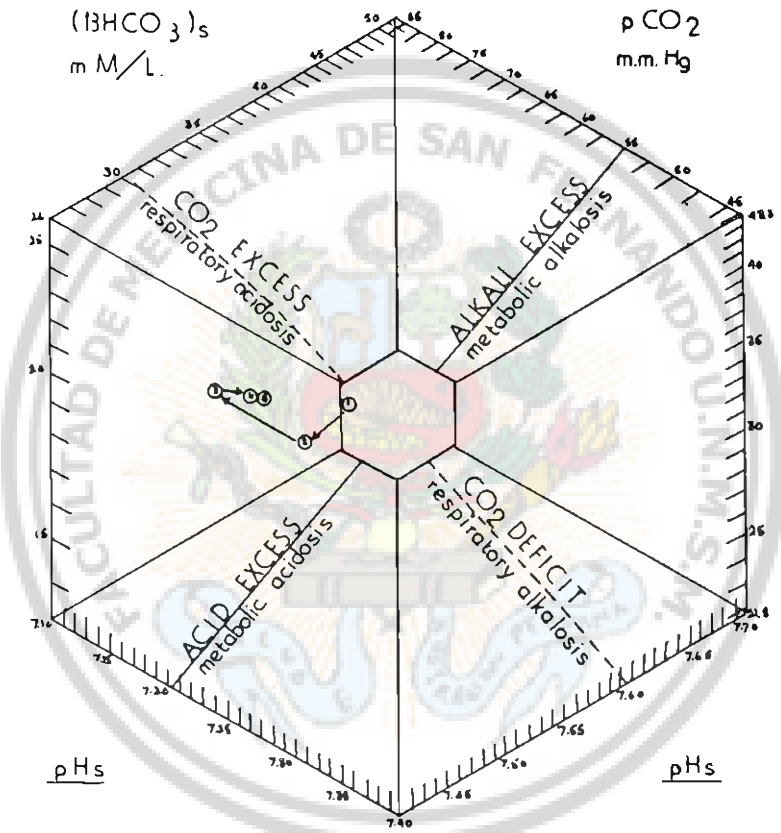
1. The physiological and biochemical systems are different at different altitudes. Their homeostatic integration brings about the "fixity of the internal milieu," which measures the equilibrium of organism and environment present in *congenital acclimatization.*

2. A measurable change of environmental altitude produces a stress, *climatic aggression,* which causes in the organism a succession of adaptative processes, so that a balanced functional state corresponding to the new altitude environment is reached. *Adaptation* leads to *acclimatization.*

3. The new concept of *acclimatization to sea-level* which must take place in the organism coming down from the high altitude is now conclusively established. The hyperoxic condition of the lowlands must be balanced by the body. The most obvious phenomenon is destruction of the red blood corpuscles, but there are also readjustments of the other functions occurring until sea-level equilibrium is attained.

TABLE 4*

ACID BASE PATH



* In Huancayo, the acid-base path is within normal limits; in Morococha (14,900 ft.) pH is shifted to the metabolic acidosis zone; and in Lima (sea-level) pH goes to the respiratory acidosis zone (*follow arrows*). After 2 months, pH has not returned to the normal value.

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4. It is most probable that there might be, for high-altitude men, reversible physiological systems that allow the high-altitude organism to adapt rapidly to the stress represented by the fast change of oxygen pressure. Such adaptability is lost or greatly reduced while approaching sea-level.

5. The inapparent mountain sickness shows two main forms: (*a*) a mild form which allows the individual to live and to reproduce and leads to *acquired acclimatization;* (*b*) a nonreproductive form: the individual lives normally but does not reproduce himself, *individual acclimatization* (such a process is very exceptional).

6. Both congenital and acquired acclimatization to high altitudes can be lost, and then chronic mountain sickness is produced. It is cured by descent to lower or sea-levels.

