angle. Three lateral contacts are not rare, and sometimes four may be observed; the only decagonal cell encountered had four contacts on both sides.

Since the average cork cell in vertical section has 5.877 sides or contacts, and two of these are the top and bottom diaphragms, it follows that the average number of lateral contacts is one half of the remainder, or 1.938. The average number of sides in cross sections of the cell was found to be 5.978. Accordingly the average total number of contacts per cell, $(1.938 \times 5.978) + 2$, is 13.59. That this average is not precisely 14 is due to the frequent elimination of a surface accompanying the production of a tetrahedral angle. The computation indicates that 40 per cent. of the cells have lost a side in this way.

Pending the outcome of reconstructions which are now being attempted, the cork cell as a whole may be pictured provisionally as follows. An orthic tetrakaidecahedron is shown in Fig. 2, and beside it a prismatic tetrakaidecahedron of the same volume and of minimal surface for the prismatic form. A shorter or taller prism would have greater surface for its volume. Cork cells, according to the season of the

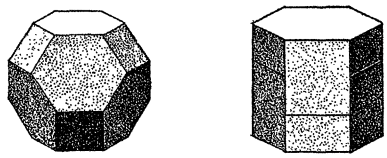

FIG. 2

year, are both shorter and taller, relatively, than the prism here pictured, which, however, is well within the limits actually observed. Although cork cells were described and figured by Hooke as if their lateral sides were flat, *i.e.*, as if they were true prisms, and although subsequently they have often been drawn in that way, it is evident that they are intermediate between the orthic and prismatic forms of the tetrakaidecahedron.

It seems impossible that this conclusion has not previously been presented elsewhere. Eminent authorities with other views as to the shape of cells might readily be cited, and also scores of cytologies where one looks in vain for a correct statement of this fundamental matter. What, however, is less obvious is the further conclusion which we have presented in other papers, namely that when a tetrakaidecahedral cell divides, whether transversely or vertically, it will produce a pair of cells each of which has eleven sides, or together twenty-two sides—an increase of eight over the original fourteen. At the same time six surrounding cells each receive an added side, making fourteen new surfaces the result of a cell division, and thus maintaining the average count of fourteen. This result, so characteristic of cells, is simply the necessary outcome of the avoidance of tetrahedral angles in every plane; and this avoidance is indeed the entire morphological explanation of the tetrakaidecahedral form. If tetrahedral angles are avoided to the *maximum possible extent,* the geometrical patterns shown in the figure will be produced. The shape becomes therefore a measure of surface tension. If, on the average, the cells are hexagonal both in transverse and vertical section, nothing in biology is easier than to prove that their average number of contacts with surrounding cells is fourteen.

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Orientation, differentiation and cleavage in the early development of the egg: EDWIN G. CONKLIN. Thirty years ago I called attention to the importance of "Protoplasmic Movement as a Factor in Differentiation" (1899). Since that time many other studies have served to confirm the importance of such cytoplasmic movements in the orientation and localization of developmental processes in eggs and cleavage cells. The actual mechanism of such movements is largely unknown but they may be stopped or modified by cold, pressure, various chemical substances, absence of oxygen, etc. On the other hand strong radiation with ultra-violet light, with X-rays or with radium does not modify appreciably these intra-cellular movements of the cytoplasm, and even a direct current of 200 mil. amp. acting for several hours has apparently no effect on these movements.

During the past summer I found that the normal movements within the eggs and cleavage cells of Crepidula plana could be greatly modified by subjecting them to a temperature of approximately O° C. for a period of from four to six hours. The first noticeable effect of such treatment is the suppression of the vortical or rotary movements within the cells and the consequent failure of the cell body to divide and the cell contents to assume their usual positions. A second effect is the formation of many local aggregations of finely granular cytoplasm. This "hyaloplasm" or "ground substance" is normally found in the cortical layer, the asters and the astral radiations of the Crepidula egg but low temperatures (or hypertonic solutions) cause it to gather into patches or islands.

If such eggs are then returned to normal conditions some of them may develop quite normally, especially if they were in the resting condition at the time of the experiment, or if the temperature was low enough to stop all developmental processes. But if they were dividing at the time of the experiment or if the temperature was not low enough to stop all differentiation the further development is very abnormal, owing to the fact that different developmental processes are differently affected. Thus nuclear growth and division may pro-

ceed when division of the cell-body has been stopped, with the consequent formation of multi-nuclear cells; or cell-division may be limited to the portion of the egg which is richest in cytoplasm, while the yolk-containing portion remains unsegmented.

