THE NEW EXPLORATION OF THE AMAZON RIVER, BY PROFESSOR ORTON.---OVER THE ANDES.

No. 6.

CHACHAPOYAS.

While most other towns in Northern Peru are but vast pig sties containing human habitations, Chachapoyas is the best built and cleanest city west of Manáos; its grand plaza and paved streets grant no indulgences to the lower animals. Perched 7,600 feet above the sea, it possesses a delightful and equable climate, with the mean temperature of 62° Fah. Here, for the first time since leaving New York, we saw bread made from native flour. Yet there is very little of that agriculture which requires a preparation of the soil: the people (to the number of 5,000) depend mainly on the voluntary gifts of Nature, scratching the ground with wooden plows to raise a little wheat, corn, potatoes, and rice. Six crops of rice can be raised without re-sowing. Flour sells for $10 a quintal; potatoes, 15 cents a pound; cleaned wool, 18 lbs. for $2; and cacao from the warmer regions at $30 a quintal. Nothing is exported but a little cascarilla bark. The best Indian tobacco grows at Bagua in the valley of the Utaubamba, and is sold at four reals for three pounds. The main woods for construction, cedar, walnut, ishpingu, and capuri, being brought a considerable distance, are very high. All boards, from Iquitos to the Pacific, are cut by hand. There are signs of valuable mines of gold, cinnabar, lead, limonite, and a gray copper ore containing silver, in the vicinity; while mountains of salt occur at San Carlos, twenty five miles northwest. Apple trees grow, but do not thrive, at Chachapoyas; the one we saw was covered with moss, yet it presented the singular spectacle of bearing blossoms and ripe fruit at the same time. Unfortunately, this city is the head center of the *garapáta*, a grublike insect whose bite not unfrequently leads to ulcers. If the road from Chachapoyas to the Marañon by the way of Olleros and the Aichiyacu, recently surveyed by Mr. Wetterman, is ever opened, it will bring the city into easy communication with the outside world.

From Chachapoyas to the next great city, Cajamarca, is about seventy miles. On the maps, this intervening country between the coast range and the central cordillera is represented as a broad valley; in the reality, it is a jumble of precipitous mountains. The road, for the first two days, is excellent, following the romantic Utcubamba and passing within sight of the lofty Cuelap mountain which is crowned with ruins too old to be Incarial.

A PRE-INCARIAL FORTRESS.

These are the ruins of a fortress, containing chambers and tombs, and consist of a wall of cut stone 560 feet thick, 3,600 long, and 150 high, above which rises another wall 500 feet thick, 600 long, and 150 high. It is estimated that it would take 20,000 men five years to build it. While the antiquarian is busy with this, the geologist may revel among ammonites and brachiopods; and on the third day, as the road rises above the clouds to the tiptop of Calla-calla, every traveller must be entranced by the magnificent panorama at his feet—a sea of mountains with the still loftier coast range in the background, hiding the Pacific. Descending from this frigid zone, by a fearfully inclined zigzag path, we soon reached the other extreme—a deep, narrow valley wedged in among the mountains, through which the Marañon struggles to reach its northern outlet. In making this descent, we passed over granite and mica schist, the first metamorphic rocks west of the Huallága, the other rocks east and west being sedimentary. This point, therefore, is the geological "Heart of the Andes."

The Marañon is crossed on a raft at the miserable mud village of Balzas, the temperature of which may be compared to that of a furnace. Here the river is from 250 to 500 feet in width according to season, with a six mile current. Again ascending, and crossing monotonous pajonals and the fertile pampas of Huanco and Polloc, we caught sight of famous Cajamarca, seated on the eastern slope of the western cordillera and fronting the most beautiful plain in all the Andes.

THE HEART OF THE ANDES.

This highland plain or campagnia, sixteen leagues in circumference, is almost as level as a billiard table, rich as the Connecticut flats, and well watered by the mint-bordered Chonta and Masscon. The roads crossing it are hedged in with century plants, and here and there rises the "sauci" (*salix humboldtiana*) the most conspicuous tree in the region. The surrounding mountains are barren and brown, but nevertheless are exceedingly picturesque.

CAJAMARCA AND ITS RELICS OF ATAHUALPA.