V. COMPARATIVE ANTHROPOLOGY

If we consider either form or function of man at different altitudes, we find that there is a linear relationship between altitude and the volume of the thorax. There is also a linear relationship between blood volume and altitude. It can be stated, then, that the respiratory activity of the lung and blood is increased. If this is so, the respiratory activity of the circulation is also increased.

Besides, we wanted to find out for an anthropological approach whether in high-altitude man there was a closer relationship between lung volume and total blood volume than in sea-level man, because, according to physical measurements, there is a closer relationship between thorax and height. With the collaboration of Vellard for anthropometry and Monge, Jr., and aided by funds from the Wenner-Gren Foundation, it was possible to plan a program of work which covered these points. The research has been carried out in Peru and Bolivia. It allowed a wider field of people to be studied and permitted a more definite comparative approach. We chose three groups of men:

a) *Lima sea-level group.*—One hundred selected sailors of the Navy School, born on the coast, who had never been in the high plateaus, and who belonged to a typical group of Peruvian sea-coast folk. Average age: twenty to twenty-four years. This group had a variable proportion of mixed blood with Europeans or Indians of the high plateaus.

b) *Bolivia group.*—Fifty young selected soldiers from the indigenous population, born at an altitude of 11,000–15,000 feet, most of them from the Titicaca Lake region. They had never been in the jungle lowlands and belonged to a typical aboriginal people.

c) *Huancayo group.*—One hundred and twenty-five selected soldiers of indigenous extraction, born at about 8,000–12,000 feet altitude, who had never been at sea-level and belonged to a typical group of aboriginal stock. Average age: twenty to twenty-four years. They may be considered as a pure Indian people.

The physical selection of these groups had been very well done, for their admittance and their stay in the armed forces allowed us to obtain the fullest information about them and provided excellent opportunities for physiological work. They all received very good physical training and were submitted to intensive military work. Besides, most of them were trained as athletes, especially the Peruvian sailors, who took part in competitive contests.

It can be seen that the Bolivian highest-altitude group has a thoracic volume 1,506 cc. greater than the thoracic volume of sea-level man and 1,031 cc. greater than the thoracic volume of the Huancayo 10,000-foot man. The Huancayo man's thoracic volume is 475 cc. greater than the sea-level man's. There

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is thus a linear relationship between altitude and thoracic volume (Table 5).

Of course, we realize that our groups allow only a comparative approach to the problem and are not fitted for general anthropological considerations. Vellard has pointed out that the Lima group includes some men with generations (in some cases very many) of high-altitude ancestors. Those men have shown thoracic anthropometric values rather close to the rest of the subjects. He believes that this has to be interpreted as their not having been influenced by the upland environment. He is not yet in a position to interpret possible genetic influence concerning shape and form of thorax at different altitudes.

We have found out that there is a close relation between physical and physiological measurements and that this relation applies also to some blood coefficients (Table 6).

We will now refer to Newman's method for thoracic blood measurements, "the dye dilution technique." The charts represent the average figures of nine experiments in Lima (sea-level men) and of eight experiments in Morococha (natives from high altitudes). According to Dr. Newman's work, central volume would represent the pulmonary blood volume. The buildup time would be an index of the volume of blood in the right side of the heart.

The total blood volume and the central (lung) volume are expressed in cubic centimeters per kilogram weight, which facilitates comparative analysis. With the dye dilution method we can obtain the following determinations: blood volume, cardiac output, lung volume, circulation time, blood in right chamber of the heart.

This method has been used by Carlos Monge, Jr. (results to be published) to compare sea-level figures to high-altitude coefficients. As predicted from biological considerations, higher blood volume, lung volume, etc., have been found at high altitude. The ratio of lung volume to total blood volume is also higher (Tables 7, 8).

TABLE 5

VARIATIONS OF THE CHEST MEASUREMENTS AT DIFFERENT ALTITUDES

Altitude (Feet)	Height (Mm.)	A.P. Diameter (Mm.)	Trans. Diameter (Mm.)	Height of Sternum (Mm.)	Thoracic Volume* (Cc.)
12,000.....	1,616	213	283	199	12,150
10,000.....	1,603	208	228	185	11,019
Sea-level.....	1,653	203	283	183	10,544

* The thoracic volume follows a linear relation with altitude.

