shape can be significantly resolved into simple changes of shape of the type defined above. The word 'significantly' is meant to express our assurance that the whole procedure is not merely an analytical device, but that the product of transformations corresponds to the combined or successive action of distinguishable physiological processes.

This interpretation of the gradient theory, which will be given a fuller treatment elsewhere, relates it to the more comprehensive methods of analysing organic form which were designed by D'Arcy Thompson. The danger of over-simplification is of course very real : for example, the outline drawings of animals with which we are obliged to start our analysis of shape are themselves affine transformations of the three-dimensional objects they represent. But once they have been recognized as such, our purely informal simplifications and assumptions lose a great deal of their virulence. There is something more in the analysis of growth-rate patterns than a determination to see order where no order exists.

[1] Thompson, D'Arcy, "Growth and Form" (Cambridge, 1917).
[2] Huxley, J. S., "Problems of Relative Growth" (London, 1932).
[3] Minot, C. S., "The Problem of Age, Growth, and Death" (New York, 1908).
[4] Davenport, C. B., *Coldspring Harbor Symposia*, **2**, 203 (1934).
[5] Robertson, T. B., "The Chemical Basis of Growth and Senescence" (Philadelphia, 1922).
[6] Richards, O. W., *J. Gen. Physiol.*, **11**, 525 (1928). Richards uses the term 'constant growth-rate' in the sense in which 'constant specific growth-rate' is used here.
[7] Medawar, P. B., *Proc. Roy. Soc.*, B, **129**, 332 (1940).

LIFE AT HIGH ALTITUDES

By Prof. A. J. Carlson
University of Chicago

MEN of science at the symposium on "Life at High Altitudes and Aviation Medicine" held at the University of Chicago on September 23 as part of the University's fiftieth anniversary celebration heard dissertations ranging from a description of an "Altitude Human Race" to the physiology of the free fall and of parachute jumping.

Since fright, rather than basic physiological reactions like blood pressure or heart action, is one of the chief causes of fainting in a delayed-opening parachute jump, use of a small guide parachute which prevents twisting and spinning in mid-air—conducive of fright—will contribute much to the safety of parachute jumpers. In addition, the 'anti-spin' chute prevents tangling with the parachute lines which sometimes occurs, if the parachutist is twisting when he pulls the rip cord.

These points, given particular emphasis by the strategic military desirability of delayed-opening jumps, were made by Prof. Andrew C. Ivy, professor of physiology and pharmacology in the Northwestern University. Prof. Ivy reported research in collaboration with Prof. Anton J. Carlson, of the University of Chicago, in a paper on "The Physiology of a Free Fall through the Air".

It is worthy of note, pointed out Prof. Ivy, that the person who is in a position where a delayed fall is advantageous would be given confidence by the early opening of the accessory, 'anti-spin' parachute, and this, plus falling in a more natural, or semi-erect posture, would decrease the likelihood of inexperienced persons fainting from fright.

It is Prof. Ivy's belief that when it is necessary to bail out of an aeroplane, a delayed opening of the parachute has certain strategic advantages : the jumper is less likely to foul another jumper, an aeroplane out of control, or falling aeroplane parts ; an open parachute is an excellent target for the enemy ; if the parachute is opened at an altitude of thirty thousand feet or more the jumper may lose consciousness from lack of oxygen unless he carries a supply with him ; if the aeroplane is moving rapidly and the parachute is opened soon after leaving the plane, the jumper is likely to be injured and the parachute and its attachments ripped. When a person jumps from an aeroplane, his rate of fall decreases or increases to an approximate rate of 120 miles per hour. At 300 miles per hour the shock load to the jumper and the parachute is five thousand pounds.

In experiments covering five jumps with a human subject, Mr. A. H. Starnes, following earlier experiments with dummies and apparatus, verified that :

(1) Except in flights as fast as would be experienced in a jump from a descending dive bomber, there is no appreciable unfavourable influence on heart-rate and blood pressure.

(2) A fleeting mental 'black-out' occurs shortly after the jerk of the riser straps caused by the chute opening. Otherwise in a calm and unfrightened jumper, mental reactions are clear, rapid and normal.

