phthisis. It is manifestly unfair to expect that any influence, such as a perfect climate—were such to be found—would be sufficient to undo what generations have produced of imperfect structural development of tissue; and, on the other hand, before pronouncing against *air cures* for consumption, it is only just to weigh carefully the influences under which people, *not affected with consumption*, have lived. When, in the latter case, it is found that such people have lived in a climate which made an out-door life almost perennially possible, and when their occupation has been either pastoral or agricultural, it becomes apparent that we have the plainest rules set forth to guide us, both for the prevention and treatment of consumption. Though experience has shown that no climate can be called perfect in regard to every condition, yet a careful analysis of the reports of the many *air cures* and other health resorts indicate very clearly the special qualities we are to look for in those climates which are favorable to the prevention or treatment of consumptive diseases.

Of these qualities the following, viz., *purity, dryness, temperateness*, and *brightness*, may be considered the most important. It is unnecessary to point out that these four qualities of the atmosphere of a healthy climate are intimately related in their causes, one to the other, since no one quality of climate can be discussed in other than a relative sense.

(*a*) *Purity of the Atmosphere.*—This not only means that the air ought to contain the normal amounts of its two principal constituents, but also that there shall not be an undue amount of carbonic acid in it, since this serves but to indicate the presence of large amounts of organic matters undergoing combustion. [An exception to this rule may be pointed out in the case where the air, at considerable mountain heights, according to Prof. R. Angus Smith, contains more than the usual amount of carbonic acid. In this case it may fairly be assumed that the excess is due rather to a rapid oxidation of existing organic matter than to its amount being greater than that on lower levels.] From this gauge of purity it follows that the air of badly ventilated rooms, of the cabins, and especially the berths of ordinary vessels, of all except the openest and cleanest of towns, and of that in proximity to marshes and other large deposits of decaying vegetable matter, must be equally avoided, since each instance indicates the progress of organic combustion, due to either chemical, physiological, or zymotic agency. The latter form of combustion is of great importance in this connection, since it is indicative of conditions favorable to the development of the Bacillus tuberculosis. From these considerations open spaces, as in the open fields of most cultivated districts, in inland localities with dry soil and good sanitary surroundings, and especially those situated at a relatively low elevation—*e. g.*, areas which have a light rainfall and possess a mountain climate—are the places to be sought out by the phthisical.

(*b*) *Dryness of the Atmosphere.*—If it be true that purity of air is one of the essential conditions if consumption is not to be produced, it is just as true that dryness of the atmosphere is one of the conditions upon which we have to depend for retarding the progress, and, much more, for effecting the cure of the disease in its early stages. These curative conditions are not only freedom from the dampness of the soil, but also the direct effects of dry air upon the tuberculizing process in the lungs. These latter are seen in the experience of the phthisical in high altitude climates, as that of Davos and Colorado, from which it would appear that—owing either to the diminished irritation produced by such dry air or to the decreased activity of the tubercle bacilli—there is less secretion from the respiratory mucous membranes. As stated by a gentleman recently living in Colorado: "Expectoration is usually less here than in the East; I suppose first on account of dryness, and second on account of a peculiar mildness or balminess of the air. My tender throat seldom feels here that raw, rasping damp air that one gets in England and the East. . . . We seldom have dew here; had more in Davos, I think." It is also a matter of universal experience that people resist the cold better in dry, even though at very low temperatures, than in moist atmospheres.

(*c*) *Temperateness of the Atmosphere.*—By this it is understood, first, that a climate ought not to be subject to great extremes of heat or cold; and, second, that the changes from heat to cold, or *vice versâ*, ought not to be either rapid or extreme. The experience of robust persons residing long in India, or subtropical America, shows the debilitating effects of great heat on the physical system; while the sufferings of delicate people in cold climates indicate the strain produced by low temperatures. Frequent and extreme changes are, however, the special points of interest in relation to temperate climates, since on these must greatly depend the relative humidity of any locality. From Glaisher's tables it appears that the capacity of a given volume of air is doubled for about every 20° F. of increase in temperature; from which it follows that an atmosphere which at noon, with a temperature of 70° F., shows a relative humidity of 50, will, at sundown, with a temperature of 50° F., be saturated; or if, as is often the case, the relative humidity at noon be 75, saturation point will be reached as the temperature approaches 60° F. If we remember that it is radiation of the earth's heat with the declining sun that lowers the temperature, and that this radiation, as well as the amount of heat absorbed by the earth during the day, is largely regulated by the amount of vapor in the atmosphere, it is perfectly plain that we must expect rapid and great daily changes in dry climates, and much less rapid changes in moist climates. From these considerations it must be apparent that tables of mean annual relative humidities, as ordinarily given in works on special health resorts, have no practical value in determining the fitness of a locality for consumptives.