VI. ADAPTATION TO HIGH-ALTITUDE CLIMATE

According to Coon and Birdsell:

> One of the major facts in the differentiation of modern racial groups has been natural selection operating in terms of stress and stimuli inherent in the extreme environment. The Mongoloid race was the last of the major groups to differentiate in the fourth glacial period as a result of extreme environmental stressing in the Arctic environment. It has been suggested that adaptation to cold was attained by developing big chests, short extremities and small globular bodies irradiating as little heat as possible. . . . Arctic people present

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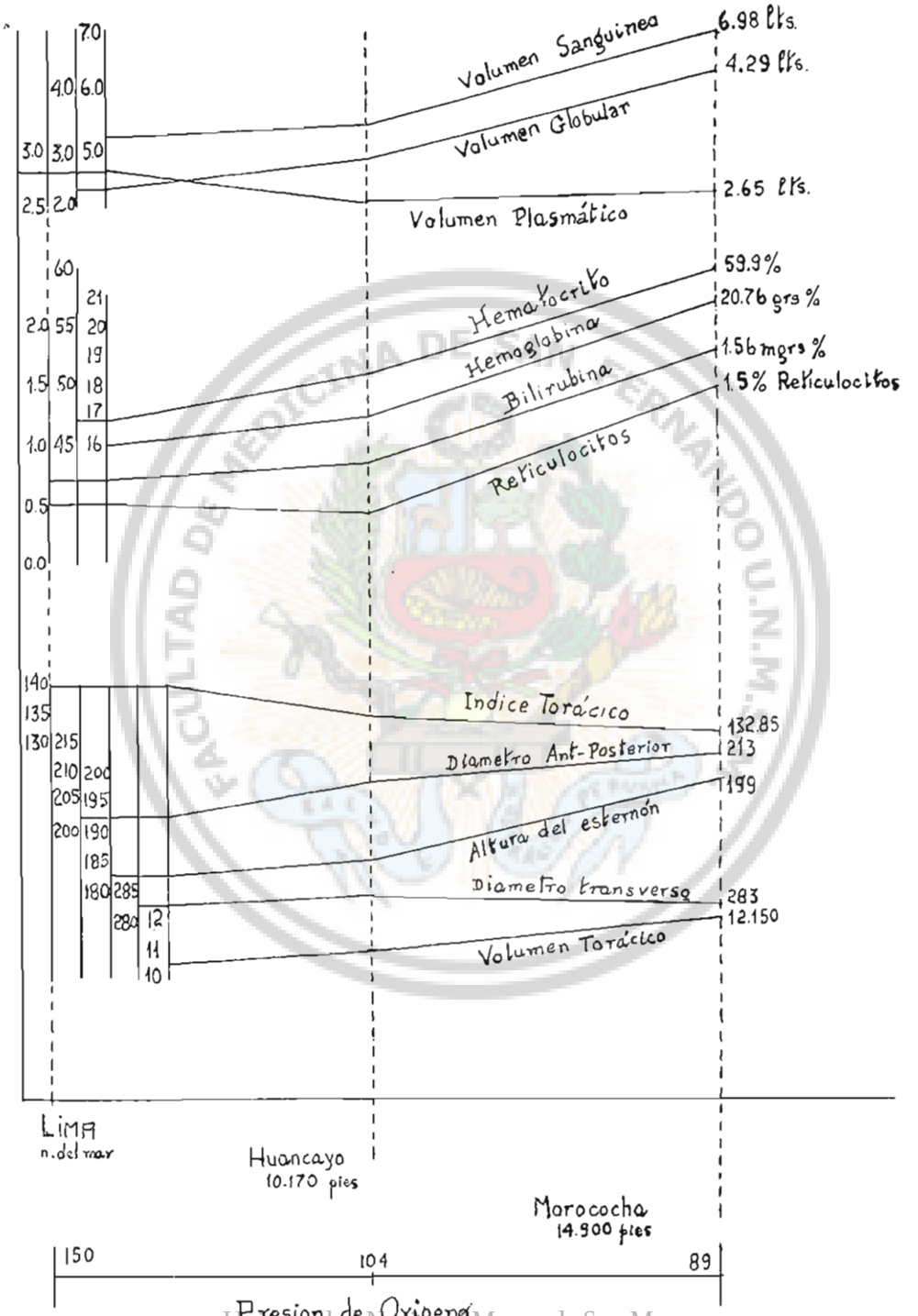
TABLE 6

