have shown that egg cells of the lower animals and of some plants may be caused to undergo division and to produce embryos even in the absence of fertilisation. Thus the unfertilised egg of a frog pricked by a needle has been caused to undergo division and development, and to give rise to fatherless tadpoles. Hence there would seem to be little doubt that, in normal fertilisation, the abrupt entrance into the egg cell of the male reproductive cell leads to the production of a wound hormone which acts specifically in provoking cell division.

It might be objected that such an hypothesis presupposes an almost incredible delicacy of protoplasmic organisation, but the objection has no weight with the plant physiologist who knows from long experience that disturbances of protoplasm, often so slight as to escape our own powers of perception, may suffice to produce marked and far-reaching effects in plants. The exposure of one side of the tip of the seedling leaf of oat or other grass to direct sunlight for periods of so brief a time as $\frac{1}{2000}$th of a second suffices to interrupt the uniformity of its upright growth and make it do obeisance to the sun. The tendril of the passion flower has a receptiveness so acute that the hanging upon it of a thread weighing no more than $\frac{1}{4000}$th of a milligram suffices to deflect the tendril from its course of growth. It curves in the direction of an incubus, the weight of which would have to be increased tenfold before we, if it were placed upon the skin, could be made aware of it by our sense of touch. The human eye is apt to distinguish small differences of light intensity. When we are young, our eyes can perceive the difference between a ninety-nine and a hundred candle-power lamp. As we grow old, acuteness of perception fails, and we are lucky if we can tell the difference between lights of one hundred and ninety-six candle-powers. A leaf can "tell the difference" between one hundred and 98·7 candle-power, so that its sensitiveness, as expressed by responsive movement, is equal to that of a fairly young eye. The trained eye is a wonderful instrument for perceiving whether or no a line be truly vertical, but I doubt whether its power is greater than that of the root of any plant. More than once a delicate experiment in plant behaviour has come to grief because the experimenter failed to notice that his table was not absolutely horizontal, and in consequence his plants not vertical. The plants themselves took heed of the displacement and set to work to rectify it to the undoing of the experiment.

(To be continued.)

Large Crystals of Iron.

THE paper by Prof. Edwards and Mr. Pfeil presented at the May meeting of the Iron and Steel Institute on "The Production of Large Crystals by Annealing Strained Iron" has now brought iron into the rapidly growing list of metals which can be obtained in the form of very large crystals. The research follows on a preliminary paper presented to the Institute by the same authors a year ago, in which they dealt with the commercial importance of coarse crystallisation in a number of defective stampings which had come into their possession. Methods of producing large metallic crystals may be classified under the following heads: (1) By slow cooling of the melt; (2) by drawing a rod slowly out of the melt; (3) by straining to a critical amount a test-piece composed of small metallic crystals, followed by heat treatment; (4) by the simultaneous application of strain and heat treatment to a metal wire. The method adopted by the authors is No. 3, which was introduced in 1921 by Carpenter and Elam in the case of the metal aluminium, and the large crystals produced are very similar in form.

It could have been predicted that iron would be more difficult to prepare by this method in the form of "single crystal" test-pieces than aluminium, for two reasons: (1) That no suitable form of commercial iron exists; and (2) that no heat treatment can be carried out above 900° C. on account of the A_3 change point at which the α to γ change occurs. Another difficulty presented itself in the course of the research to which reference will be made. The authors employed as their starting material mild steel plate 0·125 in. thick, containing 0·10 to 0·13 per cent. of carbon and the usual amounts of commercial impurities. The sheets were covered with a thin layer of scale which had to be removed by pickling in dilute sulphuric acid, leaving a dull metallic surface free from serious defects. The test-pieces used were from 8 to 12 in. in length by 1 to 2 in. in width. Chappell's earlier work having shown that the presence of carbon in iron restricts the size of the crystals which could be developed, and the authors' investigations of the defective stampings having shown that coarse crystallisation was more pronounced where decarburisation has occurred, it was decided to remove all carbon from the test-pieces before attempting to produce large crystals. It was necessary to determine carefully the conditions of decarburisation, since the problem resolved itself into obtaining an iron of suitable crystal size free from carbon. As the result of a large number of experiments, it was found that a grain size of approximately 120 grains per square millimetre is required. This was obtained by decarburising at a temperature of 950° C. for 48 hours (*i.e.* in the γ range), followed by slow annealing (12 hours from 950° to 100° C.). The complete removal of carbon was found to be necessary. From this material large crystal test-pieces could be prepared by an elongation of 3·25 per cent. produced by tensile stress, followed by annealing just below the A_3 change point (about 880° C.) for three days. The maximum size obtained was 4 in. × $1\frac{1}{4}$ in. × $\frac{1}{8}$ in.

A complication from which aluminium is free is the presence of a surface film of very fine crystals which masks the very large crystals produced, and in order to reveal them it is necessary to remove this layer. The authors' experiments show that in general this film was just one crystal thick, and they concluded that those crystals in the original material which had a "free boundary" did not undergo the same kind of change during deformation by tensile strain as the interior crystals. They found, however, that if the elongation was produced by rolling, the surface film of fine crystals was not produced after annealing.