Cajamarca, the Caxamalca of Pizarro's day, claims to have 14,000 citizens; certainly it is the largest and finest city on our route from Pará to the Pacific. Its altitude is about 9,400 feet, and the temperature ranges from 40° to 72°. The houses are generally built of adobe, and tiled; but the churches are of the coarse conglomerate from the sierra, and have elaborately sculptured fronts. The grand plaza is adorned with a fine stone fountain, around which congregates a motley crowd of Indian women every morning to vend their little piles of vegetables, fruits, grains, meats, salt, pepper, etc., for the plaza is the "market place" in Spanish towns. The following are some of the prices current: Flour, $16 for 320 lbs.; corn, $1 for 26 lbs.; rice, $24 for 260 lbs.; coffee, $4.80 an arroba; cacao, $24 a quintal; tobacco, 50 cents per mazo of three or four pounds; sugar, $4 an arroba; cotton cloth, 10 to 20 cents per vara; wool, $1.20 to $2 an arroba; hides, $2 to $3 each; horses, $70 to $100 each; cows, $25 each; oxen, $40 each; sheep, $2 each; tiles, $16 a thousand; a cedar board, 2½ varas long by ¾ vara wide (say 7 by 2 feet), $5; land on the plains, $50 per "fanigada" of eight acres. Wheat, barley, corn, and potatoes are about the only vegetable productions within sight of the city. The province yields annually over 7,000,000 lbs. of wheat, 160,000 head of sheep, 30,000 head of cattle, and 16,000 horses. The manufactures amount to nothing; and the imports greatly exceed the exports in value. A few textile fabrics of wool and cotton are made, and some straw hats, from the "tamsi" instead of the "bombonaje." The celebrated silver mines of Gualgayoc, 18 leagues northwest, are not yet exhausted, but are not so productive as formerly.

Cajamarca occupies an important place in the history of Peru. It was the favorite residence of the Inca when his empire stretched from the Rio Andasmayo north of Quito to Rio Maula in Chili. The stone walls of his palace still stand for about 15 feet; and along the eastern edge of the plain a line of vapor indicates the "Baños del Inca." These hot springs, even now used for baths, are copious, but not medicinal; we found the temperature as they issue from the ground 162° Fah. The story goes that, when conquered by the Spaniards, the Peruvians threw the throne of gold of their Inca into a crater, from the sides of which came these thermal waters. The paved "via real" or military road, designed to connect Quito and Cuzco, stopped unfinished a little beyond Cajamarca. Its construction was interrupted by the landing of Pizarro or Tumbez, who garotted Atahualpa after receiving the ransom of "$16,000,000 gold and $175,000 in silver"—one of the many fictions of history.

Again we mounted our mules to scale the last cordillera which separated us from the Pacific. The range, as we crossed it westward, presented three main aspects: the eastern half was of quartzite, and the mountains comparatively smooth and rounded; then succeeded rugged rocks of trachytic porphyry. Here the landscape was purgatorial, presenting the confusion of the "grab box" of a geologist; volcanic piles, marine and river deposits, fiercely contorted granite dykes, etc, are huddled together as if Nature had been in a hurry. Finally, as we neared the ocean, there was a fine exhibition of the ceaseless conflict between sea and land; the barren, rocky mountains, upon which even the lichen refused to grow, stubbornly yielded to the supremacy of the older ocean; and as the great Andes died away along the shore, the southerly wind covered them with a winding sheet of sand.

AN AMERICAN ENTERPRISE.

Two days from Cajamarca, we shouted for joy at the sight and sound of a locomotive. It was the sign of civilization: the signal that our hardships were at an end. The Pacasmayo railway, now completed 54 miles from the coast, is a model of American enterprise and American skill. It is the creation of Mr. Meiggs, the Vanderbilt of Peru, and will cost $7,000,000. The money comes from the sale of guano; the laborers from China; the ties from Oregon and Chili; the rails from England; and the rolling stock from the United States. The buildings are of corrugated galvanized iron. The track is broad gage, and will have, when finished, a total length of 78 miles. Starting from an iron pier, which is to reach half a mile into the sea, the road winds over the pampa, and among the sand drives, and beside the Rio Jequetipeque, and through a region of intensest interest to the archæologist—crowded with the relics of Incarial cities and cemeteries—and ends near the silver mines of Chilate, at an altitude of 4,000 feet. These mines of Chilate, just opened, promise to rival those of Potosi. They yield an assay from $60 to $200 a tun.

Upon arriving at Pacasmayo, weary and worn by our long tramp over the mountains, we were received by the managers of the road, Messrs. Faulkner and Maynadier, and by Dr. Heath of the Hospital, with such unbounded hospitality that we are totally unable to "meet our obligations" and accordingly "suspend payment." Thrice happy the American traveler who can fall into such a fraternity at the close of his voyage.

JAMES ORTON.

Heat.

Professor Frederick Guthrie recently delivered a lecture to working men at the South Kensington Museum, London, on the above subject:

The lecturer showed that true gases expand nearly precisely the same fraction of their size for the same increase of heat, each cubic foot of gas at the freezing point of water becoming larger by three tenths and six hundredths when heated to the temperature of boiling water. An appreciable divergence from this rule occurs when we are dealing with a gas near its point of liquefaction.