These facts being kept in view, it becomes a matter for careful study to determine wherein lies the happy mean between dry climates, with great daily range, and moist climates, with small daily range of temperature. In a general way, it may be said, that between the two extremes lie the conditions most favorable to health. The experience of persons on arid wastes, and in rooms which, ill-ventilated, are heated by hot-air furnaces, without any means for supplying moist air, shows that there is a limit at which dry air becomes inimical to health from its irritating qualities, and by its abstracting moisture from the mucous membrane. The injurious effects of damp air are too well known to require illustration here.

Before leaving the question of the *temperateness of the atmosphere*, some remarks are required regarding the influence of winds on health. They may most properly be considered here from their power to affect the temperature of the body. That they play a most important part in purifying the atmosphere cannot be doubted, while the fact that they are promotive of health, through the pleasant sensations they may produce, is equally evident. But their beneficent influences are dependent upon their degree of temperature, moisture, and their force. As regards temperature, it is well known that winds of low temperature are injurious in proportion to their force, from the rapidity with which they abstract heat from the body. So marked is this fact that the degree of reduction of temperature compared with the force of wind has become the subject of experiment, and has been reduced to a definite law. Colonel Charles Smart, Assistant Surgeon-General, U. S. Army, has determined the rate at which the mercury of a thermometer falls in the calm from a standard temperature, when subjected to different degrees of temperature for given lengths of time; and, also, the increased rate of *fall* when exposed to certain temperatures, *plus wind and moisture.* Thus, the ratio borne by the fall *when exposed to wind*, as compared with the fall *in the calm*, the latter being taken as unity, is:

Wind at	¼	mile per hour	increases	*fall*	1.42	over	1.00.
"	1	"	"	"	1.71	"	1.00.
"	5	"	"	"	2.63	"	1.00.
"	10	"	"	"	3.18	"	1.00.
"	14	"	"	"	3.39	"	1.00.
"	20	"	"	"	3.60	"	1.00.

The moisture in this case is not estimated in its effects, but it is a factor of extreme importance in the reduction of temperature. Heat is abstracted not only in proportion to the force of the wind, but also in proportion to its degree of moisture, for the reasons mentioned in connection with moisture in general. The force of the wind further becomes, at certain health resorts in certain seasons, a source of injury to consumptives, from its causing clouds of dust and sand to be blown along, which, being inhaled, become very irritating to affected lungs. Such effects are said to be especially noticeable in those reputed resorts of consumptives, Australia, Cape Colony, Arizona, and Southern California, and have been mentioned by Marcet as being the cause of sore throats during dry days at Cannes. From facts such as the foregoing, it is apparent that the prevalence of certain winds must affect very greatly the character of the climate of different localities, as regards their claim to being health resorts.

(*d*) *Brightness of the Atmosphere.*—This quality, which in large measure bears a direct relation to dryness, must for several reasons be considered an important element in its bearings on the subject. That the amount of sunshine is not always the gauge of the healthfulness of any locality, is seen in the mortality and disease statistics of temperate North American regions; since from some of these it appears that November is among the healthiest months of the year, although having the smallest amount of sunshine. The absence in some measure of winds, such as those of March, and the low average daily range of temperature, must be credited with this favorable result.

