sense. I should be interested to know from Professor James, whose superior knowledge of this subject I of course recognize, if others can do better, and if any blindfolded draughtsman at his command can make consecutively four such pictures as those on p. 95 with entire success, or can draw five lines out of six through the angles of an invisible hexagon as accurately as is done on p. 89. If so, my remark has no particular point. If not so, but if it be considered that the draughtsman must have seen the picture as he was drawing it, then the fact will be more valuable for what it suggests than for what it proves. It will suggest the question why the committee who conducted the experiments laid such stress on the percipient being blindfolded when he could in fact see.

S. NEWCOMB.

Sea-level and ocean-currents.

One has so little practice in differing from Professor Ferrel that it is difficult to know how to begin; but there are some points in his recent letter on 'Sea-level and ocean-currents' (*Science*, Jan. 22) that do not carry conviction. The first is, that the small head of water resulting from the superficial difference in temperature of the ocean in high and low latitudes should be as effective as he claims it to be in producing ocean-currents, and especially in producing the existing surface currents whose circuits seem to be so nearly completed without descending to great depths; for the supposition that there is a gradual rising-up of deep water at the equator in any thing like sufficient volume to feed the currents that flow thence towards the poles is not warranted by the known distribution of surface or deep-water temperatures. Professor Ferrel ascribes the origin of the southward return current from France past the African islands to an elevation of the sea-level on the western coast of Europe, where it is heaped up by the eastward pressure of the North Atlantic drift; but the homologue of this current in the South Atlantic is a well-marked stream that turns towards the equator, although it finds no land-barrier to its eastward passage beyond the Cape of Good Hope. According to the convectional theory, it is not needed at the equator, for the water that it supplies to the Gulf of Guinea ought to rise there from the abysses: it seems preferable to refer it to the winds, with which it accords very well, provided there is reason for thinking that the winds could carry it.

The effect of the winds seems to be visible in changing the direction of the currents in the Indian Ocean with the changes of the monsoons, and in altering the area of the counter-current of the equatorial Atlantic as the position of the trade-winds shifts with the seasons. A brief examination of Strachan's charts of the 'Currents and surface temperature of the North Atlantic Ocean,' published by the British meteorological committee, 1872, shows the mean velocity of the return current between Portugal and the Azores (latitude 37°.5 to 40°) to be seventeen miles a day in the four cold months, and only nine miles for the hot months. The winter average is based on forty-one determinations; the summer average, on ninety-eight.

The sufficiency of prevailing winds to establish deep currents has been discussed by Zöppritz, with results that are approved so far as I have read. His paper on 'Hydrodynamic problems in reference to ocean-currents' (Wiedemann's *Annalen*, iii., 1878, 582) furnishes a basis for the following statements. If an ocean of great depth acquire a certain velocity of motion at the surface, it will take 239 years to gain half this velocity at a depth of 100 metres; at the same depth, even a tenth of the surface velocity will not be reached for 41 years; at a depth of ten metres the times will be 2.39 and 0.41 years. But, given sufficient time, the effect of a continuous horizontal surface motion will be felt to the bottom, the velocity finally attainable decreasing with the increase of depth. From this it appears that the effect of any variations from the prevailing forces (winds) applied at the surface will be propagated downwards very slowly, and that below a very moderate depth the motion of the greater mass of the current will depend on the mean direction and velocity of motion in the surface water. To establish the currents as they now exist would require something like 100,000 years (pp. 598, 601, 607). According to Zöppritz, therefore, we should not expect to find significant changes of level in Lake Ontario as a result of our frequently shifting easterly and westerly winds; nor in the Atlantic, on account of the difference in the velocity of the wind, winter and summer. The attitude of the greater mass of water must be in both cases adjusted to the action of the mean annual winds. In view of these and other reasons, it does not seem probable that the 'strongest winds have no sensible effect' on the ocean-level and the ocean-currents. Doubtless both gravitative convection and wind friction have a share in causing the surface currents, but the latter has the larger.

W. M. DAVIS.

Cambridge, Jan. 31.

Association of sound and color.

A friend who is peculiarly sensitive to music tells me that in listening to an orchestra he invariably sees a brilliant yellow star when the triangle is struck, and a bluish green circle (hollow) at the clash of the cymbals. As I understand him, these appear instantaneously, and then fade out little by little. I should be glad to know whether any of the readers of *Science* have similar experiences.

BRADFORD TORREY.

Boston, Feb. 9.

Tadpoles in winter.

In response to the inquiry of H. M. Hill in *Science*, vii. No. 157, I would say that for the last ten years we have been able to get tadpoles in the small streams on the Ithaca flats just before they were covered with ice in the autumn, and as soon as the ice had disappeared in the spring. There has been no trouble in keeping them alive in an aquarium in the laboratory through the winter. Those so kept have transformed, and have proved to be tadpoles of Rana catesbiana, the common bullfrog.

S. H. GAGE.

Anat. lab. Cornell university, Feb. 8.

In the frozen marshes surrounding Fresh Pond, Cambridge, I saw a large number of tadpoles under the ice, and in the clear water around the edges, about the last of January. The weather for a few days previous had been very warm for winter, but this had been preceded by very cold weather. I had always supposed, as your correspondent, Mr. Hill, does, that they were only found in warm weather, and I was considerably puzzled.

WM. A. FORD.

Boston, Feb. 9.