Tensile tests were carried out on test-pieces cut from strips containing large crystals, so that the parallel portion in each case was occupied by a single crystal. Values of from 9 to 10 tons per square inch ultimate stress and 30-50 per cent. elongation on 2 inches were obtained, and may be compared with about 19 tons per square inch and 53 per cent. elongation obtained for the same material in the fine-grained condition. A single crystal cut from the coarsely crystalline strip can be rolled out to 100 times its original length and reduced from 0·125 to 0·001 in. without annealing and without showing any signs of cracking at the edges. The properties in this respect were very similar to those of the aluminium crystals made and tested by Carpenter and Elam. It was found, however, that in certain circumstances these large iron crystals were exceedingly brittle, a property not hitherto observed with aluminium. If a crystal were placed in a vice in a certain way and given a sharp blow with a hammer, fracture frequently occurred along what appeared to be a cleavage plane. A large number of crystals were broken in this way. Only in a few cases did bending occur, such as would happen in finely crystalline iron. In the large majority of crystals tested it was found possible to obtain fractures in two planes exactly at right angles. The authors consider it probable that the large crystals grown in strained iron possess a similar orientation.

Messrs. Edwards and Pfeil have established two important facts which bear on the production of large iron crystals: (1) The critical strain required to produce very large crystal-growth on subsequent annealing varies with the initial grain size of the material used, the larger the grain size the greater being the strain required. With very large crystals, sufficient strain to cause growth cannot be applied, since recrystallisation occurs at the crystal boundaries. (2) Surface crystals of the original finely crystalline aggregate behave differently from those in the interior and require a greater tensile strain before they will disappear.

The authors explain these facts in the following way. In the case of a single crystal it is considered that deformation occurs by a process of slip causing little change in the crystal lattice. Some change must occur, for single crystals of tungsten, aluminium, and iron are hardened by cold work, but in the case of single iron crystals, whatever change up to 25 per cent. elongation occurs is removed on annealing without producing recrystallisation. If, however, two crystals in contact are deformed, there will be interference with slip, owing to the change in the direction of the slip planes in passing from one crystal to the other. In these circumstances some other kind of movement must occur during deformation. X-ray analysis does not indicate any difference between the lattice constants of cold worked and annealed metals, but shows a relation in the former between the direction of the crystallographic axes and that of straining.

The second type of deformation is interpreted therefore as a rotation of the crystallographic axes accompanied by elastic strain. The depth to which this change penetrates from the boundaries depends upon the degree of deformation. With small crystals but little deformation will cause the depth to correspond with the radius of the crystals. The larger the crystals the greater the deformation necessary to cause the change to reach the centres. When this second type of deformation has penetrated to the centres (and the strain at the crystal boundaries has not exceeded a certain value) the authors consider that the degree of axial alignment due to rotation has proceeded to such an extent that, on annealing, it is easier for the atoms to form a single crystal than to revert to their original orientations. With very large crystals, however, before the second type of deformation has penetrated to the centres, the strain set up at and near the crystal boundaries has become so great that, on annealing, the atoms in these highly strained regions preferably form new crystals, *i.e.* recrystallise.

With regard to the small surface crystals, the authors consider that a greater degree of deformation produced by tensile stress is required before the change is sufficiently complete to permit of growth or absorption during annealing. When, however, the critical degree of strain is caused by rolling and the freedom of the surface crystals is thus at least partly removed, their growth or absorption can occur.

H. C. H. C.

Immigrant Cultures in Egypt.

By Sir FLINDERS PETRIE, F.R.S.

A GENERATION ago our view of Egypt was limited to three brilliant periods, without beginnings or connexions. The discovery of the prehistoric ages in 1895 showed two successive civilisations, waxing and waning, which were disentangled by the classification of sequence-dating, and appear to have come in first from the west and then from the east. The further discovery of the royal tombs of the earliest dynasties at Abydos provided a monumental basis for what had, so far, only been recorded history. There the position has rested for twenty years, but recently much more has come to light, consolidating the long view of the past.

On a jasper cylinder seal of Asiatic work, the figure of a king named Khandy was identified with the same name recorded in the VIIIth dynasty of Egypt. As that king is shown receiving homage from a Syrian, and secondarily from an Egyptian, it appears that he was ruling in Syria and holding Egypt. Other foreign names in that dynasty indicate that the VIIth and VIIIth dynasties, who succeeded the first pyramid age, were Syrian rulers. This accords with the frequent use then of button badges, always of foreign work, and bearing designs known in Babylonia and Cilicia. Excavation of the cemetery of the IXth and Xth dynasties capital, Herakleopolis, showed an entire absence of the Syrian buttons, and a throw-back on to Egyptian lines, apparently due to a Libyan immigration.

Last winter the study of the rock tombs of the Uah-ka princes of Qau—south of Assyut—of the IXth and Xth dynasties, has opened a fresh view. It had already been noted that certain black granite sphinxes from Upper Egypt, which resembled the kings of the XIIth dynasty, were markedly of the Galla type. At