Due to the fact that typical cytoplasmic movements are interrupted mitotic figures are often out of proper position, with the result that the direction of cleavage and the size and quality of cleavage cells are abnormal. Thus the first cleavage spindle frequently lies in or near the chief axis of the egg instead of at right angles to it, in which case the first cleavage is equatorial instead of meridional and subsequent cleavages are limited largely if not entirely to the upper one of the two cells.

If the first cleavage had occurred normally before the experiment, the spindles for the second cleavage may be in any position with respect to the egg axis or the first cleavage plane; thus both second cleavage planes may be parallel with the first, giving rise to four cells in a row, or one cell of the two-cell stage may divide at right angles to the other. In many cases the spindles for the second cleavage occupy exactly the positions they take in the normal third cleavage, with the result that two micromeres are separated from two macromeres by a dexiotropic division. In later cleavages of such eggs a second set of micromeres is given off in a laeotropic direction, a third set in a dexiotropic direction and all subdivisions of these micromeres take place in a normal way, except that because of the omission of the second cleavage there are only two macromeres and consequently two micromeres of each set, instead of four as in normal eggs. In short the second cleavage has been permanently omitted without otherwise changing the normal course of development. This indicates that cleavage and differentiation may be more or less independent; cleavages may be omitted or additional ones may be intercalated, as I have found in other experiments, without changing the regular course of differentiation.

One of the most striking instances of the separableness of cleavage and differentiation is found in the eggs of the ascidian Styela partita. Fertilized eggs of this ascidian in which the nuclei divide but the cell-body does not sometimes undergo partial development which in some respects is similar to that of normally segmenting eggs. The areas of cytoplasm which normally give rise to ectoderm, mesoderm, and endoderm are typical in position and staining reactions in such egg-embryos and the nuclei in these different areas are similar in size and staining to those in the ectoderm, mesoderm and endoderm of normal embryos. Sometimes in later stages cell walls form around some of these nuclei, thus giving rise to typical cells of ectoderm, mesoderm, endoderm, or notochord. Finally at the time when normal larvae are undergoing metamorphosis these egg-embryos undergo corresponding changes in staining reactions.

Such unsegmented egg-embryos never take the shape of normal embryos or larvae; the gastrula invagination, the elongation of the embryo and other typical form changes evidently depend upon the formation of cell-walls, and upon the subsequent movements of cells. No differentiations occur in eggs in which the nucleus does not undergo repeated division. During these divisions a large amount of nuclear material passes from the nucleus into the cytoplasm, while a reverse movement of material from the cytoplasm into the nucleus takes place during the resting period. This interchange between nucleus and cytoplasm is an essential feature of chemodifferentiation. On the other hand the orientations of development are the results of typical movements within cells, and these two processes can be separated experimentally.

Long ago F. R. Lillie (1902) found that under experimental conditions differentiation without cleavage might occur in the eggs of the annelid, Chaetopterus. My results on the differentiation of unsegmented eggs of the ascidian are essentially similar to Lillie's.

The production of dwarf larvae from fragments of the annelid egg and the problem of localization: EDMUND B. WILSON. As is well known, the unfertilized eggs of sea-urchins and certain other animals may be fragmented during or subsequent to the maturation period and the fragments, upon fertilization, may develop into complete dwarf larvae. It is also known, from both observation and experiment, that some of the most fundamental operations of localization take place during the maturation-fertilization period. As yet this period has been insufficiently explored by experimental methods, especially in case of the more extreme types of so-called determinate or mosaic cleavage and development, of which the annelid egg offers a classical example. Previous experimental studies on egg-fragments in annelids include only some brief notes by Delage on *Lanice* (1899) and an important work of F. R. Lillie on *Chaetopterus* (1909). In both cases it was found that the first cleavage of the fragment is unequal in the same proportion as in whole eggs. Neither observer followed the development beyond this point; but Lillie indicated the importance of his discovery for the problem of localization, while Delage figured a dwarf larva derived from such a fragment. The writer has followed in *Chaetopterus* the development of fragments of various sizes and contents obtained by Lillie's method of centrifuging the whole eggs early in the maturation period. On being fertilized such fragments—large and small alike, if not too small, and irrespective of their visible contents—may undergo complete development and produce actively swimming dwarf larvae. In a large proportion of cases the cleavage-pattern of the fragments is practically identical with that of the whole egg in respect to the arrangement and size-relations of the blastomeres and the typical alternation of clockwise and anti-clockwise spiral cleavages. Though the dwarf larvae are often abnormal in various degrees they usually show certain of the normal structures (including very commonly the apical flagellum) and some of them closely approach the normal whole larvae in form, structure and mode of swimming. These results closely parallel those earlier obtained by the writer in case of the nemertine *Cerebratulus* (1903)