Brightness, or diathermancy of the air, which is used to express the intensity of sunshine, may be said to be in direct proportion to the relative humidity of the air. From Jourdanet's and Denison's tables it appears that the intensity of sunshine increases directly with the altitude. This intensity is measured by the difference between the temperature in *sun* and in *shade*, and has been represented by the following rule of Denison, viz.: *One degree greater difference between temperature in sun and shade for each rise of 235 feet.* The experiments of many others, as Piazzi Smyth on the Peak of Teneriffe, and of Vacher and others at Davos, abundantly prove the intensity of the sun's rays in high altitudes. This intensity, as is readily understood, is associated with the fact that there is sunshine in such localities on almost every day throughout the year. That sunshine has, when the heat is not too great, most beneficial effects upon man, as upon most living animals, is too commonplace a remark to require reasserting. Some of the ways by which such good influences are exerted are well known. Dr. Thaon, in his "Clinique Climatologique," has well summarized these influences. He remarks that solar heat increases all the functions of animal as well as vegetable life; the blood circulates with greater rapidity, respiration is increased, peripheral circulation is more active to the advantage of internal organs, which thus free themselves from stagnant blood charged with excrementitious principles. Light, also, as seen in vegetation, plays a most important part through its active rays. "It reddens the blood, it cures chlorosis in the same manner as it restores the color to plants bleached in darkness."

Slight consideration must make it apparent that the numberless variations in the combinations of these factors cannot fail to create climates with equally varying characteristics; nor can we fail to remark that the same locality throughout the year is subject to equally numerous changes in the combinations. Further, when it is remembered that the conditions of phthisical persons, depending upon *hereditary* or *induced* causes, are infinite in their differences, we are not surprised that the question of what climate will best suit individual cases becomes of extreme difficulty as well as importance.

The sex of persons, their ages, their education and tastes, their companionships, their attendants, their pecuniary abilities, the progress of the disease, etc., may all be questions equal in importance to that of climate, if not even more important—so susceptible is the physical well-being to æsthetic and psychical influences.

The question of climate as regards the prevention of phthisis is of greater importance by far than that regarding its cure. Experience has shown that in every climate consumption has increased with the increasing population, and therefore the first step in its prevention, as in its cure, is to see that the sanitary surroundings of people in their homes, and when employed in their daily vocations, are of the most perfect nature possible. But inasmuch as it has become the *mode* to draw distinctions between climates fitted for the phthisical at different stages, it will not be improper for us to give some directions which experience has proven to be of some value in the treatment of consumption.

In all early stages of the disease, before hæmoptysis has occurred, bright, dry climates, where the air is invigorating, as at varying heights rising to five thousand feet above the sea, where the rarefied air allows of greater lung expansion, and where life with active exercise in the open air may be engaged in, are those which seem likely to produce most gratifying results. Owing, however, to the extreme daily range of temperature, protection from the night air in well-ventilated dwellings or in tents is markedly indicated. That height is probably not the necessary element in the cure, except so far as it is the gauge of brightness and dryness, is seen in the almost uniformly good effects of *surveying* and *camping out* in the bracing air of the Northwestern prairies, as of Montana and the British Territories. Such, too, are the experiences of consumptives at the far-famed health resorts of the whole Riviera in the winter season. When pronounced hæmoptysis has taken place both theory and experience contraindicate treatment by high altitudes, with their rarefied air, unless by the most gradual ascents. Jaccoud illustrates the first by patients going to the mountains direct by rail from Paris, only to have a hemorrhage occur on their arrival,—a hemorrhage, however, which ceases immediately on their descending again. Dr. Paul Regnard has given statistics greatly qualifying the tendency as stated by Jaccoud. In such cases the bracing air of the Northwestern prairies would seem to be of the greatest value. When the disease progresses but slowly, high altitudes with their tonic influences and effects upon digestion and nutrition do produce good effects. In cases with much cough and bronchitis, the inland lake districts on the Laurentides of Canada, with their immense evergreen forests of cedar, hemlock, and pine, supply conditions eminently tonic and soothing. The temperature is equalized by the evaporation from the lakes, and the trees diminish the violence of the winds. Then, besides, the cool waters which flow from the northern watershed into the innumerable small lake basins make the air cool and invigorating in the midst of summer, and afford the opportunities for camp life, with unlimited facilities for fishing and hunting, thus giving variety and exercise without the danger of fatigue, so often incident to hill climbing. The average height of these lakes is about one thousand feet above the sea.

Reference has been made to purity, dryness, and brightness as being the chief elements that give therapeutic qualities to the atmosphere; and that these qualities usually exist in their highest degree in mountain climates has been indicated by experimental work made during the past ten years by numerous workers, which has added much to our knowledge of the physiological changes going on at high altitudes. The most comprehensive exposition of this work and the conclusions based upon it is that by Dr. Paul Regnard, Paris. Similar conclusions are set forth by Dr. Solly, Colorado Springs, in his recent work. These with other competent observers insist that tuberculosis practically does not exist in high altitudes except when introduced, and Regnard, summing up the reasons for this, says:

1. That Freudenrich affirms that the rarity of the bacillus is due to the degeneration induced in this organism by its life in cold atmospheres for many months—a fact proven experimentally.