COMPARATIVE RELATIONSHIP BETWEEN PHYSICAL AND PHYSIOLOGICAL MEASUREMENTS IN REGARD TO THE SHAPE OF THE CHEST AND TO SOME BLOOD COEFFICIENTS



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the least possible skin surface to the outside world in proportion to volume and weight.

On the other hand, it would be pertinent to point out the following statement taken from Wulsin:

Mongolia is a dry plateau with an average altitude of about 4,500 feet. Most of the population are pastoral nomads, migratory herders of sheep. The summers are hot and the winters cold with high winds, snow, and temperatures of –40°, –50° F. In their migrations to circumpolar regions they attain 60° latitude north.

Certainly we find here reproduced conditions of environment approximating those found in the upper lands of central South America: extreme cold, dry atmosphere, and altitude, which have a strong influence over the climate on account of the latitude. Thus it can be suggested that the Mongolian ancestors in South American high plateaus settled in places where they could maintain their physical traits; physiological adjustments; and resistance to cold, hunger, and altitudes. Furthermore, Coon suggests a second effect of cold by its influence on the growing organism through stimulation of adrenals to make people short and globular. This is a mere hypothesis to explain what happened at the end of the fourth glacial period at around 60° latitude.

Today it has been proved in experimental biology that adrenals increase

TABLE 7

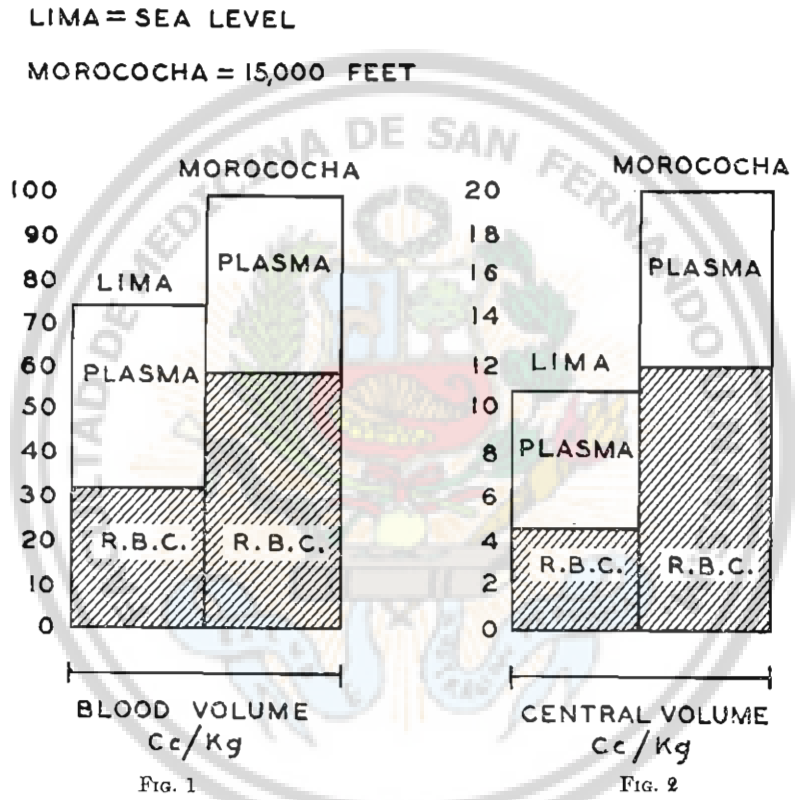

FIG. 1 FIG. 2

FIG. 1.—The values are expressed in cubic centimeters and refer to 1 kilo of body weight
FIG. 2.—The values refer to the lung volume at sea-level as compared to the same at high altitude

