intercrystalline boundaries is clearly visible on the specimens. An example of the channels formed in this way is shown in Fig. 1, reproduced from the paper. An interesting confirmation of the authors' views is further found in the fact that while the boundaries between adjacent crystals always exhibit this deep channel, the boundaries of twin-crystals do not show such a groove; since the crystal units on either side of a "twin" boundary fit into one another in a regular manner there is no room for amorphous matter in these boundaries, hence the absence of the groove. With the metals antimony, cadmium, and aluminium the authors obtained irregular losses of weight which neither confirmed nor refuted their views; they put these views forward merely as a suggestive working hypothesis, and do not claim to have furnished a valid proof of its truth.

Incidentally, the method of heating metals in high vacua furnishes an interesting means of developing their micro-structure, and this method has been used by the authors to study the conditions under which twinned crystals are developed in silver. One of their photomicrographs showing the structure of a twinned crystal of silver is reproduced in Fig. 2.

THE SURFACE-TENSION OF LIVING CELLS.¹

PROF. CZAPEK'S pamphlet contains most important experimental work upon one of the fundamental physical attributes of the living protoplasmic cell, namely, the surface-tension of its external limiting layer. He makes it clear that the tension conditions obtaining in this layer, which intermediates between each metabolic unit and its environment, are of great significance for secretion and for absorption, and he has established that the surface-tension of the cells of the higher plants is maintained fairly constant at the value of about 0.685, the surface-tension of water in contact with air being taken as unity.

This very important conclusion is the outcome of a line of research which began at an apparently remote point, the successive stages of which may be briefly set out. The work started with the investigation of the curious precipitates that could be produced in the living cells of many plants by the action of dilute ammonia or 0.2 per cent. caffeine, such as had been described as "aggregation" by Charles Darwin, in the tentacles of *Drosera*. Czapek first established that this "myelin-like" precipitate is a compound of caffeine with the soluble tannin of the living cell, and is produced in all cells that contain tannin, the mesophyll of *Echeveria* and *Sedum* being the most suitable material. He then found that if such living cells are immersed in solutions of organic substances for some hours, the power of giving a precipitate with caffeine may be entirely lost. This loss was traced to exosmosis of the tannin from the living cell, and it was further found that for each organic substance there was a particular limiting concentration below which no effect was produced and above which the exosmosis became very rapid. On comparing these limiting concentrations for the series of monovalent alcohols it was found that at each step in the homologous series the molecular concentration required diminished to one-third. Such a relation was, however, exactly what Traube had established for the surface-tension effect of the members of this series.

Following up this clue, Czapek measured the surface-tension of a large number of solutions of organic substances, and compared their action in causing exosmosis from the cell with their activity in lowering the surface-tension of water. He thus was able to establish securely the unexpected generalisation that on dissolving in water sufficient of any organic substance whatever to lower the surface-tension to about 0.685, a solution is obtained which just causes the exosmosis of the contents of living cells. The critical concentration may require twelve to twenty-four hours to produce its effect, but stronger solutions with a lower surface-tension work very quickly and thoroughly, so that after a short time treatment of the cells with caffeine gives no intravital precipitate at all.

The power of the protoplast to retain its dissolved contents is thus shown to be a matter of physical organisation, depending upon the surface-tension of the cell being below that of the medium in contact with its outer surface.

From true solutions Czapek passed to try the effect of emulsion-colloids of a lipid nature (proteids and carbohydrates do not lower surface-tension enough to give the critical value of 0.685). The lipid emulsions are, however, extremely active, and give exactly the same effects as true solutions.

The last step in the progress was an attempt at identification of the substance actually present in the plasmatic membrane which causes it to have normally so low a surface-tension as 0.685. Czapek finds that saturated emulsions of neutral fats lower the surface-tension just to this value and no further, so that it seems very probable that these are the effective substances in the living cell.

We have thus striking support for the view, widely adopted from the work of Overton and Meyer, that the plasmatic membrane is of a lipid nature. Overton's later view was that lecithin and cholesterol rather than neutral fats were the particular lipoids present, but these give a lower surface-tension down to about 0.5. The present line of work indicates that these may be the effective substances in some cells, not those of the higher plants, for yeast and red-blood corpuscles require a medium of about this lower surface-tension to bring on exosmosis of invertase and hæmoglobin respectively.

Many supporters of the lipid theory of the constitution of the plasmatic membrane have interpreted it to mean that there exists at the surface of the cell a continuous film of a lipid nature, and this has raised difficulties in understanding the intake of typical nutrient substances which are freely soluble in water, but not in fat. Czapek points out that an emulsion containing only a small percentage of fat is all that is needed to endow the cell with the observed specific properties.

Willard Gibbs showed from thermodynamical considerations that substances in a solution which strongly reduce surface-tension must accumulate in the surface-layer until their return by local excess of osmotic pressure produces a state of equilibrium between the surface and the mass. With emulsified fat particles, however, the osmotic pressure is very slight, and very great accumulation in the surface-layer must result.

This piece of work may serve as a model of scientific method on account of the way in which the mysterious phenomenon of "aggregation," described by Charles Darwin, has been followed on and on until it has led to the evaluation of so fundamental a vital constant as the surface-tension of the living cell.

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¹ "Ueber eine Methode zur direkten Bestimmung der Oberflächenspannung der Plasmahaut von Pflanzenzellen." By F. Czapek. Pp. iv+86. (Jena: Gustav Fischer, 1911). Price 2.60 marks.