It is therefore only necessary to measure the angles with the same precision as the base, to insure equally precise results. This is so far attainable, that the latest great primary triangulation of the coast and geodetic survey, enclosed between two measured bases six hundred miles apart, met nearly midway, at a line about twenty-nine miles and a half long. The computed lengths of the line, from measured bases distant about three hundred miles from either of them, agreed within about five-eighths of an inch.

It follows from the above, that, in any system of triangulation carefully conducted, the relation of every point in the system to every other point may be determined with a degree of precision almost absolute. It renders the position of each apex of a triangle infallible; since its error, if any, can only be detected by application of similar methods of precision, which will themselves be liable to the same sources of error.

Referring to what has been written as to cumulative errors belonging to all ordinary local topographical or other surveys, it is evident, that, if these surveys include two or more trigonometrical points within their limits, the inevitable error involved in their methods is checked and corrected as each such point is successively reached. If it is not exactly hit, the local survey is wrong, and must be corrected to meet the triangulation-point, which stands as infallible in its assigned position as the pope claims to be in his.

The triangulation gives the relation of every point in the system to every other point. To apply the data thus obtained to its chief use in the construction of accurate maps, from the local surveys thus checked and corrected, another class of observations and reductions becomes necessary to fit the framework which has been constructed to its proper place upon the surface of the earth. This, with the triangulation, constitutes what may properly be called geodesy. No better definition of this term can be given than that by the late Gen. R. D. Cutts: "Geodesy, in practice, may be described as a system of the most exact land-measurements, extended in the form of a triangulation over a large area; controlled, in its relation to the meridian, by astronomical azimuths; computed by formulae based on the dimensions of the [adopted] spheroid; and placed in its true position on the surface of the earth by astronomical latitudes and differences of longitude from an established meridian."

The whole system of triangulation thus combined and co-ordinated, and made to occupy its true position upon the earth's surface, may be compared to a human skeleton. As the skeleton is the framework on which is built and sustained the varied elements of the human body, each fitted to and held in its place by the unyielding structure sustaining it, so the triangulation is the framework on which each varied portion of the earth's surface within its range is also fitted to and held in its true position, and the resulting map becomes an absolutely true topographical picture of the country it purports to represent.

But this is only one, and not the greatest, good represented by a well-executed and complete geodetic survey. Every point of the triangulation is carefully marked above and beneath the surface for reference in future ages. Every recorded distance between any two points thus marked becomes a base-line, whose length is known with a degree of precision unattainable by ordinary methods. So, also, is the azimuth or angle with the true meridian made by every such line, thus affording means for ascertaining the local magnetic variation and its yearly change. The recorded and published latitude and longitude of any station will enable future astronomers to find close at hand the means of fixing their precise relations to other and distant observatories. As the country increases in population and wealth, its topographical features change. New towns are built, and new roads and new railroads laid out. New maps will be called for, and easily supplied, since the framework of the triangulation, executed half a century before, perhaps, is there, always correct and reliable. As the elevations of all the stations above the mean level of the sea have been determined in the original survey, so, if schemes of drainage are planned to bring swamp-lands into use for arable purposes, these differences of level will afford data for obtaining the amount of fall and its proper direction. And so long as the earth and sea maintain their relative positions, so long the beneficent effect of early and exact triangulation will continue to be felt.

This is essentially a national work. It cannot be defined by, or confined within, state boundaries. Whatever views may be held as to local topographical surveys, and who shall execute them, it is evident that the framework on which they are to be built must be independent of political boundaries. The triangle sides leap across bays and lakes, or from mountain to mountain and hill to hill, or they travel 'upon stilts' across the level swamps and prairies. Nature only fixes its limits. It is homogeneous and universal by its own conditions of existence. The geodetic survey of all our country is therefore a work eminently proper for the national government to carry on, leaving the other questions of local topographical surveys for national or state action, or for both combined, as in Massachusetts.

The National academy of sciences, which is, by law, the adviser of congress and the executive upon scientific matters, has twice, at the call of congress, advised the early execution of this great work, and that its execution should be intrusted to the coast and geodetic survey as best fitted, in men, means, and training, to carry it on. Lately the need of prompt action in the same direction has been well and strongly set forth by Prof. W. P. Trowbridge of Columbia college, whose large experience gives weight to his words.

If states whose interests require good maps will join with commercial bodies and scientific men in urging legislation, the plan proposed by the national academy in 1878, and again in 1884, may be carried out with no duplication of other work, but, on the contrary, with cordial and complete co-ordination with other surveys. The whole country would be benefited thereby to an amount far exceeding the outlay.

C. O. BOUTELLE.

Washington, May 11.

Double vision.

Your correspondent, Dr. George Keller, will find the phenomena of double vision discussed in Helmholtz's 'Physiological optics,' and in LeConte's book on sight. The latter is a small volume published by D. Appleton & Co., New York. The production of binocular images, apparently suspended in mid-air, on regarding a tessellated pavement or papered wall

with visual lines appropriately crossed, is discussed but incorrectly explained by Sir David Brewster in his book on the stereoscope, many of his experiments having been performed more than forty years ago.