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when exposed to cold (Monge, Encina, Caviese). This has been proved in rats brought from lowlands to 15,000 feet altitude. In regard to the explanation that the change in thorax shape is reversible, if a phenotypical change of a temporary nature follows an alteration in environment, it seems to me that the rarefied atmosphere plus cold strongly supports Coon's point of view.

VII. HUMAN BEHAVIOR

In the preceding sections we pointed out the biological basis which builds up the physiological substratum of Andean man. The stress produced by the high-altitude climate is so striking that it is interesting to recall the reactions of modern philosophers and physiologists about their experiences in the highlands of South America. Keysser-

TABLE 8*

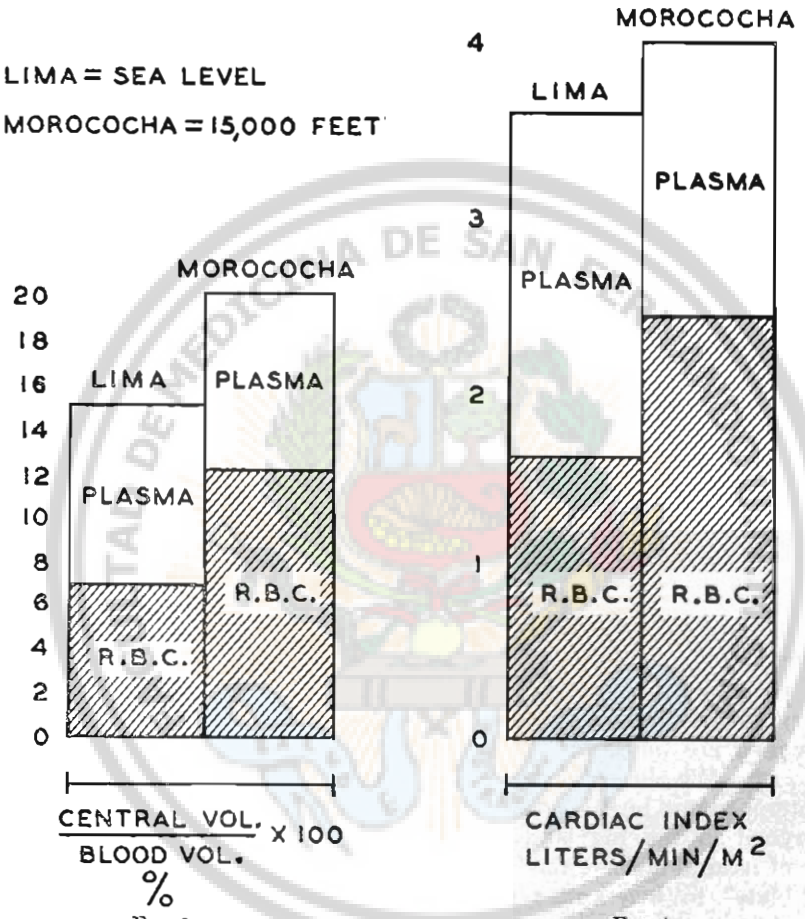

FIG. 3 FIG. 4

* The values of Tables 7 and 8 have been taken from the works of Drs. C. Monge, Jr., and A. Cazorla.

FIG. 3.—Relationship between lung volume and total blood volume. It shows a higher blood bed in the chest at high altitudes.

FIG. 4.—No special signification.

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ling says: "Those altitude men must have a different mineralization. In the high steppes on the Andes there are only two possibilities for a man: to adapt himself or to die." Quite different is the opinion of physiologists tied to the sea-level official knowledge. Barcroft, for instance, impressed by the stress and strain of the anoxia he suffered, wrote in *The Respiratory Function of the Blood:* "The acclimatized man is not the man who has attained to bodily and mental powers as great in Cerro de Pasco (Peru) as he would have in Cambridge. Such a man does not exist. All dwellers at high altitudes are persons of impaired physical and mental powers."