2. That persons rich in blood constituents are seldom inoculated with the disease, its onset depending upon anæmia and general depreciation of the health, and that these conditions but seldom prevail in mountain climates, owing to the fact that the blood, at these high altitudes, is richer in red corpuscles than it normally is at low levels.

3. That while a cold fresh air prevails in the mountains even in the summer, there is the additional fact that in winter mountain atmosphere is fresh and dry with sunshine of great intensity.

When the change of residence is first made from a low level to that of a mountain resort the individual is likely to experience what is known as the *maladie de la Montagne*, the symptoms of which are heat sensations, turgidity of lips and conjunctiva, with flushed face, nose-bleeding, sleeplessness, breathlessness, headache, and vertigo. This is rapidly followed by improved appetite, a sensation of *bien-être*, improved spirits, decrease of nervousness and dyspnœa. The first symptoms were due, according to Regnard, to an anoxæmia and the physiological needs created by this condition. Under the stimulus of this demand for more oxygen a condition of hyperhæmoglobinæmia soon becomes established. In other words, the blood of anæmic persons who transfer their residence from a low to a high altitude will soon contain the amount of oxygen which a fairly healthy person would possess at the lower level, and this can only be attained through an increase in the number of red blood corpuscles; for experiments on animals subjected for weeks to atmospheres of reduced atmospheric pressure show that the capacity of red corpuscles to hold oxygen varies directly with the decreased pressure or with elevation above sea level. The corpuscles will rise in number from a normal at sea level of 4,000,000 per cubic millimetre of blood to 6,000,000 or 7,000,000, according to height, within a fortnight. Paul Bert's law is thus expressed:—If at 760 mm. (30 ins. on barometer) blood absorbs 20 c.c. of oxygen, at 370 mm. it absorbs only 16.5 c.c., and at 30 mm. it absorbs only 7.4 c.c.

Regnard, after a review of the experimental evidence regarding nutrition, the changes in the composition of the atmosphere and the increased hæmatopoiesis having an intimate relation to it, says that when the atmospheric pressure diminishes, the oxygen supplied for organic combustion diminishes. Then the red corpuscles begin to increase, and soon the normal condition of tissues is restored and even passes the normal. It is certain, then, that in the mountains the appetite, stimulated by the fresh air and walking, determines a more active nutrition and more intense combustion. Similarly, there is an excess in the moisture given off in the mountains by pulmonary respiration. Probably, however, there is a tendency to increase in weight by residence in the mountains.

Much may be said concerning the stimulating influences derived from the ozonized air and the salt breezes blowing from the ocean. These must, however, be associated with a mild air, otherwise the dampness and fogs of the coast cannot fail to injure all except early cases of consumption, in which general debility is chiefly present. In such cases the coast from Boston southward during the summer, and the Gulf of Mexico during the winter, seem to best fulfil the indications. Los Angeles, etc., on the Pacific coast may, with good cause, be considered in this connection. The equable character given to the climate of the Pacific coast by the *return equatorial current* flowing from the north to join the parent stream at the equator, has of recent years given it many claims to prominence in the treatment of consumption. In many respects the climate of Southern California supplies America with a resort in a fair way of becoming as celebrated a winter residence for invalids as the far-famed Riviera of the Mediterranean; and, if lacking in some of the historic interest attaching to the latter, it certainly surpasses it in a freedom from the unsanitary conditions too often present in these old towns.

Any attempt to enumerate the almost infinite number of health resorts whose special claims have, even in America, but especially in France, Italy, Germany, Spain, England, Scotland, Switzerland, Algiers, Australia, and Tasmania, been set forth by special advocates, would be as impossible as it would be unscientific; and it is only by a careful review of the many conditions in connection with each case that satisfactory results are at all likely to be arrived at as regards its treatment.

P. H. Bryce.

CONTAGION. See *Infectious Diseases.*

CONTRACTILITY, CONTRACTION.—Contractility is one of the fundamental and inherent properties of living matter. Nearly all of the movements which are so characteristic of living nature are due to this property; that is, they are due to the contraction of protoplasm.