Dr. Keller seems to be affected slightly with divergent strabismus; which, however, has not resulted, as it so often does, in the loss of power to secure binocular vision. He will find the phenomena of vision by optic divergence discussed in a series of articles entitled 'Notes on physiological optics,' published in the *American journal of science* for November and December, 1881, March, April, May, October, and November, 1882.

W. LECONTE STEVENS.

170 Joralemon Street, Brooklyn,
May 15.

Diathermancy of ebonite.

Absence from home has prevented me seeing sooner *Science* for April 30.

In referring to my paper read before the April meeting of the National academy of sciences, you state, "Prof. Alfred M. Mayer, in describing recent work, stated that he had succeeded, by the use of a lens of ebonite, in inflaming various substances by the concentration of dark rays, for which ebonite is translucent." The statement is not what I stated before the academy. The title of my paper, as published by the academy, is, "On the diathermancy of ebonite and obsidian, and on the production of calorescence by means of screens of ebonite and obsidian."

The focus of dark rays was obtained by 'screens' of ebonite and of obsidian placed across the cone of rays reflected from a large mirror, or those refracted by a lens of glass of twenty inches diameter. I have obtained foci of dark rays with a combination of thin lenses of ebonite, but the heat of such foci is not sufficient to inflame substances.

ALFRED M. MAYER.

Hoboken, N.J., May 13.

Pharyngeal respiratory movements of adult amphibia under water.

The letter of Profs. S. H. and S. P. Gage, in your issue of April 30, induces me to recall and publish an observation made by me in 1877.

During a stay of some months in New York in the summer of that year, I several times visited a museum and aquarium, situated, if I remember aright, on 6th Avenue. I saw there a very fine specimen of Cryptobranchus Alleghaniensis about twenty inches long. I watched from time to time for several hours, but never saw it rise to the surface for air. As it lay at the bottom of its clear glass tank, I saw very distinctly continuous rhythmical respiratory movements. These, however, were not confined to the pharyngeal region, but seemed to me to extend the whole length of the body-cavity. It was a kind of squirming or wriggling movement running down the body. I looked carefully for currents issuing from gill-slits, but could see none.

At that time I concluded that the movements served the purpose of churning up the air in the lungs so as to utilize as much of the oxygen as possible. This seemed the more necessary in amphibians on account of the simplicity of their lung-sac. I had fully intended to draw scientific attention to the subject, but on returning home I could not at once lay my hand on a good account of the gill apparatus of the adult Cryptobranchus, and meanwhile other things engaged and diverted my attention.

It might be well for those who are studying this subject to at least bear in mind the suggestion that rhythmic movements may possibly serve to utilize more perfectly the oxygen contained in the lungs of animals capable of remaining long under water. In my boyhood I have often waited, rifle in hand, three hours for an alligator to rise; and that, too, in mid-summer, when their vitality is highest.

JOSEPH LECONTE.

Berkeley, Cal., May 10.

Absorption of mercurial vapor by soils.

In the issue of *Science* for April 23, it is stated (p. 370) that the mercurial-vapor remedy has, in the hands of myself and assistant, failed to produce its promised results as a phylloxera insecticide.

This sweeping statement is not justified by the facts given by me in the issue of this journal for Dec. 4, 1885, and by its further elaboration as given in the 'Report on viticultural work,' since published. It has been demonstrated by our experiments that the reported total failures were due to improper materials used in the preparation of the mercurial mixtures, whereby the formation of mercurial vapor in the soil was practically prevented, and that when reasonably pure mercury is employed, and proper means used for its distribution in the soil, all insects within the mercurialized area died in the course of from thirty to forty-eight hours at the ordinary temperature, and much more rapidly at a higher one. It therefore appears perfectly practicable to protect vines planted in uninfested ground from attack coming from without, by surrounding the stocks with a sufficiently thick (eight to ten inch) layer of mercurialized soil, which, without obstructing or repelling the entering insects, will insure their being fatally poisoned before they can pass through it. This would leave the choice between grafting on resistant stocks on the one hand, and the mercurial protection on the other, in the planting of new vineyards, the cost being (in California) about the same in either case; it would also serve for protection against threatened invasion, in the case of vineyards already planted, since, apart from the case of open soil-cracks giving access to the vine-roots, the stocks are the only known route by which the phylloxera reaches the root. Such are the presumptions created by our small-scale experiments: how far the process will prove available in large-scale practice, remains to be determined by experience, but there is no especial reason to question its feasibility.

As regards, however, the treatment of ground and vines already infested, our experiments tend to show that the diffusion of the mercurial vapor is too slow, at the ordinary soil-temperatures, to promise success; especially in the case of clay soils, which absorb and render inert a large amount of mercurial vapor before an effective excess can be obtained.

It has been abundantly shown that the mercurialized soil exerts no unfavorable action upon the growth of the vine; and there is every reason to expect that an application once made will remain effective during the life of the vine.

E. W. HILGARD.

Berkeley, Cal., April 8.