There are two reasons for this misleading interpretation. The first one is that adaptation starts as a malady sometimes unrecognized because of apparent well-being. Barcroft never found high altitudes congenial. Unfortunately, man is prone to hasty generalizations. The second one is that to orthodox sea-level knowledge the deviated physiological findings and abnormal chemical data found at high altitudes appear as facts of pathological significance. Even at present some investigators think that Andean men are borderline to pathological cases. We do not believe this. Our criteria about health and disease and survival in the highlands follow the line of natural history: the "wisdom of the body" to live and reproduce since prehistoric times.

Such a profound influence of the climate up to the point of originating a physiological variety of human people is at the basis of the biological architecture of Andean man and determines his attitudes in every respect—constitution, individual life, migrations, and sociological behavior.

In the following paragraphs we will limit ourselves to presenting some brief references.

INDIVIDUAL BEHAVIOR; ATHLETIC CONSTITUTION OF ANDEAN MAN; PHYSICAL CULTURE AND PHYSICAL EXERTION THE HIGH-ALTITUDE LAW TO MAINTAIN ACCLIMATIZATION; CONTESTS FOR NOBILITY (*huaracu*); NUPTIAL CEREMONIES (*acataymita* AND *paltay*); URGE TO RETURN TO THE SAME CLIMATIC ENVIRONMENT

The native Andean, as well as the conqueror who overcame the aggression of the high altitude and became an acclimated being, developed an adequate constitution. Doubtless the training of athletes at sea-level consists mainly of inuring them to anoxia by means of repeated exercises; such is actually the case, for it is the essence of training that the body is taught to function under extreme conditions beyond the limits normally set by the intake of oxygen. The high-altitude atmosphere being anoxic, it is to be inferred that the individual living at high altitude either becomes an athlete, as it were, or perishes as a victim of fatigue. Logically, then, athleticism must be the norm for the survival of man in the high altitudes.

We find on this subject very enlightened references of historic character, for example the following:

Garcilazo de la Vega, who regards the feast of *huaracu* as equivalent to that of arming knights, assures us that

> the boys passed through a most rigorous novitiate, they were chosen from the age of sixteen and they used to go to a house which had been built especially for these procedures in the section of the city called Collcampta, to which I myself walked once and saw a part of these activities. They used to make them fast very strictly for six days. Anyone who seemed thin or weakened by this fast or who asked for more food would be reproached and thrown out of the novitiate. When the fast was over and they had been comforted with a little more food, they examined them for lightness of foot, for which they made them run

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from the hill called Huanacauri to the very fortress of the city, which must be almost a league and a half, and the first one to arrive was chosen to be captain of the rest [*Comentarios reales* (Lima, 1918), LXXXIII, 194].

CLIMATIC AGGRESSION; ITS EVIDENCE; ANDEAN "AIR-TEMPER" DAMAGING TO COASTAL DWELLERS; COASTAL ATMOSPHERE DAMAGING TO ANDEANS; ITS UTILIZATION BY THE INCAS

The Viceroy Prince of Esquilache (1621) in the statement which he left for his successor, the Marquis of Guadalcazar, says:

It is to be noted that the Indians are divided into three groups: some are called *yungas* and they are the ones that live on the plains and in the hot valleys, others are the *chaupuyungas* and these are the ones that live in higher regions which correspond to what we in Castilla call foothills, and where air-temper is medium, tending more toward coolness and heat; and the others are the real uplanders, born and raised in these cold lands, and what is done with great care and scruple in the government is not to permit them to change their place of service from one air-temper to another [*Relaciôm que el Prícipe de Esquilache hace el Senor Marquez de Guadalcazar sobre el estado en que deja las provincias del Perú* (Madrid: Biblioteca Historia Hispano Americana, 1921), Vol. I].