The contraction of a body or of a substance implies an alternating compensatory expansion or relaxation. If it were not for the alternating contraction and expansion (or relaxation), a repetition of a movement could not occur, and the end for which contractility seems to exist could not be accomplished.

Contraction is active, while relaxation is passive. Contraction can be accomplished only through a catabolism of the living substance, while relaxation involves no catabolism and may take place at the same time with anabolism.

I. The Significance of Contractility.—Contractility in its most primitive form is possessed by the active protoplasm of unicellular plants and animals. In a more advanced form it is the property of more or less specialized portions of the metaphyta and of the metazoa. The active protoplasm of higher plants forms so small a portion of the plant body, and the activities of this portion are so obscured by the more prominent and apparent portions of the plant, that one is likely altogether to lose sight of the importance of contractility in the plant kingdom.

On the other hand, the extreme prominence of this property and of the highly specialized muscular tissue which manifests it in the higher animals leads the casual observer to associate contractility with the animals, and to look upon it as one of the characteristics distinguishing animals from plants.

Being an inherent property of living matter, contractility must have a significance which bears a fundamental relation to life.

Only through the study of primitive forms can one elucidate these problems of life. Let us suppose that one has before him under a microscope an amœba just

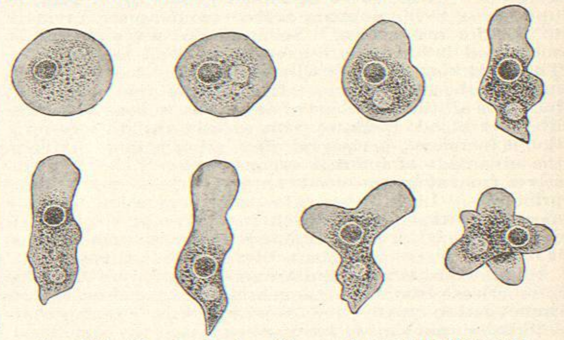

Fig. 1499.—Showing Various Phases of Amœboid Movement.

taken from an aquarium (Fig. 1499). When first seen under these conditions the organism is likely to be a fairly compact subspherical grayish mass. Presently one sees a portion of the mass slowly extending out from the main body. Other portions may extend out in other directions. These extensions or pseudopodia seem to be feelers. Through them the organism seems to get information regarding its immediate environment. Presently one of the pseudopodia gets rapidly larger through a

flowing of the protoplasm into the growing pseudopodium from the cell body and its other extensions. In this way the organism moves across the field.

Should it by accident or otherwise come in contact, at any part of its periphery, with a small solid body, such as a unicellular plant of smaller dimensions than itself, it immediately flows around the foreign body, thus engulfing it. A plant body thus engulfed or swallowed is actually digested and assimilated by the amœba.

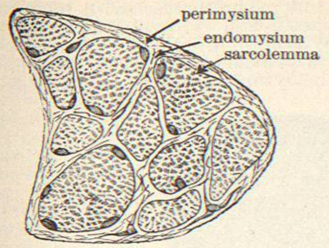

Fig. 1500.—Cross-Section of a Fasciculus of Muscle. Note that each muscle fasciculus is surrounded by a sheath called the perimysium; that the fibres which constitute a fasciculus are separated from one another by endomysium, and that each fibre is surrounded by a cell wall called the sarcolemma. The dots just within the sarcolemma represent nuclei.

If the glass slide upon which the organism is resting be jarred, or if in any way the animal is suddenly stimulated, it quickly draws up in a spherical mass, and remains thus contracted until everything is quiet and the way seems clear for another reconnoitring of the environment—another foraging tour.

Finally, after a preliminary period of rest the old amœba divides into two young ones, thus completely merging its individuality into that of the succeeding generation. This act of reproduction is accomplished through the means of a certain amount of contraction and movement.

The foregoing is, of course, an interpretation of the movements of the amœba in terms of the known activities of the higher animals, especially of man. How far this is justifiable is, of course, a question; but if we interpret the actions of low organisms at all we must of necessity do so in terms of our own experience.

Accepting this as a basis for our reasoning, we may say, then, that there are three fundamental ends served by the movements of the amœba: (*a*) nutrition; (*b*) protection; (*c*) reproduction.

