## Distribution of Ribonucleic Acid in the Cytoplasm of Growing Cells Studied with Phosphorus-32

THE occurrence of ribonucleic acid in the submicroscopic particles obtained by centrifugation of extracts of organs (granules, microsomes, liponucleoprotein complexes) has suggested the hypothesis that these particulate structures might have a role in the synthesis of proteins, and that they may even be identifiable with the viruses and plasmagenes. This idea implies not only that these particles actually exist in the cytoplasm but also that ribonucleic acid is really part of them. It is possible, of course, that they are artefacts which appear upon homogenization of the cells. Indeed, Kleczkowski[1] and Lauffer[2] have shown that a nucleoprotein, the tobacco mosaic virus, is able to form complexes with different proteins under the influence of small changes in the medium, and it is also known that the distribution of ribonucleic acid among the different fractions separable by ultracentrifugation of a tissue extract depends on the salt concentration of the extraction medium[3]. Brachet and Jeener[4] observed in 1943 that high-speed centrifugation of a piece of frog liver displaced a large part of the ribonucleic acid towards the centrifugal ends of the cells; but this phenomenon was not seen when mammalian liver was used. Furthermore, the conditions under which centrifugation is carried out are quite abnormal (using concentrated sugar solutions of the same density as the tissue).

It appeared that the use of labelled atoms might give some idea as to the distribution of the constituents of the granules in the cytoplasm, when the latter is maintained under strictly physiological conditions. Labelled phosphorus was injected into gravid mice, hen's eggs or into pigeons, the crop glands of which were actively proliferating after injections of prolactin. The mouse embryos, chick embryos or crop glands were removed two hours after the injection of the labelled phosphorus and mechanically homogenized with phosphate buffer at *p*H 7·3 containing 30 per cent sucrose. The extract thus obtained was cleared of nuclei and cellular debris by a short centrifugation at low speed and then fractionated by further centrifugation into three parts: (*a*) the 'pellet' of granules obtained after centrifuging for 14 min. at $13 \times 10^3$ *g*, (*b*) the pellet resulting from 60 min. centrifugation at $60 \times 10^3$ *g*, and (*c*) the supernatant liquid resulting from (*b*). The specific radioactivity of the phosphorus of the ribonucleic acid was determined by the Schmidt–Thannhauser method as modified by Spiegelman and Kamen[5]. In order to get rid of the inorganic labelled phosphate ions an excess of normal phosphate ions was added and the whole eliminated as ammonium magnesium phosphate. A control experiment showed that the ratio between optical density at 255 mμ and the phosphate hydrolysed by 1 *N* hydrochloric acid in three hours at 100° C. was the same in the case of the solution of mononucleotides studied and of a similar solution prepared from purified yeast ribonucleic acid.

As the accompanying table demonstrates, the specific radioactivity of the phosphorus of the ribonucleic acid of each of the three fractions is quite different (there is a probable error of ± 4 per cent). However, it is still impossible to tell to what degree the labelled phosphorus found in the nucleic acid of the different fractions is a measure of the renewal of nucleic acid molecules or of an increase in their number during the growth of the cells.

Specific radioactivity of phosphorus in ribonucleic acid (in arbitrary units per 100 γ P)

| | Supernatant of $60 \times 10^3$ *g* | Pellet of $60 \times 10^3$ *g* | Pellet of $13 \times 10^3$ *g* |
|---|---|---|---|
| Mouse embryo | 100 | 16 | 75 |
| | 124 | 38 | 82 |
| | 605 | 223 | 498 |
| | 1365 | 440 | 1000 |
| Crop gland of pigeon | 316 | 272 | 475 |
| | 5960 | 143 | 5170 |
| Chick embryo | 155 | 97 | 101 |
| | 263 | 45 | 37 |

But an important conclusion can be drawn from the facts just stated. It is that nucleic acid is seen to be at least partially associated with particles, and that these really exist in the cytoplasm of the living cell. It would be difficult to explain otherwise how the radioactivity of the phosphorus of the nucleic acid differs from one fraction to another, for such would certainly not be the case if nucleic acid existed in a free state in the cell, associating with other substances to form granules only as a result of the extraction procedure. The results show further that at least three different fractions of ribonucleic acid exist, as well as at least two kinds of granules which contain it.

It may also be pointed out that it seems quite certain that the differences in specific radioactivity which have been observed are definitely present in the living organism and not merely appearing in the extracts during the various procedures, for the turnover of nucleic acid phosphorus in the extracts is three hundred times too small to account for the differences seen.

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## The Weiss–Heisenberg Theory of Ferromagnetism and a New Rule Concerning Magnetostriction and Magneto-Resistance

IT is considered an open question[1] whether the Weiss–Heisenberg model or the band model, which is based on the conception of the itinerant electron, is the more appropriate one for the description of ferromagnetic phenomena. On the whole, the original Weiss treatment translated into modern language is surprisingly powerful when compared with numerous later attempts at an improvement.

It occurred to me that arguments for or against the Heisenberg model might be derived from a consideration of the properties of ranges of alloys in which the mean number of Bohr magnetons passes through an integral value. The Heisenberg model leads one to expect that the exact filling up of all lattice-points with an equal number of electrons will make itself felt in some properties of the ferromagnetic alloy. From the point of view of the band theory, however, a singling out of such an alloy from