Returning to the relative expansions of solids, a few practical applications were briefly considered, subh as the fusing of glass about platinum on making apparatus for the analysis of gas, or for passing electric sparks through confined gases. Inequality of expansion is also made use of in the gridiron or compensating pendulum. In this a copper bar is placed side by side with a shorter zinc bar, the lower ends being fastened together; the upper end of the zinc bar carries the bob, and the whole is hung from the upper end of the copper bar. The greater expansion of the shorter zinc bar upwards exactly counterbalances the lesser expansion of the longer copper bar downwards, and the center of oscillation remains a constant distance below the point of support, so that the rate of oscillation does not vary with the temperature. So a little rod of zinc, pointing inwards and fastened at one end to the circumference of the balance wheel of a watch, expands inwards as the wheel increases in size in warm weather, and makes the time of vibration constant. The watch become a chronometer. A certain quantity of mercury placed in a cylinder is also used, instead of the ordinary bob of a pendulum. The mercury expands more than the metal of which the rod is formed for equal columns, and therefore, by taking unequal columns, equality of expansion may be obtained. A most sensitive thermometer can be formed by availing oneself of the inequality of expansions of mercury and alcohol. A little platinum diving bell is partly filled with alcohol and placed in mercury, and provided with a slender platinum wire arising above the mercury. The whole floats. When the temperature increases, the alcohol expands more than the mercury. Some of the latter is driven out of the bell, and the latter rises; the motion of the exposed end of the platinum wire exhibits the rise.

As a rule, gases expand more than liquids and liquids, more than solids for the same increase of temperature; and so, according to the well known law of mechanics, we should expect to find the force of expansion of solids greater than that of gases. Accordingly the force exercised by expanding solids is almost irresistible. Iron rods are bent or snapped when their centers are pulled by contracting metals. A semi-solid mass, as glass, suddenly cooled becomes brittle. A drop of hot glass cooled in water becomes solid and rigid on its outside; then the inside cools and shrinks so that the whole, when cool, is in a condition of internal strain or unstable equilibrium. Disturbed in one place, the whole crumbles to pieces in its endeavour to assume the proper size due to itst temperature. The process of annealing depends upon the so gradual cooling of a soft body that the parts get to their proper distance. The bursting of pipes in winter time proves two things: first that the ice is lighter than water; and second, that the ice is almost incompressible. Water frozen in a bomb shell two inches thick will burst it.

The expansion of liquids by heat furnishes us with means for measuring temperature. An ounce of mercury immersed in freezing water always has a certain size. In boiling water, it always has another and greater size. And at any intermediate temperature, got by mixing together different proportions of freezing and boiling water, the mercury has an intermediate size. According, by measuring the size of any constant weight of mercury, we can tell what its temperature is. Thermometers are made by enclosing any convenient quantities of mercury or alcohol in glass bulbs, with very narrow stems, so that, when the liquid gets warm and expands, it may rise a considerable bight in the stems. Plunge such a bulb into freezing water, and the mercury shrinks in the stem to a certain point; plunge it into boiling water, it rises to a higher mark. The lower mark is is sometimes called 0° and the other 100° (C.), or 80°(R.), or the lower is called 32° and the higher 212°(Fah.) Water is at its greatest density at 4° C. If we take a flask full of pure water bearing a narrow stem and cool it from, say, 10° C., we find it shrink pretty regularly as it cool still it gets to 4° C. It then expands as it cools so that at 3° it is of about the same volume (and density) as at 5°, at 2° as at 6°, at 1° as at 7°, and at 0° as at 8°. It then freezes and swells in that act to a very great amount, measured by the proportion between the whole volume and submerged volume of a piece of floating ice. When a pond of water is freezing, the surface water is at 0°, the bottom at 4°, C.

Heat travels from point to point in space in three ways: (1), by conduction; (2), by convection; and (3), by emanation or radiation. It moves by conduction when the body which receives the heat does not move as a whole, but allows the heat to travel through it. Heat moves by convection when a hot body moves. It moves by radiation when a hot body gives off heat into empty space or into some medium which does not intercept it. The gradual heating from end to end of a poker in a fire illustrates the first of these methods, the flight of a red hot cannon ball the second, and the roasting of meat or the solar heat the third.

Metals, as a class, conduct heat better than any other class of bodies. Hence, when both are above blood heat, metals feel hotter than wood. When below, they feel colder. So that paper is scorched when heated in contact with wood, but not so easily when in contact with copper. Hence, also, lead may be melted in paper. Among the metals, silver and copper are pre-eminent. That copper conducts heat better than iron is shown by heating rods of the two at the plane of contact, and noting the melting of fragments of wax arranged along the two. The great conducting power of metals is shown by the cooling effect they have upon the mixed gases of a burning body. The metal withdraws so much heat from the gas in its neighborhood that combustion is impossible. The miner's lamp is based upon this principle.

Liquids conduct heat as a class worse than solids. The conducting power of liquids is measured by heating the upper surface of a film of liquid, and noting the expansion of the air in a chamber upon whose upper side the liquid film rests. The more complex the composition of a liquid is, the more opposition does it present to the passage of heat by conduction. Chlorine, iodine, and bromine are especially strong in resisting heat conduction. Water is by far the best conductor amongst non-metallic liquids.

Gases are far worse conductors than liquids, and the imperfect conduction of many solids is due to the gases, generally air, which they inclose in their pores or between their fibers. Clothing thus protects the body from loss of heat in cold weather and from the scorching heat of the sun in hot weather. A red hot ball may be carried in the hand if a mass of asbestos, which incloses the air, is interposed. Hydrogen conducts heat far better than other gases, and accordingly cools bodies in contact with it with great rapidity.

Gold may be readily cast; but it contracts so much in cooling that the process of casting is seldom employed in the arts.