The rearrangement of the tracks west of Bergen Hill provides for a system of separated crossings, so arranged that none of the tracks intersect at a common level. The four tracks on emerging from the open cut are carried below the Delaware, Lackawanna & Western Railroad and beneath Tonnele Avenue. Here they diverge into six tracks, one inbound and one outbound for each of the three groups of trains. From Tonnele Avenue the Susquehanna tracks rise on an embankment and cross the west-bound main line and west-bound Newark branch. They are carried on a viaduct across the freight tracks of the Erie Railroad, after which the two tracks run side by side to the point at which the Susquehanna and the Northern Railroad trains separate. The west-bound tracks of the Erie main line pass under the passenger and freight tracks of the Susquehanna. The Erie main line east-bound track passes below the Susquehanna freight tracks, and then both these tracks rise on separate embankments and run parallel on a bridge over the west-bound Newark branch, and the Newark branch freight connection. The two tracks then descend on an embankment and run parallel to a point at which the main line trains and those of the New Jersey and New York lines diverge. Similar skill has been shown in working out the arrangements of the other lines that converge to the open cut through Bergen Hill.

From the above description it will readily be understood that the construction of the new layout of the tracks called for some heavy and costly work, involving a large amount of embankment and bridge work. Altogether 8.4 miles of new double track have been constructed and 8.7 miles of the existing double track have been abandoned, the last named, however, being very largely available for future freight traffic. Included in the bridge work is the construction on one of the new lines of a two-track drawbridge with 449 feet of girder approaches and a draw-span measuring 339 feet over all. The construction of the new embankments calls for the moving of over half a million cubic yards of material, part of which will come from the big cut, and part will be taken from "borrow pits" at the side of the embankment.

Although the new four-track system through Bergen Hill has been spoken of as an open cut, it is not strictly such, since it contains four short tunnels where the tracks pass beneath the various avenues and streets. Going west the first tunnel, below Hudson County Boulevard, is 190 feet in length. The next, beneath St. Paul's Avenue and Bevan Street, is 285 feet in length. Following that is a tunnel 235 feet long below Summit Avenue, while the fourth tunnel, the longest of all, is 580 feet in length and lies below Central and Hoboken Avenues.

Several considerations led to the choice of an open cut in preference to a continuous tunnel. First, there are the constructional difficulties attending the excavation of a tunnel wide enough to accommodate four tracks, and the extra cost as compared with an open cut; secondly, there are the advantages of comfort for the passenger and convenience of operation; and, lastly, there is the great value of the crushed trap rock of this vicinity for use as ballast, and for making concrete. The excavation of the cut involves the taking out of 114,000 cubic yards of earth and 420,000 cubic yards of rock, and the four tunnels call for 79,000 cubic yards of rock excavation. The earth excavation is being used for building the embankments upon the Hackensack meadows, and the rock is carried to a large crushing plant, erected a little to the west of Bergen Hill, where an enormous pile of the crushed material has already been collected.

The new improvements are being carried out on such an extensive scale that they will be more than sufficient to take care of the present traffic, and will allow for an extensive growth in the future. One important result will be that the New York, Susquehanna & Western, which at present makes use of the Pennsylvania terminal station in Jersey City, will in the future run its trains into the Erie terminal.

## SCIENCE AND THE SCHOOLBOY MIND.

BY H. W. HORWILL.

If the study of one's failures is part of the preparation for future success, teachers of science would do well to ponder the significance of the amusing examination answers that occasionally get into print. These are ordinarily published for the entertainment of the general reader, and they certainly serve that purpose well. But they may easily be made a means of edification as well as diversion. They often point to some flaw in methods of teaching, and suggest in what direction there is need for reform.