(3) The same difficulty in hearing was found as is experienced facing, or with the back to, a high wind. Vision was not impaired when goggles were worn ; the eyes watered without goggles.

(4) There was no feeling of nausea even in spinning, because of the brevity of the time. (The longest drop was 16,500 feet at 158 miles per hour, which took seventy-one seconds.)

(5) Contrary to the findings of Dr. H. G. Armstrong of the U.S. Army, there was no sensation of floating in space when the eyes were closed. Subjectively Mr. Starnes was aware of the drop because of the wind rush and other sensations. He "felt that he was falling, and falling rapidly".

The "Altitude Human Race", a biological entity differing radically in several respects from other branches of mankind, was postulated to describe the dwellers of the Andes mountains of South America by Dr. Carlos Monge, of the University of San Marcos, in Lima, Peru.

Listing a score of vital differences between the man of sea-level and the man of the Andes, living at 10,000–16,000 ft. above sea-level—Mt. Whitney, highest peak in the United States, is 14,495 ft. ; there are thirty-three South American peaks higher than seventeen thousand feet, the highest, on the Chile-Argentine border, Mt. Aconcagua, 22,834 ft.—Dr. Monge also described the disease 'chronic mountain sickness', which afflicts lowlanders when they start to live in the high altitudes.

In the Andes, Dr. Monge pointed out, twelve million persons are living all the time under conditions at an altitude where the oxygen pressure is 85. mm as contrasted with the sea-level pressure of 150 mm.

Describing the high-altitude human race, Dr. Monge said the heart of Andean natives actually beats more slowly following exertion. It seems that increased vagal action causes the bradycardia, which may be considered the law of the altitude heart. We find all the conditions of athletic heart. Chronic anoxia (lack of oxygen, such as that characterizing high altitudes) is a permanent stimulus to improve heart efficiency.

Dr. Monge suggested that this man has some of the biological characteristics needed for an aviator, and that perhaps a better knowledge of the physiology of the man born and living at fifteen thousand feet would help the learning of the required conditions of fitness for high-altitude flight. Since 1928, Peruvian aviators have flown over the Andes continuously at higher than fifteen thousand feet elevation.

Comparing the acclimatization of high-altitude dwellers to the instinctive force which causes the annual migrations of birds, Dr. Monge cited the factor of altitude as one which in the recent Bolivian-Paraguayan war "killed more people [high altitude soldiers made to fight in the lowlands] than the enemy's bullets". The day will come, he pointed out, when these vital matters will receive due consideration for the welfare of the altitude human race.

Men of the Andes may be considered as belonging to a special climato-physiological variety of the human race. In fact they are closely related to their geographical surroundings : altitude, radiation, humidity, ionization, and so on. The sociological behaviour of such men and the telluric (earth-related) environment appear as a whole, as a biological system which cannot be divided, as a climato-physiological unity. They have to adapt themselves on coming down to the coast ; they cannot always stand the meteorological conditions of lower lands ; they become predisposed to disease of the lungs, as has already been reported by Dr. Monge.

But the struggle for life obliges them to come down ; and then ensues a fact which is worth noting. Every year about one hundred thousand men come down to sea-level for agricultural work, but after about three months they go back to the altitude. They never stay at the coast no matter what it offers them.

These peculiar annual human migrations of high-plateau societies are a very well-known fact of biological significance. "Like the swallows, Andean men have the sense of returning home". Therefore, they have the same problems of acclimatization to face when going down to a land not always fitted for their physiological equipment. Usually acclimatization at the coast is easier than that on the highlands. But there are the facts, the study of which is of utmost importance for the knowledge of Andean populations.

How the body mechanisms which constantly tend to maintain the vital balance between acidity and alkalinity adjust to high altitude by stimulating increased breathing, but offsetting the chemical effects of this increase on the blood, was reported by Major David B. Dill, of the U.S. Army Air Corps. Major Dill spoke on "Acid-Base Balance in High Altitudes".

Reporting the Andean expedition to Chile in 1935, in which members of the expedition lived at 17,500 ft. and worked at 18,000 ft., Major Dill described the "beautiful integration of the mechanisms of the organism which combat disturbances of the balance arising from abrupt and prolonged exposure to oxygen deficiency".