but are more striking because of the asymmetrical and more highly differentiated pattern of cleavage in the annelid. The question remains undecided whether or not fragments from any region of the egg may produce a complete dwarf, as seems to be the case in the nemertine. The annelid egg may be like that of the mollusk *Dentalium* (Wilson, 1904), which, even before maturation begins, contains a prelocalized area in the lower hemisphere, perhaps equivalent to an "organizer," the presence of which, wholly or in part, is essential for the complete development of an egg-fragment. No evidence for this was, however, found beyond the problematical fact that the first cleavage of the fragments may take place either with or without the formation of a polar lobe. In any case it seems probable, alike in case of the nemertine, the mollusk and the annelid, that at a sufficiently early period all protoplasmic regions of the egg are equipotent and that localization is essentially an epigenetic process. Further light on this question may be expected from a study of fragments of fertilized eggs of the annelid at intervals during the maturation-fertilization period, such as has been made in the nemertine by Yatsu and by Zeleny. It is hoped to make such a study hereafter.

Are there genetically based mental differences between the races? C. B. DAVENPORT. While it is commonly recognized that the different races of mankind differ in various morphological characters, it has long been contended that there is no good evidence that these races differ in mental capacity; that is, that they are unlike in inborn, genetic traits that belong to the mental sphere. That dogs differ in innate instincts and mental traits no one denies. But humans, it is thought, may be exceptional in this regard. To test this matter a number of Negroes, Whites and hybrids between them, all living on about the same social level and having about the same education, were subject to certain mental tests. Some of these related to sensory discrimination; others to such elementary things as ability to fit blocks to a form board opening, to copy geometric figures, to draw a man, to repeat a series of numbers, to show the difficulty in absurd sentences, to meet the Army Alpha tests. First of all, the scores on the mental tests, in general, follow the law of variation of physical characters. In some mental tests that seem to be good tests of innate capacity there is the same sort of difference between the races that physical measurements show. Thus in discrimination of pitch and of rhythm by the Seashore test the full-blooded adult Negroes did clearly better than the adult Whites. On the other hand, in sense of harmony there is no certain difference. In copying geometric figures the adult Whites are much superior to the colored groups. In drawing a man without a copy the adult Whites did significantly the best of the adult groups. In reconstruction of a manikin the adult Whites finished in much the shortest time of all adult groups and made the fewest errors. In interpreting the form of the hole that would result from opening out a notched paper the adolescent and adult Whites were superior to the other-colored groups. In the form board test, the substitution test, the cube imitation test, criticism of absurd sentences and in the Army Alpha tests of common sense, synonyms and antonyms, restoring pied sentences and general information, the Whites are clearly best. In the other Alpha tests the differences between the groups are not surely significant. On the other hand, in ability to repeat seven figures, not the Whites but the hybrids seem to be superior. One may conclude: first, that races differ in innate mental traits as really they do in physical characters; second, that when full-blooded Negroes and Whites of the same social status, occupation and education are compared the Negroes show a superiority over the Whites in at least certain parts of the field of sense discrimination. In ability to retain and reproduce a series of figures they seem to be at least equal, if not superior, to the Whites, but in tests involving some organization, foresight and planning, as in the form board test, in drawing the figure of a man, in reconstructing a manikin, in the cube imitation test, as well as in certain of the Army tests involving common sense and something of a logical faculty, the Negroes seem to be inferior to the Whites. The fact that, in general, the grades of the Browns are strictly intermediate between those of Blacks and Whites in the case of mental traits, exactly as in the case of physical traits, seems to be a fact of especial importance, for the Blacks and Browns live side by side in rural Jamaica and, indeed, they can frequently be distinguished only by their pedigree. Therefore difference in social status or training can hardly be responsible for the fact that Browns tend in their mental reactions toward the Whites. We are driven to the conclusion that there is a constitutional, hereditary, genetical basis for the difference between the two races in mental tests. We have to conclude that there are racial differences in mental traits.

Immunity relations between female parent and offspring: THEOBALD SMITH. The communication deals with two routes for the transmission of protective antibodies among mammals from female parent to young—the placenta and the udder. In some species it is one route, in some the other that predominates. The withholding of these protective substances in the case of calves by feeding ordinary milk in place of the first milk or colostrum is followed by prompt disease and death in three fourths of the animals so treated. The protection in the colostrum is referred to antibodies accumulating in the quiescent udder derived from the blood before parturition. The blood serum of the cow is only partially protective. The main agent of disease during the first few days is *Bacillus coli*. A serum prepared by injecting cows with *Bacillus coli* protects all calves against the early diseases when the serum is fed in place of the first milk. This fact militates against the view that vitamins are the chief protecting factors in the colostrum. In the calves fed immune serum certain diseases may appear in the second month of life in one third of the animals. This indicates a lack of protection in directions other than that directed against *Bacillus coli*.

(*To be continued*)