Of late years many educational authorities have shown a tendency to minimize the use of textbooks and trust to oral instruction. But the risk attached to teaching by word of mouth is clearly seen in numerous instances of a pupil's confusing some important word with another that resembles it in sound. Here are some examples: "The equator is a menagerie lion running round the earth." "The earth's climate is the hottest next the creator." "Sound effects the oratory nerves." "The blood is putrefied in the lungs by inspired air." A confusion with the word "rotation" is of course responsible for the definition of the axis of the earth as "an imaginary line on which the earth is supposed to take its daily routine." Scientific teaching offers a large number of opportunities for such confusions when technical terms reach the mind through the ear only, and not also through the eye. Really, one cannot be hard on a child who tells us that food passes through the "elementary" canal, or that one of the brightest stars is called "Juniper."

When a word that is in common use has a special scientific meaning, it is always necessary for the teacher to take pains to avoid a misconception. Unless he is warned against the error, it is hard for a pupil to get out of his mind the idea that "shed" in "watershed" must point to some kind of a building. Thus we get such examination answers as these: "A watershed is a place where there is water and rocks overhead that form a shed." "A watershed is a house between two rivers, so that a drop of water falling on one side of a roof runs into one river, and a drop on the other side goes into the other river."

In a great many instances the root of the trouble is evidently an imperfect explanation of the fact or phenomenon described. When an examination candidate declares that "a parallel straight line is one which, when produced to meet itself, does not meet," how is it possible to escape the conviction that an attempt has been made to load the memory with a definition without the least endeavor to get hold of its meaning? Such an answer reflects far more seriously upon the teaching received than does the statement that "parallel straight lines, even if produced to all eternity, cannot expect to meet each other." In the latter case, in spite of the confusion between the words "infinity" and "eternity," there is at any rate a fairly substantial idea of what parallel lines are. Mere rotework teaching, again, would account for the declaration that "air usually has no weight, but when placed in a barometer it is found to weigh about fifteen pounds a square inch." Clearly, there can have been little laboratory teaching in the school from which came the answer that "if a small hole were bored in the top of a barometer tube, the mercury would shoot up in a column thirty feet high," though one cannot understand how any small boy with ordinary curiosity could have refrained from attempting to verify such a fascinating statement by independent experiment. The lazy mind, catching up vaguely something it has heard while escaping the least exertion of thought, is further illustrated in the startling proposition that "things which are equal to each other are equal to anything else."

A subtle danger, to which even the most efficient teacher is sometimes exposed, is that of making an unimportant feature so interesting that the really significant matter is overlooked. A specimen case is the answer that "gravity is chiefly noticeable in the autumn, when the apples are falling from the trees." Evidently the picturesque story related of Sir Isaac Newton had impressed the mind to the obscuring of the truth involved. And this child was by no means a mere repeating parrot, for he had reflection enough to reach, independently of his teacher's assistance, the conclusion that, if it is in falling apples that gravitation is chiefly illustrated, the autumn is the time of year when it must be most frequently visible.

Some of the funniest answers reported are, after all, better testimonies to the quality of the teaching than many replies which conform more nearly to the phraseology of the books. The following account of the law of gravitation is not quite a model of scientific expression, but it certainly shows that the examinee has been thinking the matter out for himself and not without success. "If the earth was to have no gravity, and if we climbed to the top of a hill and jumped a little above the top, we would stick fast in the air, and thus there would be an end to our existence; or if there was no gravity, then some of the furniture in our houses would be above the floor of the house, and thus if we let a thing fall it would not fall to the ground, but stick just in the place where it fell out of our hands." Here, too, is a piquant illustration of the law that liquids expand when heated: "If a kettle is placed on the fire with water in it, and all means of ventilation stopped up, the kettle would bounce off the fire from the great force which was made inside it which it wanted to let escape." Happily many instances might be given in disproof of the frequent accusation that present-day school teaching stifles originality. The mental activity with which a pupil, when at a loss for an answer, will construct one out of his own head is often such as gives promise of conspicuous distinction if once the habit of diligence could be formed. It is not mere adroit evasion to say that "the difference between water and air is that air can be made wetter, but water cannot." No less thoughtful was the lad who in an essay on "The Elements" said: "Air is the most necessary of all the elements; if there was no such thing as air, I would not be writing this essay now; also there would be no pneumatic tires, which would be a sad loss." A mind capable of detecting the subtlest analogies of nature must surely have been possessed by the boy who wrote: "Mushrooms always grow in damp places, and so they look like umbrellas." We may be sure that it was not from a San Francisco school that there came the assertion that "the probable cause of earthquakes may be attributed to bad drainage and neglect of sewage." At any rate, the zeal for sanitation shown thus early ought to guarantee a diligent career as health inspector. A particularly curious instance of independent but inaccurate observation is this answer to a question respecting the differences between steamers and sailing vessels: "A steamer cut or part the water aside; but with a sailing vessel it is not the case, for it sail up and down on the waves and billows." This answer, possibly, is due in some measure to the pictures—advertisements of steamship companies and the like—which represent steamers as aggressively cutting their way through the water, as compared with the quieter representations of the progress of sailing ships. Perhaps similarity with the domestic uses of electricity is accountable for the statement that "electricity and lightning are of the same nature, the only difference being that lightning is often several miles in length, while electricity is only a few inches."