In the long-run process of acclimatization, when the acid-base relation is thrown out of equilibrium because of limited availability of oxygen, he said, the increase in the number of red blood cells (oxygen carriers) makes it possible for arterial blood to take up as much oxygen as at sea-level.

In the short-run compensation for acute oxygen shortage, Major Dill listed four steps by which the balance is temporarily maintained: the reduced oxygen in the arterial blood stimulates increased breathing by the action of the carotid body, a small emergency mechanism lying beside the carotid artery (in the neck); this raises the oxygen content of the blood, but causes an increase in alkalinity; this excess is absorbed through the buffering capacity of body proteins, thus relieving the inhibition which alkalosis characteristically exerts on the respiratory centre in the brain, producing a balance between the activity of the respiratory centre and the carotid body.

The chain of events involved in acclimatization (as contrasted with short-run compensation) has been seen to involve a series of reactions:

(1) Lactic acid in the blood remains unchanged while at rest.

(2) After the first few hours of adjustment, the saturation of oxygen in the arteries attains a constant level.

(3) Lung ventilation is maintained at an increased rate.

(4) Arterial blood, after initial alkalinity, eventually assumes its usual reaction.

(5) Both free and combined carbon dioxide in the blood are reduced, but the ratio between them (which governs the respiratory centre) is eventually restored to its usual value.

Taking part in these reactions, Major Dill pointed out, are the lungs, the respiratory centre, the carotid body, the blood-forming tissues, and the kidneys. The over-all result is that man, without taking thought, is enabled to live and work in an atmosphere that contains only half as much oxygen as at sea-level.

Although in experiments in which atmospheric pressure was reduced to one-sixth its sea-level value, the exchange of gases in the lungs goes on as usual, it must be admitted that the possibility of a disturbed acid-base balance exists at any altitude above thirty thousand feet if the period of exposure is long enough. Decompression illness, or bends, may be experienced. If this affection becomes acute, one sees increased respiratory volume, and unless return to lower altitude is prompt there may be circulatory failure and collapse.

The symptoms here seen are like those of shock at ground-level. The stimulus to the respiratory centre presumably originates from a diminished blood supply to the brain and the accumulation of carbonic acid in the respiratory centre. With return to low altitudes, relief is usually prompt.

OBITUARIES

Dr. E. S. Beaven

THE passing on November 12 of Dr. Edwin Sloper Beaven at the age of eighty-four, after a brief illness, will be deeply regretted by a wide circle of friends in Great Britain, and by many in other countries to whom he was known either by personal contact or through his published works.

Dr. Beaven was born near Heytesbury in Wiltshire, and for the greater part of his life resided in the neighbouring town of Warminster, where he carried on the business of malting. Early in his career Beaven became associated with Messrs. Arthur Guinness, Son and Co., the celebrated brewers, an association which influenced the science of brewing, and more particularly all aspects of barley production in the British Isles, in a remarkable manner.

As a maltster the involved question of quality in malting barley attracted Beaven's inquiring mind, and one of his earliest investigations, carried out in collaboration with his friend Dr. J. M. H. Munro, dealt with conditions influencing this important attribute.

But Beaven came of yeoman stock, and it was not long before the convictions engendered by such an ancestral background led him to extend his investigations to the many questions affecting the production of barley. Thus, starting first in the garden of his residence, and later on a more extended scale on land acquired for the purpose, Beaven began a series of nursery and field experiments, now world-famous. These investigations, started on his own initiative, and continued for a period of more than half a century, entirely at his own expense, were a consuming interest throughout his long life. Largely because of the care in execution and then in the clarity of exposition of the results derived therefrom, the experiments at Warminster have for many years been a source of inspiration to visitors from all parts of the world.

One of the most valuable features of the material gathered together at Warminster with meticulous care and patience, was a world collection of species and varieties of barley. This material eventually formed the basis of an authoritative classification of the genus, published by Beaven in 1906, which remains a standard exposition of the subject.

Beaven's most active years coincided with the reappearance of Mendel's theory of heredity, and he applied the new conception enthusiastically in the production of improved varieties of barley. Early in the century he began a long series of hybridizations that culminated in the production of the now well-known and widely grown variety Plumage-Archer. This barley, which will always be honourably asso-