In serving these three great realms of life activity, contractility stands in most intimate relation to the whole of life. If we study the higher ranks of living nature, we shall find that contractility holds just as important a relation to nutrition, protection, and reproduction as is observed in the protozoan.

Fig. 1501.—Portion of a Fibre of Human Muscle. Note the transverse bands or striations. The light discs are divided by a dotted line (plane), first described by Krause and supposed by him to be a membrane.

II. The Structure of Contractile Substance.—It has been stated above that all living substance possesses the property of contractility as one of its inherent characteristics. It follows that the discussion of *the structure of contractile substance* is really the discussion of the structure of *living substance*. It is the intention of the writer to discuss in detail only those features of protoplasmic structure which are of especial significance in contractility.

Beginning with that substance which is most highly specialized as to contractility, viz., muscle tissue, one notes that the cell is a fibre and that the cell substance is fibrillated. In action it is observed that the cell becomes shortened in its long axis while its lateral dimensions increase, the volume remaining the same. The shortening of the muscle fibre (cell) is universally conceded to be the result of the shortening of the fibrillæ, which take a prominent part in the structure of each muscle cell.

Each fibre or cell is surrounded by a delicate cell wall, the *sarcolemma*, shown in Fig. 1500.

In the figure the shaded areas (areas of Cohnheim) into which the cross-section of each fibre is divided, represent bundles of fibrillæ, *muscle columns*, which are separated by the sarcoplasm.

The proportion of sarcoplasm to fibrillar substance may vary enormously in the muscles of different species as well as in the different muscles of the same animals. "Those muscle fibres which serve the most persistent or most strenuous actions are richest in sarcoplasm." "The great pectoral muscle of the best fliers (among the birds) consists exclusively, or almost exclusively, of plasmic (rich in sarcoplasm) fibres, while in the weak-winged

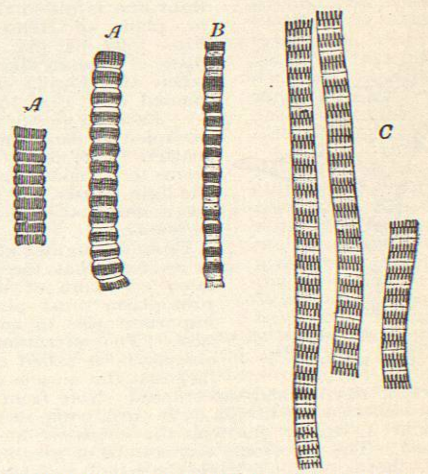

Fig. 1502.—Wing Muscles of an Insect. (After Shäfer.) *A*, Contracted; *B*, same, relaxed; *C*, moderately extended.

fowls it consists predominantly of aplasmic (poor in sarcoplasm) fibres." "There can be no doubt that energetic chemical changes go on in the sarcoplasm, as is proved by the frequent appearance within it of fat drops." "All indications favor the proposition that *the sarcoplasm* furnishes the pabulum which nourishes the fibrillæ during its activity." "If, then, it really is the rôle of the interfibrillar plasma (sarcoplasm) to preside over the nutrition of the contractile substance, the greater abundance of sarcoplasm in the muscles which serve the most strenuous and persistent functions is readily intelligible." (Quotations from Biedermann's "Electro-Physiology.")

The structure of the fibrilla has been under discussion for many years. Many of the points at issue are still

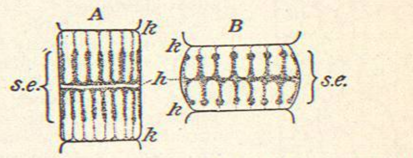

Fig. 1503.—Diagram of a Sarcomere. (After Shäfer.) *A*, Extended; *B*, contracted. The shaded portion of each sarcomere is a sarcosome. *h*, Plane of Hensen; *k*, *k*, membranes of Krause; *s. e.*, poriferous sarcous element.

unsettled. Fig. 1501 shows a human muscle fibre under high magnification. Note that the fibre presents alternating light and dark bands and that the light bands are subdivided by a fine dotted line. This line is called *Krause's membrane*, because it was at first thought to be a membrane. The whole fibre is composed of a great number of parallel fibrillæ. Each fibrilla is segmented and presents the same alternating dark and light seg-