## SCIENCE NOTES.

The quantity of sulphuric acid in mine water varies according to the district and condition of the mine. Some mine water has been found to contain only a few grains, while the water in other workings often contains over 100 grains per gallon.

Some experiments have been recently carried out which appear to show that the sea water round the coast of Ireland possesses a richness in radium not hitherto expected. This result has been extended by measurements made on samples of water collected between Madeira and England, and also on water from the Arabian Sea. In a paper recently delivered it is shown that the deep-lying sediments of the ocean are exceptionally rich in radium. The materials dealt with were partly from the "Challenger," partly from the "Albatross" collections. Some globigerina ooze from the west coast of Ireland was also treated.

Dr. H. F. Schmidt, of Berlin, has completed an exhaustive study of the effect of Roentgen rays on the development of amphibia. Thirty-five axolotl eggs were placed in a shallow dish in water and exposed to the rays for half an hour. Thirty-one eggs from the same animal were simultaneously exposed to the air of the laboratory, in a similar dish of water, but shriveled from the Roentgen rays. The two batches of eggs were then kept in identical conditions and observed from time to time. When the larvæ appeared the effect of the rays was strikingly apparent, the larvæ from the eggs exposed to the Roentgen rays being much smaller than the others and curved in a peculiar manner. Only a small percentage of the exposed eggs hatched, and all the larvæ which came from them died within a few days. The thirty-one eggs which were not exposed to the rays produced as many larvæ, all of which were alive and very active after the death of the others. Microscopic examination of the larvæ killed by the rays showed that the membraneous envelope of the brain was almost destroyed and that the brain and spinal cord were seriously injured. Similar effects of radium rays on the eggs and larvæ of frogs have been observed by other experimenters.

## THE CURRENT SUPPLEMENT.

A paper by Mr. William P. Durtnall entitled "The Generation and Electrical Transmission of Power for Marine Propulsion and Speed Regulation" opens the current SUPPLEMENT, No. 1703. The city of Gary, Ind., is installing a sewer system which presented unusual difficulties to the engineer because of quicksand. A novel method of draining the wet excavation instead of emptying it in the usual way is described by Mr. C. M. Ripley. Mr. R. B. Woodworth's paper on "New Shapes of Steel for New Uses" is concluded. An important development which will exercise a far-reaching influence upon the commercial prosperity of Egypt, and which would tend to increase the agricultural prosperity of the country, has been effected by the completion of the first section of the Libyan Desert railroad. The English correspondent of the SCIENTIFIC AMERICAN describes and illustrates the work in detail. "Darwin and After Darwin" is the title of a paper by Prof. Henry Edward Crampton in which the newer discoveries in biology are simply explained. The twenty-fourth installment of Prof. Watson's elements ol electrical engineering deals with electrochemistry. In an article entitled "The Respiration of an Inland Lake," Prof. E. A. Birge describes the part played by the absorption and distribution of oxygen in small bodies of inland waters.