That the military experience of the Incas taught them the injury which the coast did to their uplands soldiers may be noted once more during the reign of Hauayna Capac, who, after the conquest of Quito,

went down to the plains, that is the coast, desiring to conquer them. . . . During this time the Inka has his army renewed three or four times, for as some came, others left, because of the risk to their health which the inlanders run when on the coast, since the latter is a hot region and the other cold [Garcilazo de la Vega, *Comentarios reales*].

BIOLOGICAL BEHAVIOR; RACIAL ACCLIMATIZATION; INTERNAL COLONIZATION (*mitimaes*); BIOCLIMATIC SOCIOLOGY OF INDIANS IN LAND OF INCAS

Much evidence has been found concerning the biological fundamentals of Inca legislation. Some citations are pertinent. We believe that the organization of the *mitmaccuna*, or *mitimaes*, as they are generally called, has a greater importance than that assigned thereto up to the present time. The organization corresponds to what is today known as a policy for interior colonization. One must admit that it fulfilled certain political and economic needs, but it cannot be denied that fundamentally it meant family wandering, by dint of which the adaptation of the Andes people to different climatic environments could be maintained.

HOW THE INKAS DISPOSED OF THEIR NEWLY POSSESSED LANDS, SETTLING STRANGE INDIANS IN THEM WHICH THEY CALLED MITIMAES, AND THE DIFFERENCES THERE WERE IN THEM. The first thing these Kings did upon winning a new province was to take out of it six or seven thousand families and transfer them to other parts in the quiet and pacific provinces, distributing them in different towns; and in exchange for them they put in an equal number of people which they made leave the places where the strangers had been settled, or from wherever they thought best, and among them many nobles of the royal blood. . . . They took care in this inter-migration that those who were transferred, both the newly conquered and the others, should not move to just any region but more or less to one of the same air-temper and qualities or very similar at least to the region they had left or in which they had grown up. . . . When some province was sterile as to food such as all the provinces of Collao, because of their great cold, the Inka had indicated lands in the hot valleys of the seacoast on the one hand and on the opposite side of the Andes too, that they sow in those more temperate valleys the things which their people lacked; and since these valleys were twenty, thirty or more leagues away from

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their own country and they were not able to go and sow the crops there as an enterprise of the entire community as was usually done in the rest of the kingdom, the chiefs were careful to send people in time to do it, who, once they had got their harvest, returned with it to their own towns [Padre B. Cobo, *Historia del Nuevo Mundo* (Seville, 1897), Vol. II].

Even at present this migratory process continues, despite its having gone unnoticed. We once called attention to the nomadism of the workers in the mining regions as well as in the agricultural zones of the lowlands. However, sooner or later he returns to his place of origin, where nature and the accustomed economy of his community furnish him with his ideal life-condition. These cycles are usually annual. No one is surprised any more at the commonplace incident of the workingman who suddenly, when everything seems favorable for him on the coast, leaves for no apparent reason to return to his upland home. Thus he obeys without realizing it an ancestral biological law.

It is not our purpose to derive definite conclusions in this regard. It is up to the sociologists to interpret these phenomena properly. We should rather state that these problems belong to anthropological knowledge and applied anthropology. Biologically we cannot avoid the clear imperative to give them an explanation closely adjusted to the general processes, within which the life of plants, animals, and men develops in the high regions of the Andes.

We have been able to prove that, after a six-month stay at sea-level, young Indians coming from the highlands were not yet equilibrated with the external environment. To attain the fixity of their internal milieu, it was necessary to wait longer. The knowledge of this fact is of the utmost importance for individual health. We do not yet know how long it takes to become acclimatized in the high plateaus in the sense of a perfect equilibrium between internal milieu and environment.

There is a promising field of research concerning the influence of high-altitude climates upon men and their sociological behavior. We are convinced that a systematic research at sea-level carried out along the same lines may prove useful in determining the influence of function upon the body as a biological basis of human behavior.

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